Medical Policy

BlueCross BlueShield Kansas
An Independent licensee of the
Blue Cross Blue Shield Association

Title: Ambulatory Event Monitors and Mobile Cardiac Outpatient Telemetry

Professional / Institutional
Original Effective Date: April 1, 2007
Latest Review Date: June 15, 2026
Current Effective Date: June 15, 2026

State and Federal mandates and health plan member contract language, including specific provisions/exclusions, take precedence over Medical Policy and must be considered first in determining eligibility for coverage. To verify a member's benefits, contact Blue Cross and Blue Shield of Kansas Customer Service.

The BCBSKS Medical Policies contained herein are for informational purposes and apply only to members who have health insurance through BCBSKS or who are covered by a self-insured group plan administered by BCBSKS. Medical Policy for FEP members is subject to FEP medical policy which may differ from BCBSKS Medical Policy.

The medical policies do not constitute medical advice or medical care. Treating health care providers are independent contractors and are neither employees nor agents of Blue Cross and Blue Shield of Kansas and are solely responsible for diagnosis, treatment and medical advice.

If your patient is covered under a different Blue Cross and Blue Shield plan, please refer to the Medical Policies of that plan.

Populations	Interventions	Comparators	Outcomes
Individuals: • With signs and/or symptoms suggestive of arrhythmia	Interventions of interest are: • Patient- or auto-activated external ambulatory event monitoring • Continuous ambulatory monitoring storing information >48 hours	Comparators of interest are: • Electrocardiogram only or 24- to 48-hour Holter monitoring	Relevant outcomes include: • Overall survival • Morbid events
Individuals: • With atrial fibrillation following ablation	Interventions of interest are: • Long-term ambulatory cardiac monitoring	Comparators of interest are: • Electrocardiogram only or 24- to 48-hour Holter monitoring	Relevant outcomes include: • Overall survival • Morbid events • Medication use • Treatment-related morbidity
Individuals:	Interventions of interest are:	Comparators of interest are:	Relevant outcomes include: • Overall survival

Populations	Interventions	Comparators	Outcomes
• With cryptogenic stroke with negative standard workup for atrial fibrillation	• Long-term ambulatory cardiac monitoring	• Standard evaluation for stroke, including electrocardiogram and 24-hour Holter monitor	• Morbid events • Medication use • Treatment-related morbidity
Individuals: • Who are asymptomatic with risk factors for atrial fibrillation	Interventions of interest are: • Long-term ambulatory cardiac monitoring	Comparators of interest are: • No additional evaluation/ standard care	Relevant outcomes include: • Overall survival • Morbid events • Medication use • Treatment-related morbidity
Individuals: • With signs and/or symptoms suggestive of arrhythmia with infrequent symptoms	Interventions of interest are: • Patient- or auto-activated implantable ambulatory event monitors	Comparators of interest are: • No additional evaluation/standard care • Patient- or auto-activated external ambulatory event monitors	Relevant outcomes include: • Overall survival • Morbid events • Treatment-related morbidity
Individuals: • With signs and/or symptoms suggestive of arrhythmia	Interventions of interest are: • Outpatient cardiac telemetry	Comparators of interest are: • Patient- or auto-activated external ambulatory event monitors	Relevant outcomes include: • Overall survival • Morbid events

DESCRIPTION

Various devices are available for outpatient cardiac rhythm monitoring. These devices differ in the types of monitoring leads used, the duration and continuity of monitoring, the ability to detect arrhythmias without patient intervention, and the mechanism of delivering the information from patient to clinician. These devices may be used to evaluate symptoms suggestive of arrhythmias (eg, syncope, palpitations), and may be used to detect atrial fibrillation (AF) in patients who have undergone cardiac ablation of AF or who have a history of cryptogenic stroke.

OBJECTIVE

The objective of this evidence review is to determine whether outpatient cardiac rhythm monitoring improves the net health outcome in individuals being monitored for arrhythmia or atrial fibrillation.

BACKGROUND

Cardiac Arrhythmias

Cardiac monitoring is routinely used in the inpatient setting to detect acute changes in heart rate or rhythm that may need urgent response. For some conditions, a more prolonged period of

monitoring in the ambulatory setting is needed to detect heart rate or rhythm abnormalities that may occur infrequently. These cases may include the diagnosis of arrhythmias in patients with signs and symptoms suggestive of arrhythmias as well as the evaluation of paroxysmal atrial fibrillation (AF).

Cardiac arrhythmias may be suspected because of symptoms suggestive of arrhythmias, including palpitations, dizziness, syncope or presyncope, or because of abnormal heart rate or rhythm noted on exam. A full discussion of the differential diagnosis and evaluation of each of these symptoms is beyond the scope of this review, but some general principles on the use of ambulatory monitoring are discussed.

Arrhythmias are an important potential cause of syncope or near syncope, which in some cases may be described as dizziness. An electrocardiogram (ECG) is generally indicated whenever there is suspicion of a cardiac cause of syncope. Some arrhythmic causes will be apparent on ECG. However, for patients in whom an ECG is not diagnostic, longer monitoring may be indicated. The 2009 joint guidelines from the European Society of Cardiology and 3 other medical specialty societies suggested that, in individuals with clinical or ECG features suggesting an arrhythmic syncope, ECG monitoring is indicated; the guidelines also stated that the "duration (and technology) of monitoring should be selected according to the risk and the predicted recurrence rate of syncope."[1,] Similarly, guidelines from the National Institute for Health and Care Excellence (2023) on the evaluation of transient loss of consciousness, have recommended the use of an ambulatory ECG in individuals with a suspected arrhythmic cause of syncope. The type and duration of monitoring recommended is based on the individual's history, particularly the frequency of transient loss of consciousness.[2,] The Holter monitor is recommended if transient loss of consciousness occurs several times a week. If the frequency of transient loss of consciousness is every 1 to 2 weeks, an external event recorder is recommended; if the frequency is less than once every 2 weeks, an implantable event recorder is recommended.

Similar to syncope, the evaluation and management of palpitations is patient specific. In cases where the initial history, examination, and ECG findings are suggestive of arrhythmia, some form of ambulatory ECG monitoring is indicated. A position paper from the European Heart Rhythm Association (2011) indicated that, for individuals with palpitations of unknown origin who have clinical features suggestive of arrhythmia, referral for specialized evaluation with consideration for ambulatory ECG monitoring is indicated.[3,]

Atrial Fibrillation Detection

AF is the most common arrhythmia in adults. It may be asymptomatic or be associated with a broad range of symptoms, including lightheadedness, palpitations, dyspnea, and a variety of more nonspecific symptoms (eg, fatigue, malaise). It is classified as paroxysmal, persistent, or permanent based on symptom duration. Diagnosed AF may be treated with antiarrhythmic medications with the goal of rate or rhythm control. Other treatments include direct cardioversion, catheter-based radiofrequency- or cryo-energy-based ablation, or one of several surgical techniques, depending on the patient's comorbidities and associated symptoms.

Stroke in AF occurs primarily as a result of thromboembolism from the left atrium. The lack of atrial contractions in AF leads to blood stasis in the left atrium, and this low flow state increases the risk of thrombosis. The area of the left atrium with the lowest blood flow in AF, and therefore the highest risk of thrombosis, is the left atrial appendage. Multiple clinical trials have

demonstrated that anticoagulation reduces the ischemic stroke risk in patients at moderate- or high-risk of thromboembolic events. Oral anticoagulation in patients with AF reduces the risk of subsequent stroke and is recommended by American Heart Association, American College of Cardiology, and Heart Rhythm Society (2014) joint guidelines on patients with a history of stroke or transient ischemic attack.[4,]

Ambulatory ECG monitoring may play a role in several situations in the detection of AF. In patients who have undergone ablative treatment for AF, if ongoing AF can be excluded with reasonable certainty, including paroxysmal AF which may not be apparent on ECG during an office visit, anticoagulation therapy could potentially be stopped. In some cases where identifying paroxysmal AF is associated with potential changes in management, longer term monitoring may be considered. There are well-defined management changes that occur in patients with AF. However, until relatively recently the specific role of long-term (i.e., >48 hours) monitoring in AF was not well-described.

Patients with cryptogenic stroke are often monitored for the presence of AF because AF is estimated to be the cause of cryptogenic stroke in more than 10% of patients, and AF increases the risk of stroke.[5,6,] Paroxysmal AF confers an elevated risk of stroke, just as persistent and permanent AF does. In individuals with a high risk of stroke, particularly those with a history of ischemic stroke that is unexplained by other causes, prolonged monitoring to identify paroxysmal AF has been investigated.

Cardiac Rhythm Ambulatory Monitoring Devices

Ambulatory cardiac monitoring with a variety of devices permits the evaluation of cardiac electrical activity over time, in contrast to a static ECG, which only permits the detection of abnormalities in cardiac electrical activity at a single point in time.

A Holter monitor is worn continuously and records cardiac electrical output continuously throughout the recording period. Holter monitors are capable of recording activity for 24 to 72 hours. Traditionally, most Holter monitors have 3 channels based on 3 ECG leads. However, some currently available Holter monitors have up to 12 channels. Holter monitors are an accepted intervention in a variety of settings where a short period (24 to 48 hours) of comprehensive cardiac rhythm assessment is needed (eg, suspected arrhythmias when symptoms [syncope, palpitations] are occurring daily). These devices are not the focus of this review.

Various classes of devices are available for situations where longer monitoring than can be obtained with a traditional Holter monitor is needed. Because there may be many devices within each category, a comprehensive description of each is beyond our scope. Devices vary in how data are transmitted to the location where the ECG output is interpreted. Data may be transmitted via cellular phone or landline, or by direct download from the device after its return to the monitoring center. The device classes are described in Table 1.

Table 1. Ambulatory Cardiac Rhythm Monitoring Devices

Device Class	Description	Device Examples
Noncontinuous devices with memory (event recorder)	Devices not worn continuously but rather activated by patient and applied to the skin in the precordial area when symptoms develop	• Zio® Event Card (iRhythm Technologies) • REKA E100™ (REKA Health)
Continuous recording devices with longer recording periods	Devices continuously worn and continuously record via ≥1 cardiac leads and store data longer than traditional Holter (14 days)	• Zio®XT Patch and ZIO ECG Utilization Service (ZEUS) System (iRhythm Technologies)
External memory loop devices (patient- or autotriggered)	Devices continuously worn and store a single channel of ECG data in a refreshed memory. When the device is activated, the ECG is then recorded from the memory loop for the preceding 30-90 seconds and for next 60 seconds or so. Devices may be activated by a patient when symptoms occur (patient-triggered) or by an automated algorithm when changes suggestive of an arrhythmia are detected (auto-triggered).	• Patient-triggered: Explorer™ Looping Monitor (LifeWatch Services) • Auto-triggered: LifeStar AF Express™ Auto-Detect Looping Monitor (LifeWatch Services) • Auto-triggered or patient-triggered: King of Hearts Express® AF (Card Guard Scientific Survival)
Implantable memory loop devices (patient- or auto-triggered)	Devices similar in design to external memory loop devices but implanted under the skin in the precordial region	• Auto-triggered or patient-triggered: Reveal® XT ICM (Medtronic) and Confirm Rx Insertable™ Cardiac Monitor (Abbott) • Auto-triggered: BioMonitor (Biotronik)
Mobile cardiac outpatient telemetry	Continuously recording or auto-triggered memory loop devices that transmit data to a central recording station with real-time monitoring and analysis	• CardioNet MCOT™ (BioTelemetry) • LifeStar Mobile Cardiac Telemetry (LifeWatch Services) • Zio AT(iRhythm) • SmartCardia 7L (SmartCardia)

ECG: electrocardiogram.

There are also devices that combine features of multiple classes. For example, the LifeStar ACT Ex Holter (LifeWatch Services) is a 3-channel Holter monitor, but is converted to a mobile cardiac telemetry system if a diagnosis is inconclusive after 24 to 48 hours of monitoring. The BodyGuardian® Heart Remote Monitoring System (Preventice Services) is an external auto-triggered memory loop device that can be converted to a real-time monitoring system. The eCardio Verité™ system (eCardio) can switch between a patient-activated event monitor and a continuous telemetry monitor. The Spiderflash-T (LivaNova) is an example of an external auto-triggered or patient-triggered loop recorder, but like the Zio Patch, can record 2 channels for 14 to 40 days.

REGULATORY STATUS

Some of the newer devices are described in the Background section for informational purposes. Because there may be many devices within each category, a comprehensive description of individual devices is beyond the scope of this review. U.S. Food and Drug Administration product codes include: DSH, DXH, DQK, DSI, MXD, MHX.

POLICY

A. The use of patient-activated or auto-activated external ambulatory event monitors, OR continuous ambulatory monitors that record and store information for periods longer than 48 hours may be considered **medically necessary** as a diagnostic alternative to Holter monitoring in the following situations:

1. Individuals who experience infrequent symptoms (less frequently than every 48 hours) suggestive of cardiac arrhythmias (ie, palpitations, dizziness, presyncope, or syncope).

2. Individuals with atrial fibrillation who have been treated with catheter ablation, and in whom discontinuation of systemic anticoagulation is being considered.

3. Individuals with cryptogenic stroke who have a negative standard work-up for atrial fibrillation including a 24-hour Holter monitor (see Policy Guidelines).

B. The use of implantable ambulatory event monitors, either patient-activated or auto-activated, may be considered **medically necessary** in the following situations:

1. In the small subset of individuals who experience recurrent symptoms so infrequently that a prior trial of other external ambulatory event monitors has been unsuccessful.

2. In individuals who require long-term monitoring for atrial fibrillation or possible atrial fibrillation (see Policy Guidelines).

C. The use of outpatient cardiac telemetry (also known as mobile cardiac outpatient telemetry) as a diagnostic alternative to AEMs in individuals who experience infrequent symptoms (less frequently than every 48 hours) suggestive of cardiac arrhythmias (i.e., palpitations, dizziness, presyncope, syncope) may be considered **medically necessary** when any of the following criteria are met:

1. Evaluation of recurrent unexplained episodes of presyncope, syncope, palpitations or dizziness when:
   a. Symptoms are thought to be due to a cardiac arrhythmia; **AND**
   b. Holter monitor and/or external AEM has been nondiagnostic or contraindicated; **AND**
   c. There is documentation that real-time monitoring is essential for patient safety and will lead to immediate clinical changes such as medication or other emergent procedures; **OR**

2. Evaluation of cryptogenic stroke thought to be caused by atrial fibrillation, with non-diagnostic 24- to 48-hour Holter monitor or 48-hour telemetry.

D. Other uses of ambulatory event monitors, implantable ambulatory event monitors, and outpatient continuous cardiac telemetry, are considered **experimental / investigational**, including, but not limited to, monitoring asymptomatic individuals with risk factors for arrhythmia, monitoring effectiveness of antiarrhythmic medications, and detection of myocardial ischemia by detecting ST segment changes.

POLICY GUIDELINES

A. When CPT code 33285 is considered not medically necessary, CPT codes 93297 and 93298 will also be considered not medically necessary.

B. The available evidence suggests that long-term monitoring for atrial fibrillation after cryptogenic stroke or post ablation is associated with improved outcomes, but the specific type of monitoring associated with the best outcomes is not well-defined. Trials that have demonstrated improved outcomes have used either event monitors or implantable monitors. In addition, there are individual considerations that may make one type of monitor preferable over another.

C. Therefore, for the evaluation of individuals with cryptogenic stroke who have had a negative standard workup for atrial fibrillation including 24-hour Holter monitoring, or for the evaluation of atrial fibrillation after an ablation procedure, the use of long-term monitoring with an external event monitor, OR a continuous ambulatory monitor that records and stores information for periods longer than 48 hours, OR an implantable ambulatory monitor may be considered medically necessary for individuals who meet the criteria outlined above.

Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

RATIONALE

This evidence review was created using searches of the PubMed database. The most recent literature update was performed through December 2, 2025.

Evidence reviews assess the clinical evidence to determine whether the use of technology improves the net health outcome. Broadly defined, health outcomes are the length of life, quality of life, and ability to function-including benefits and harms. Every clinical condition has specific outcomes that are important to patients and managing the course of that condition. Validated outcome measures are necessary to ascertain whether a condition improves or worsens; and whether the magnitude of that change is clinically significant. The net health outcome is a balance of benefits and harms.

To assess whether the evidence is sufficient to draw conclusions about the net health outcome of a technology, 2 domains are examined: the relevance, and the quality and credibility. To be relevant, studies must represent 1 or more intended clinical use of the technology in the intended population and compare an effective and appropriate alternative at a comparable intensity. For some conditions, the alternative will be supportive care or surveillance. The quality and credibility of the evidence depend on study design and conduct, minimizing bias and confounding that can generate incorrect findings. The randomized controlled trial (RCT) is preferred to assess efficacy; however, in some circumstances, nonrandomized studies may be adequate. RCTs are rarely large enough or long enough to capture less common adverse events and long-term effects. Other types of studies can be used for these purposes and to assess generalizability to broader clinical populations and settings of clinical practice.

This review is structured around 3 questions: First, in what clinical situations, and with what classes, do ambulatory event monitors (AEMs) improve health outcomes? Second, under what circumstances are implantable AEMs associated with improved outcomes? Third, under what circumstances is real-time monitoring associated with improved outcomes?

For some of AEMs discussed herein, including those that include real-time monitoring and analysis, the technologies represent an enhancement to existing technology and are intended to improve outcomes compared with event monitors. As such, to demonstrate an improvement in health outcomes, there must be a clinically significant incremental benefit when the additional technology, such as real-time monitoring, is added.

Ambulatory Event Monitors in the Detection of Arrhythmias

The first 4 sections of the policy focus on clinical situations for which the use of long-term AEMs may be associated with improved health outcomes.

- The use of long-term AEMs in the diagnosis of cardiac rhythm abnormalities in individuals with signs and/or symptoms of arrhythmias (eg, dizziness, syncope or near syncope, palpitations) is discussed. Specific arrhythmias may be relatively nonspecific in terms of the symptoms they cause. However, the diagnosis of some arrhythmias has well-defined management implications that are known to improve outcomes, such as the use of an implantable cardioverter defibrillator in individuals with potentially lethal arrhythmias, or antiarrhythmic drugs or pulmonary vein isolation for the treatment of atrial fibrillation (AF). Therefore, identification of an arrhythmia is considered a reasonable endpoint in this case.
- The use of long-term AEMs for the detection of AF in patients following catheter ablation, for which management (use of anticoagulation therapy) may be changed based on AF detection.
- The use of long-term AEMs for the detection of AF in patients following cryptogenic stroke, for which management (use of anticoagulation therapy) may be changed based on AF detection.
- The use of long-term AEMs for the detection of AF in asymptomatic patients.

The last 2 sections of the policy focus on types of long-term AEMs: implantable AEMs and outpatient cardiac telemetry.

AUTO-ACTIVATED EXTERNAL OR CONTINUOUS AMBULATORY EVENT MONITORING FOR PATIENTS WITH ARRHYTHMIA SYMPTOMS

Clinical Context and Test Purpose

The purpose of patient- or auto-activated external ambulatory event monitoring or continuous ambulatory event monitoring in individuals who have signs and/or symptoms of arrhythmia is to provide an alternative detection method for AF.

The following PICO was used to select literature to inform this review.

Populations
The relevant population of interest is individuals with signs or symptoms suggestive of arrhythmia.

Interventions
The intervention being considered is patient- or auto-activated external event monitoring or continuous ambulatory event monitoring. Patient-activated devices are applied to the skin in the precordial area by the patient when symptoms are developing. Continuous event monitoring devices are worn continuously and are recording activity continuously and can store data longer than the Holter monitor.

Comparators
Alternative AF detection methods that are used include an electrocardiogram (ECG) or 24- to 48-hour Holter monitoring. An ECG provides information on cardiac electrical activity at one point in time. A Holter monitor is worn continuously and records cardiac electrical output continuously throughout the recording period. Holter monitors are capable of recording activity for 24 to 72 hours.

Outcomes
The general outcome of interest is diagnostic yield of the monitors in detecting arrhythmias. To measure incremental benefits of the patient-activated or continuous monitors, direct comparisons with the Holter monitor, or indirect comparisons of the number of detections in the first 48 hours with the number of detections during longer monitoring periods can be made.

Study Selection Criteria
For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.
- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse). Below are studies providing evidence on the diagnostic yield of long-term AEMs in symptomatic patients.

Long-Term Ambulatory Event Monitoring in Symptomatic Patients
Newer devices are available that record cardiac rhythms continuously for longer periods of time than traditional Holter monitors. Several studies have evaluated the diagnostic yield of continuous monitoring for more than 48 hours, either directly through comparison with Holter monitoring or indirectly by calculating the proportion of arrhythmias detected in the first 48 hours of monitoring. The diagnostic yield of monitoring with external event monitors depends on the underlying population, the inherent sensitivity of the device, and the duration of monitoring.

REVIEW OF EVIDENCE

Systematic Review

Hoefman et al (2010) published a systematic review on diagnostic tools for detecting cardiac arrhythmias.[7,] The literature search, conducted through March 2007, identified 28 studies for inclusion; 12 were single-arm studies and 16 were comparative studies. A meta-analysis was not possible due to the heterogeneity of the study populations and the devices tested. This review included studies of patients presenting with palpitations and compared the yield of remote monitoring for several classes of devices: Holter monitors, patient-activated event recorders, auto-triggered event recorders, and implantable loop recorders (ILRs). The yield varied among devices, with auto-trigger devices providing the highest range of detection (72% to 80%), followed by patient-activated devices (17% to 75%), and Holter monitors (33% to 35%).

Observational Studies

Farris et al (2019) reviewed the records of patients who had undergone 30-day rhythm monitoring with the LifeWatch device at a single institution.[8,] A total of 3.4% of the patients had a new diagnosis of AF (402 per 1000 patient-years). The most common management response to the new diagnoses was to initiate anticoagulation therapy.

Turakhia et al (2013) evaluated the diagnostic yield of the Zio Patch.[9,] Data from the manufacturer were used to identify 26,751 first-time users of the device. The most common clinical indications were palpitations (40.3%), AF (24.3%), and syncope (15.1%). Mean duration of use was 7.6 days, and 95.9% of patients wore the device for more than 48 hours. At least one episode of arrhythmia was detected in 16,142 (60.3%) patients. The authors compared the detection rate in the first 48 hours with the detection rate over the entire time the device was worn, with 70.1% of patients having their arrhythmia detected within the first 48 hours and 29.9% having their first arrhythmia detected after the first 48 hours. The overall yield was significantly higher when comparing the total monitored period (62.2%) with the first 48 hours (43.9%; $p<.001$). These data confirmed previous studies that had shown that while a substantial proportion of arrhythmias in symptomatic patients can be detected within a 48-hour period of monitoring, longer monitoring periods increase the detection rate.

Barrett et al (2014) compared arrhythmia detection rates in 146 patients who underwent simultaneous monitoring with a 24-hour Holter monitor and a 14-day Zio Patch monitor.[10,] Included were patients referred for evaluation of a suspected cardiac arrhythmia at a single institution. For the detection of atrioventricular block, sinus pause, polymorphic ventricular tachycardia, supraventricular tachycardia (SVT), or AF, Holter monitoring detected 61 arrhythmias, while the Zio Patch detected 96 arrhythmias ($p<.001$). Over the monitoring period, the same 60 arrhythmia events were detected by both devices, with 36 only detected by the Zio Patch and 1 only detected by the Holter monitor. The investigators conducted within-subject comparisons of arrhythmia detection for the 24-hour period during which both devices were worn. Holter monitoring detected 61 arrhythmia events compared with 52 arrhythmias detected by the Zio Patch ($p=.013$). This study also suggested that extended monitoring may increase the diagnostic yield of cardiac monitoring. However, a relatively large number of missed events occurred with the Zio Patch during the period of simultaneous monitoring, which might have clinical significance if its performance is similar in nonresearch settings.

Solomon et al (2016) evaluated the diagnostic yield for potentially high-risk arrhythmias during 14 days of continuous recording with the Zio Patch among 122,454 patients (122,815 recordings)

included in a manufacturer registry.[11,] Patients included in the series all underwent monitoring with the device from November 2011 to December 2013. Mean wear time was 9.6 days. Overall, there were 22,443 (18%) patients with sustained ventricular tachycardia, 1766 (1.4%) patients with sinus pauses of 3 seconds or more, 521 (0.4%) patients with AF pauses of 3 seconds or more, 249 (0.2%) patients with symptomatic pauses, and 1468 (0.4%) with high-grade heart block, which were considered potentially high-risk arrhythmias. After 24 and 48 hours of monitoring, 52.5% and 65.5%, respectively, of potentially high-risk arrhythmias were detected. Seven days of monitoring identified 92.9% of potentially high-risk arrhythmias.

Wineinger et al (2018) reported on 13,293 individuals with paroxysmal AF who were referred for extended cardiac rhythm evaluation based on a clinical indication and wore the Zio Patch as part of standard clinical care.[12,] The median time to the first detected paroxysmal AF event was 24.9 hours (interquartile range [IQR], 2.7 to 83.9 hours). After 24 hours of monitoring, 49.4% of individuals had experienced a paroxysmal AF event, increasing to 63.1% after 48 hours of monitoring and to 89.7% after 7 days of monitoring.

In a retrospective cohort study using data from 2 integrated health care delivery systems in California, Go et al (2018) examined the association of AF burden with the risk of stroke in patients with paroxysmal AF who were not receiving anticoagulants.[13,] The analysis included data from 1965 patients who were receiving monitoring with the Zio Patch. The highest tertile of AF burden (11.4% or higher), as measured by up to 14 days of continuous monitoring, was associated with a more than 3-fold higher risk of ischemic stroke compared to the lower 2 tertiles, even after controlling for known stroke risk factors.

Bolourchi et al (2015) evaluated the diagnostic yield of 14 days of monitoring with the Zio Patch in a series of 3209 children included in a manufacturer registry.[14,] Patient age ranged from 1 month to 17 years. Indications for monitoring included palpitations (n=1138 [35.5%]), syncope (n=450 [14.0%]), unspecified tachycardia (n=291 [9.1%]), paroxysmal SVT (n=264 [8.2%]), and chest pain (n=261 [8.1%]). The overall prevalence of any arrhythmia was 12.1%, with 44.1% of arrhythmias occurring after the first 48 hours of monitoring. Arrhythmias were detected in 10.0% of patients referred for palpitations, 6.7% referred for syncope, 14.8% referred for tachycardia, 22.7% referred for paroxysmal SVT, and 6.5% referred for chest pain.

Multiple single-center studies, summarized in Table 2, have reported on the diagnostic yield and timing of arrhythmia detection in patients monitored with the Zio Patch for a variety of arrhythmias. These studies generally have reported high rates of arrhythmia detection.

Table 2. Single-Center Studies Reporting on Zio Patch Diagnostic Yield

Study	Population	Monitoring Indication	Main Findings
		Indication (%)	
Eisenberg et al (2014)[15,]	524 consecutive patients evaluated in an academic EP practice	• Surveillance for unspecified arrhythmia or palpitations (47) • Known/suspected AF (30)	• Significant arrhythmias detected in 297 (57%) • 66% had 1st arrhythmia detected within 2 days of monitoring

Study	Population	Monitoring Indication	Main Findings
		• Syncope (8) • Bradycardia surveillance (4) • Tachycardia surveillance (5) • Chest pain (2)	• 25% of patient-triggered events associated with clinically significant arrhythmias
Schreiber et al (2014)[16,]	174 patients with symptoms suggestive of arrhythmia seen in an ED	• Palpitations (44.8) • Syncope (24.1) • Unspecified arrhythmias detected in the ED (11.5)	• >1 significant arrhythmia other than chronic AF (≥4 beats VT, paroxysmal AF, ≥4 beats SVT, ≥3-second pause, 2nd-degree Mobitz II or 3rd-degree AV block, or symptomatic bradycardia) detected in 83 (47.7%) • Median time to arrhythmia detection: ○ Any arrhythmia: 1.0 day (IQR, 0.2 to 2.8) ○ VT: 3.1 days ○ Sinus pause: 4.2 days ○ Significant heart block: 5.8 days
Mullis et al (2019) [17,]	59 consecutive patients seen in an outpatient EP clinic	PVCs	• Median of minimum 24-hour PVC burden: 4.5% (IQR, 2.6% to 11.2%) • Median of maximum 24-hour PVC burden: 16.2% (IQR, 11.7% to 26.2%) • Mean 24-hour PVC burden: 9.0% (IQR, 6.4% to 17.9%) • Median difference between maximum 24-hour PVC burden and minimum 24-hour burden: 2.45-fold (IQR, 1.68- to 5.55-fold)
Reed et al (2018)[18,]	86 patients evaluated in an ED	Syncope	• 9/86 (10.5%) had a symptomatic significant arrhythmia endpoint (95% CI, 4.0% to 16.9%)

AF: atrial fibrillation; AV: atrioventricular; CI: confidence interval; ED: emergency department; EP: electrophysiology; IQR: interquartile range; PVC: premature ventricular contraction; SVT: supraventricular tachycardia; VT: ventricular tachycardia.

Comparison of Devices

Eysenck et al (2019) compared 4 external cardiac monitors (Zio XT Monitor, NUUBO vest, Carnation Ambulatory Monitor, and Novacor R Test) with the gold standard of permanent pacemakers in the ability to detect AF.[19,] Patients who had permanent pacemakers (n=21) wore each of the external monitors for 2 weeks, in randomized order. A total of 1108 AF episodes were identified by the pacemakers during the study period. Results showed that the Zio, NUUBO, and Carnation monitors were more accurate in AF diagnosis compared with the Novacor R Test, when using the pacemaker detection episodes as the reference standard.

Health Quality Ontario (2017) published an assessment comparing long-term continuous AEMs with external cardiac loop recorders for detecting arrhythmias.[20,] The assessment included a

systematic review of the literature on the effectiveness of both devices for detecting arrhythmias. No studies directly comparing long-term continuous AEMs with external loop recorders (ELRs) were found, so indirect comparisons were constructed using 24-hour Holter monitors as the common comparator. Twelve cohort studies were included; 7 addressed long-term AEMs and 5 addressed ELRs. Using a meta-regression model to control for variation in device-wearing time and baseline syncope rate, the estimated difference between the long-term continuous AEMs and ELRs in their ability to detect arrhythmias was small (risk difference, 0.01; 95% confidence interval [CI], -0.18 to 0.20). Both devices were more effective than a 24-hour Holter monitor. However, the quality of evidence was evaluated as poor using GRADE criteria.

Some evidence suggests that auto-triggered event monitors have an inherently higher yield than patient-activated AEMs. Several studies, including an analysis of a database of 100,000 patients, have compared the diagnostic yield of automatic and patient-activated arrhythmia recordings and reported an improved yield with auto-triggering devices.[21,22,23,]

Clinically Useful
A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence
Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. No RCTs supporting clinical utility were identified.

Chain of Evidence
Indirect evidence on clinical utility rests on clinical validity. Clinical validity of long-term ambulatory monitoring in patients with arrhythmia symptoms was demonstrated in several large observational studies showing additional AF detection beyond the time frame of when a Holter monitor would be used (24 to 48 hours). When arrhythmia events are detected, management of patients typically involve antiarrhythmic or anticoagulant therapies, which are proven effective in stroke prevention. Therefore, longer term monitoring may improve health outcomes.

Section Summary: Auto-Activated or Continuous Ambulatory Monitoring for Patients with Arrhythmia Symptoms
The available evidence on continuously worn cardiac monitors that can store data for longer periods of time than standard Holter monitors indicates that such devices typically detect greater numbers of arrhythmias during extended follow-up compared with 24- or 48-hour Holter monitoring. Several observational studies indicated that patients who had arrhythmias detected were more likely to receive anticoagulant therapy, antiarrhythmic therapy, and ablation or other cardiac procedures. Because these treatments have been proven effective for stroke prevention, it can be concluded that longer term monitoring of patients with arrhythmia symptoms will improve outcomes.

LONG-TERM AMBULATORY CARDIAC MONITORING FOR PATIENTS WITH ATRIAL FIBRILLATION FOLLOWING ABLATION

Clinical Context and Test Purpose

All individuals treated with ablation are given anticoagulation for up to 3 months postprocedure, with many individuals remaining on long-term anticoagulation. In individuals with an apparently successful ablation who do not show signs or symptoms of recurrent AF at time periods longer than 3 months postablation, a decision whether to continue treatment with anticoagulants needs to be made. Studies have demonstrated that late recurrences are not uncommon after ablation and that these recurrent episodes are often asymptomatic.[24,25,] However, the presence of recurrent episodes of AF is a predictor of future thromboembolic events. In a large observational study of 565 individuals postablation, Chao et al (2011) found the 2 major predictors of thromboembolism were the $CHADS_2$ score and the presence of recurrent episodes of AF.[26,]

The purpose of AEMs (either patient-activated or continuous) in individuals with AF following ablation is to provide an alternative detection method for recurrent AF in order to accurately assess the need for anticoagulation therapy.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with AF following ablation.

Interventions

The intervention being considered is patient- or auto-activated external event monitoring or continuous ambulatory event monitoring. Patient-activated devices are applied to the skin in the precordial area by the patient when symptoms are developing. Continuous event monitoring devices are recording activity continuously and can store data longer than the Holter monitor.

Comparators

Alternative surveillance methods that are used include an ECG or 24- to 48-hour Holter monitoring. An ECG provides information on cardiac electrical activity in 1 point in time. A Holter monitor is worn continuously and records cardiac electrical output continuously throughout the recording period. Holter monitors are capable of recording activity for 24 to 72 hours.

Outcomes

The general outcome of interest is diagnostic yield of the monitors in detecting arrhythmias. If arrhythmias do not recur following ablation, individuals may consider discontinuing anticoagulation therapy.

Study Selection Criteria

For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.
- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

REVIEW OF EVIDENCE

Randomized Controlled Trial
In a prospective, randomized study, Kapa et al (2013) compared ILRs with conventional transtelephonic recorders in the assessment of arrhythmia burden after catheter ablation.[27,] Forty-four patients were enrolled and randomized; all patients received the ILR postablation. Six patients were excluded due to requests for device removal or loss to follow-up. During the first 6 months after ablation, all subjects underwent conventional monitoring that consisted of twice daily, 1-minute pulse rate assessments by the patient and 3, 30-day transtelephonic monitoring periods. At 6 months postablation, patients were allocated to the randomization arm (on a 1:1 basis at initial enrollment) of either the ILR (transmission of data every 31 days) or conventional monitoring (twice daily, 1-minute pulse rate assessment, 1 transtelephonic recording for 30 days at month 11). At 6 months postablation, conventional monitoring detected AF in 7 (18%) of 38 patients and the ILR confirmed AF in all of these patients. ILR monitoring also detected AF in an additional 11 (29%) patients. During the subsequent 6-month period, 5 of 18 patients in the conventional monitoring arm refused ongoing monitoring due to discomfort and lifestyle restrictions; of the remaining 13, 5 (38%) had a recurrence of AF. In the ILR group, 5 (25%) of 20 patients had recurrence of AF. During the randomization period, 71% of patients in the ILR group discontinued their antiarrhythmic drugs compared with 44% in the conventional monitoring group over the randomization period (p=.04).

Observational Study
Reporting on the prospective Discerning Symptomatic and Asymptomatic Episodes Pre- and Post-Radiofrequency Ablation of AF study, Verma et al (2013) evaluated the incidence of asymptomatic AF episodes for 3 months before and 18 months after ablation in 50 patients implanted with a cardiac monitor.[28,] Patients were instructed to keep a standardized diary record of arrhythmia symptoms. Asymptomatic AF recurrences were defined as implantable cardiac monitor (ICM) events lasting 2 minutes or longer, without a corresponding diary entry. Based on diary reporting of symptoms, 29 (58%) of 50 patients were arrhythmia-free after ablation; based on monitor recordings from intermittent (every 3 month) ECG or Holter monitor, 28 (56%) patients were arrhythmia-free postablation. Patient detection of symptoms underestimates the AF occurrence rate following ablation, with 12% of patients having arrhythmias that were only detected through monitoring.

Clinically Useful
A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. No RCTs were identified. Below is an observational study providing indirect evidence.

Several observational studies have followed patients who stopped anticoagulation after a comprehensive evaluation, which included ambulatory monitoring, that indicated the patient had a low risk for recurrent episodes. These patients experienced a low subsequent rate of thromboembolic events. In one study, Themistoclakis et al (2010) evaluated 3355 patients from 5 clinical centers, of whom 2692 discontinued anticoagulation at 3 to 6 months postablation and 663 continued anticoagulation medication.[29,] During a mean follow-up of 28 months, 2 (0.07%) patients who discontinued anticoagulation experienced an ischemic stroke. This rate did not differ significantly from the stroke rate in patients who continued anticoagulation (0.45%). In addition, the adverse event rate of major hemorrhage was lower for patients who discontinued anticoagulation (0.04%) compared with those who continued (2%; $p<.001$).

Chain of Evidence

Indirect evidence on clinical utility rests on clinical validity. An RCT and observational studies have shown that ambulatory monitoring was able to detect AF recurrences that were not detectable based on symptoms alone. No RCTs were identified that compared health outcomes for patients managed with and without ambulatory monitoring. However, there is a large observational study demonstrating that following ablation and a comprehensive evaluation including ambulatory monitoring that indicates a patient is low-risk, patients may consider discontinuing anticoagulation therapy. Patients who discontinued anticoagulation therapy following ablation experienced comparably low rates of stroke compared with patients remaining on anticoagulation therapy, and had statistically lower occurrences of major hemorrhage.

Section Summary: Long-Term Ambulatory Cardiac Monitoring for Patients With Atrial Fibrillation following Ablation

Evidence includes an RCT and several observational studies that make a strong indirect argument that long-term monitoring for asymptomatic episodes of AF with AEMs will lead to changes in management with long-term anticoagulation. One study reported that patients who discontinued anticoagulation therapy after ambulatory monitoring was negative for recurrent episodes experienced a low rate of stroke similar to patients who remained on anticoagulation therapy. In addition, patients discontinuing anticoagulants experienced fewer major hemorrhages. These changes in management based on ambulatory monitoring are likely to improve outcomes. Because different long-term monitoring devices were used across the studies, the specific type of monitoring associated with the best outcomes is not established.

LONG-TERM AMBULATORY CARDIAC MONITORING FOR PATIENTS WITH CRYPTOGENIC STROKE

Clinical Context and Test Purpose

Approximately 5% of individuals with cryptogenic stroke will have AF diagnosed on ECG and/or telemetry monitoring in the hospital. Individuals with a history of cryptogenic stroke who have had AF detected, are typically treated with anticoagulants. Studies comparing the use of

continuous telemetry monitoring at the bedside with Holter monitoring for individuals hospitalized for stroke or transient ischemic attack (TIA) have reported inconclusive results as to which is the preferred method for AF detection.[30,31,] Longer term ambulatory event monitoring has been shown to identify additional individuals with asymptomatic episodes, with rates of detection estimated at 6% to 26% of individuals.[5,32,33,]

The purpose of long-term ambulatory cardiac monitoring in individuals who have a history of cryptogenic stroke is to provide an alternative detection method for AF in order to accurately inform the decision to receive anticoagulation therapy.

The following PICO was used to select literature to inform this review.

Populations
The relevant population of interest is individuals with a history of cryptogenic stroke with negative standard workup for AF.

Interventions
The intervention being considered is patient- or auto-activated external event monitoring or continuous ambulatory event monitoring. Patient-activated devices are applied to the skin in the precordial area by the patient when symptoms are developing. Continuous event monitoring devices are worn continuously and are recording activity continuously and can store data longer than the Holter monitor.

Comparators
The comparator is standard evaluation for stroke, including ECG or 24- to 48-hour Holter monitoring. An ECG provides information on cardiac electrical activity in 1 point in time. A Holter monitor is worn continuously and records cardiac electrical output continuously throughout the recording period. Holter monitors are capable of recording activity for 24 to 72 hours.

Outcomes
The general outcome of interest is diagnostic yield of the monitors in detecting arrhythmias. Accurate detection of arrhythmias may be used to inform management decisions concerning anticoagulation therapy.

Study Selection Criteria
For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.
- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse). Below are systematic reviews and RCTs

providing evidence for the clinical validity of long-term ambulatory monitoring of individuals with cryptogenic stroke.

REVIEW OF EVIDENCE

Systematic Reviews

Ho et al (2024) conducted a systematic review of studies with wearable devices for detection of AF in patients with cryptogenic stroke or embolic stroke of undetermined source.[34,] Both ECG-based devices (eg, wearable, handheld, patch, mobile cardiac telemetry, smartwatch) and photoplethysmography-based devices (eg, smartphone, smartwatch) were included. Among the 27 studies that were identified, only 2 were randomized. There were 4 studies that compared wearable devices to Holter monitoring or ILRs. The analysis of these 4 studies did not demonstrate a difference in AF detection compared to Holter monitoring or ILRs (odds ratio, 2.35; 95% CI, 0.74 to 7.48; I^2=70%), or compared to Holter monitoring alone (odds ratio, 3.20; 95% CI, 0.91 to 11.28; I^2=73%).

Sposato et al (2015) conducted a systematic review and meta-analysis of studies assessing rates of newly diagnosed AF after cryptogenic stroke or TIA based on cardiac monitoring, stratified into 4 sequential screening phases: phase 1 (emergency department) consisted of admission ECG; phase 2 (in-hospital) comprised serial ECG, continuous inpatient ECG monitoring, continuous inpatient cardiac telemetry, and in-hospital Holter monitoring; phase 3 (first ambulatory period) consisted of ambulatory Holter monitoring; and phase 4 (second ambulatory period) consisted of mobile cardiac outpatient telemetry (MCOT), ELR, and ILR.[35,] In total, 50 studies with 11,658 patients met the inclusion criteria. Studies were mixed in their patient composition: 22 (28%) included only cryptogenic stroke cases, 4 (5%) stratified events into cryptogenic and noncryptogenic, and 53 (67%) included unselected patient populations. The proportion of patients diagnosed with poststroke AF during the ambulatory phases was 10.7% (95% CI, 5.6% to 17.2%) in phase 3, and 16.9% (95% CI, 13.0% to 21.2%) in phase 4. The overall AF detection yield after all phases of sequential cardiac monitoring was 23.7% (95% CI, 17.2% to 31.0%). In phase 4, there were no differences between the proportion of patients diagnosed with poststroke AF by MCOT (15.3%; 95% CI, 5.3% to 29.3%), ELR (16.2%; 95% CI, 0.3% to 24.6%), or ILR (16.9%; 95% CI, 10.3% to 24.9%; p=.97).

Kishore et al (2014) conducted a systematic review and meta-analysis of prospective observational studies and RCTs that have reported detection rates of newly diagnosed AF in patients with ischemic stroke or TIA who had had any cardiac monitoring for at least 12 hours.[36,] Thirty-two studies were selected: 18 studies included patients with ischemic stroke only, 1 study included TIA only, and 13 studies included both ischemic stroke and TIA. Reviewers reported significant study heterogeneity. Among unselected patients (i.e., selected on the basis of stroke pathogenesis, age, or prescreening for AF), the detection rate of any new AF was 6.2% (95% CI, 4.4% to 8.3%); among selected patients, it was 13.4% (95% CI, 9.0% to 18.4%). In cryptogenic strokes, new AF was detected in 15.9% of patients (95% CI, 10.9% to 21.6%). Among selected patients, the AF detection rate during 24-hour Holter monitoring was 10.7% (95% CI, 3.4% to 21.5%), while the detection rate during monitoring beyond 24 hours (including more prolonged Holter monitoring, implantable and nonimplantable loop recording, and MCOT) was 14.7% (95% CI, 10.7% to 19.3%).

The Kishore et al (2014) study and others suggest that longer periods of cardiac monitoring increase the likelihood of AF detection. However, many of these asymptomatic episodes of AF are brief and their relation to the preceding stroke uncertain. The ideal study to evaluate the role of cardiac monitoring in the management of patients with cryptogenic stroke would be trials that randomize patients to a strategy involving event monitoring or routine care with evaluation of rates of detection of AF and stroke-related outcomes.

Randomized Controlled Trials

Five RCTs were identified that evaluated ambulatory monitoring in patients with cryptogenic stroke (Table 3). Two were small pilot trials. One small pilot RCT published by Kamel et al (2013) randomized 40 patients with cryptogenic ischemic stroke or high-risk TIA to usual care or to 21 days of MCOT.[37,] There were no cases of AF detected in either group (Table 4).

A second small pilot trial published by Higgins et al (2013) randomized 100 patients with ischemic stroke and no history of AF presenting within 7 days of a cryptogenic ischemic stroke to either standard care, which included 12-lead ECG, 24-hour Holter monitoring, and/or echocardiography, at the discretion of the treating practitioner, or to standard care plus cardiac event monitoring with Novacor R-test Evolution 3, an ELR device (Table 3).[38,] Sustained AF (recorded for the complete 20-second rhythm strip after event triggering) was detected significantly more often with the ELR than with standard care at 14-day follow-up. The difference did not differ statistically at 90-day follow-up (Table 4).

Sanna et al (2014) reported on results from the Cryptogenic Stroke and underlying Atrial Fibrillation (CRYSTAL AF) trial, an RCT that evaluated whether long-term monitoring with ICMs in patients who had cryptogenic stroke would lead to changes in anticoagulant management and/or improved outcomes (Table 3).[39,40,] The trial randomized 441 patients to continuous monitoring with the Reveal XT ICM or routine care. Eligibility criteria included no known history of AF, cryptogenic stroke, or TIA with infarct, and no mechanism determined after a workup that included 12-lead ECG, 24-hour Holter monitoring, transesophageal echocardiography, computed tomography (CT) or magnetic resonance angiography of the head and neck, and hypercoagulability screening (for patients <55 years old). Analysis was intention-to-treat. Of the 441 patients randomized, 416 (94.3%) completed 6-month follow-up, 2 were lost to follow-up, 5 died, and 18 exited the trial before 6 months. Crossover occurred in 12 patients in the ICM group and 6 in the control group. AF was detected in 8.9% of the ICM group compared with 1.4% of the control group (hazard ratio [HR], 6.43; 95% CI, 1.90 to 21.74) (Table 4). Median time from randomization to detection of AF was 41 days (IQR, 14 to 84 days) in the ICM group and 32 days (IQR, 2 to 73 days) in the control group. Most AF episodes in the ICM group were asymptomatic (74%) compared with 33% in the control group. The rate of AF detection was similarly greater in the ICM group at the 12-month follow-up (Table 4). A majority of patients who had AF detected were prescribed anticoagulation therapy. Five (2.4%) of the 208 ICM inserted were removed due to infection or erosion of the device pocket. Brachmann et al (2016) reported 3-year follow-up results from the CRYSTAL AF trial.[41,] At trial closure, 48 subjects had completed 3 years of follow-up (n=24 in each treatment group). By 3 years, the HR for detecting AF for ICM-monitored versus control patients was 8.8 (95% CI, 3.5 to 22.2; p<.001).

Gladstone et al (2014) reported results from the Atrial Fibrillation in Patients with Cryptogenic Stroke study, an RCT that compared 30-day auto-triggered external loop cardiac event monitors with conventional 24-hour monitors for the detection of AF in patients with cryptogenic stroke

(Table 3).[42,] Patients were ages 55 years or older, with no known history of AF, and an ischemic stroke or TIA of undetermined cause within the prior 6 months. All patients underwent standard screening for AF with 1 or more ECGs and 1 or more 24-hour Holter monitors. In total, 572 patients were randomized to an ELR (ER910AF Cardiac Event Monitor, Braemar) or to a 24-hour Holter monitor. Among intervention group subjects, 82% completed at least 3 weeks of monitoring. AF was detected in 45 (16.1%) of 280 patients in the intervention group compared with 9 (3.2%) of 277 patients in the control group (risk difference, 12.9 percentage points; 95% CI, 8.0 to 17.6; p<.001) (Table 4). At 90-day follow-up, patients in the intervention group (18.6%) were more likely to be treated with anticoagulants than those in the control group (11.1%; absolute treatment difference, 7.5 percentage points; 95% CI, 1.6 to 13.3; p=.01).

Kaura et al (2018) compared monitoring with the Zio Patch to short-term Holter monitoring in 120 patients following TIA or ischemic stroke.[43,] Patch-based monitoring was superior to standard monitoring for the detection of paroxysmal AF over the 90-day follow-up period (16.3% vs. 2.1%; odds ratio, 8.0; 95% CI, 1.1 to 76.0; p=.026).

Table 3. Summary of Randomized Controlled Trial Characteristics for Ambulatory Event Monitors for Cryptogenic Stroke

					Interventions (n)	
Study	**Country**	**Sites**	**Dates**	**Participants**	**Active**	**Comparator**
Kamel et al (2013)[37,]	United States	1	2009-2011	Cryptogenic ischemic stroke or high-risk TIA	MCOT (20)	Standard (20)
Higgins et al (2013)[38,]	United Kingdom	2	2010-2011	Transient or persistent symptoms of acute TIA	ELR (50)	Standard (50)
Sanna et al (2014)[40,] Brachmann et al (2016)[41,]	Canada, Europe, United States	55	2009-2012	Cryptogenic ischemic stroke or TIA	ILR (221)	Standard (220)
Gladstone et al (2014)[42,]	Canada	16	NR	Cryptogenic ischemic stroke or TIA	ELR (280)	Standard (277)
Kaura et al (2019)[43,]	United Kingdom	2	NR	Cryptogenic ischemic stroke or TIA	Zio Patch (60)	Standard (60)

ELR: external loop recorder; ILR: implantable loop recorder; MCOT: mobile cardiac outpatient telemetry; NR: not reported; TIA: transient ischemic attack.

Table 4. Summary of Randomized Controlled Trial Results for Ambulatory Event Monitors for Cryptogenic Stroke

Study	**FU**	**AF Detection**			**Additional Findings**
		AEM, %	Standard, %	p-value	
Kamel et al (2013)[37,]	90 days	0	0	NS	• MCOT identified atrial tachycardia in 2 patients (1 incorrectly labeled as AF by telemetry software) • MCOT identified 2 nonsustained ventricular tachycardia

Study	FU	AF Detection			Additional Findings
Higgins et al (2013)[38,]	14 days 90 days	18 22	28	<.05 .09	• No difference between groups for recurrent stroke, TIA, or mortality
Sanna et al (2014)[40,]; Brachmann et al (2016)[41,]	6 months 12 months 3 years	8.9 12.4 30	1.4 2.0 3.0	<.001 <.001 <.001	• Percent patients on oral anticoagulation therapy significantly higher in ILR group versus standard group • At 3-year follow-up, recurrent stroke or TIA occurred in 20 patients in ILR group and in 24 in standard group
Gladstone et al (2014)[42,]	90 days	16.1	3.2	<.001	• Atrial premature beats was identified in a regression model as a potential predictor of AF detection
Kaura et al (2019)[43,]	90 days	16.3	2.1	.026	• AF detection at 28 days was 14.0% (6 patients) in the Zio Patch group versus 2.1% (1 patient) in the standard group (p=.05)

AEM: ambulatory event monitor; AF: atrial fibrillation; FU: follow-up; ILR: implantable loop recorder; MCOT: mobile cardiac outpatient telemetry; NS: not significant; TIA: transient ischemic attack.

Nonrandomized Studies

Nonrandomized and noncomparative studies published before the RCTs described above have reported on AF detection rates after cryptogenic stroke and long-term monitoring with various devices, including ILRs,[6,44,45,] and continuous monitors with longer recording periods,[46,] along with a pilot study evaluating the Zio Patch for AF detection poststroke.[47,]

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. No RCTs were identified demonstrating clinical utility.

Chain of Evidence

Indirect evidence on clinical utility rests on clinical validity. Clinical validity of long-term ambulatory monitoring in patients with cryptogenic stroke has been demonstrated in systematic reviews and RCTs that showed higher rates of AF detection with long-term monitoring. Because most patients with a history of stroke who have AF detected will be treated with anticoagulation, and because anticoagulation is an effective treatment for stroke prevention, it can be concluded that longer term monitoring of patients with cryptogenic stroke will improve outcomes.

Section Summary: Long-term Ambulatory Cardiac Monitoring for Patients with Cryptogenic Stroke
Randomized studies, including 2 large RCTs, have demonstrated that long-term monitoring is associated with higher rates of AF detection compared with Holter monitors among patients with cryptogenic stroke. Because most patients with a history of stroke who have AF detected will be treated with anticoagulation, and because anticoagulation is an effective treatment for stroke prevention, it can be concluded that longer term monitoring of patients with cryptogenic stroke will improve outcomes. Because different long-term monitoring devices were used across the studies, the specific type of monitoring associated with the best outcomes is not established.

LONG-TERM AMBULATORY CARDIAC MONITORING FOR ASYMPTOMATIC PATIENTS

Clinical Context and Test Purpose
Screening for AF in asymptomatic individuals has been proposed to reduce burden of stroke. Evaluating the net benefit of screening for AF in asymptomatic individuals requires considering: risk of stroke in the absence of screening; incremental benefit of earlier versus later treatment for stroke when AF is detected; and potential harms of over-diagnosis.

Assessing the prevalence of asymptomatic AF is difficult because of the lack of symptoms. Approximately one-third of all individuals with AF are estimated to be asymptomatic.[48,] Studies have suggested that most paroxysmal episodes of AF are asymptomatic.[49,50,] It is uncertain whether individuals with paroxysmal AF have a stroke risk comparable to those with persistent or permanent AF; some studies have suggested the risk of stroke is similar[51,52,] while in a systematic review of 12 studies (total N=99,996), Ganesan et al (2016) found that the risks of thromboembolism and all-cause mortality were higher with nonparoxysmal than with paroxysmal AF.[53,] The clinical management of symptomatic and asymptomatic AF is the same. Anticoagulation should be initiated if reduction in risk of embolization exceeds complications due to increased bleeding risk.

Screening for AF in asymptomatic individuals could be either systematic or targeted to high-risk populations. European guidelines for screening for AF are based on a large-cluster RCT (Fitzmaurice et al [2007]; N=14,802) of opportunistic pulse taking versus systematic screening with 12-lead ECG or standard care in general practice.[54,] This RCT showed that systematic and opportunistic screening detected similar rates of AF and both were superior to standard care. The mechanisms of how and when to screen for AF in unselected populations have not been well-studied.

The purpose of long-term ambulatory cardiac monitoring in individuals who are asymptomatic with risk factors for AF is to provide an alternative method of detecting AF.

The following PICO was used to select literature to inform this review.

Populations
The relevant population of interest is asymptomatic individuals with risk factors for AF.

Interventions
The intervention being considered is patient- or auto-activated external event monitoring, continuous ambulatory event monitoring, or an ILR. Patient-activated devices are applied to the skin in the precordial area by the patient when symptoms are developing. Continuous event monitoring devices are worn continuously and are recording activity continuously and can store data longer than the Holter monitor.

Comparators
The comparators are no additional evaluation or standard care. Standard care may include an ECG and/or pulse palpation.

Outcomes
To assess clinical validity, the general outcome of interest is diagnostic yield of the monitors in detecting arrhythmias. Accurate detection of arrhythmias may be used to inform management decisions of the asymptomatic individuals.

Study Selection Criteria
For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring, or ILRs, for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.
- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

REVIEW OF EVIDENCE

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

Systematic Review
Langen et al (2025) performed a meta-analysis of RCTs of AF screening.[55,] A total of 7 RCTs were included, of which 6 trials used noninvasive monitoring and one trial used implantable monitoring (the LOOP trial). An analysis of all 7 trials showed a lower risk of stroke or systemic embolism with screening (risk reduction, 0.932; 95% CI, 0.873 to 0.996; I^2=0%; p=.037) and no difference in major bleeding or all-cause mortality. However, when only the 6 trials that used noninvasive monitoring were analyzed, there was no difference in the risk of stroke or systemic embolism (risk reduction, 0.942; 95% CI, 0.880 to 1.008; I^2=0%; p=0.083), major bleeding (p=0.86), or all-cause mortality (p=0.59).

Table 5. Comparison of Trials/Studies Included in Systematic Review/Meta-Analysis

Study	Langen et al (2025)[55,]
Benito et al (2015)[56,] EARLY	●
Halcox et al (2017)[57,] REHEARSE-AF	●
Gladstone et al (2021)[58,] SCREEN-AF	●
Svendsen et al (2021)[59,] LOOP	●
Svennberg et al (2021)[60,] STROKESTOP	●
Lopes et al (2024)[61,] GUARD-AF	●
Kemp Gundmundsdottir et al (2024)[62,] STROKESTOP II	●

Table 6. Systematic Review & Meta-Analysis Characteristics

Study	Dates	Trials	Participants	N (Range)	Design	Duration
Langen et al (2025)[55,]	2015-2024	7	Without known AF who were screened for AF with ECG-based methods	76,458 (822 to 28,768)	RCT	5.1 years

AF: atrial fibrillation; ECG: electrocardiogram; RCT: randomized controlled trial.

Table 7. Systematic Review & Meta-Analysis Results

Study	All-cause stroke or systemic embolism	Major bleeding	All-cause mortality
Langen et al (2025)[55,]			
	74,145	73,289	76,458
RR (95% CI)	0.932 (0.873 to 0.996)	0.996 (0.935 to 1.060)	0.987 (0.945 to 1.031)
I^2 (p)	*0%* (.037)	*0%* (.876)	*0%* (.550)

CI: confidence interval; RR: relative risk.

Randomized Controlled Trials

Three RCTs reported the diagnostic yield of ambulatory event monitoring compared to usual care.[57,58,59,] Characteristics of the trials are shown in Table 8 and diagnostic yield in Table 9. All 3 studies found that ambulatory event monitoring resulted in a greater diagnostic yield than usual care. These studies are discussed in detail in the Clinically Useful section, below. A fourth RCT, mSTOPS, included a concurrent observational study with 3-year outcomes, and is discussed in the Observational Studies section.[63,]

Observational Studies

Observational studies have shown that the use of ambulatory monitors would result in higher AF detection compared with routine care.

Turakhia et al (2015) reported on results for a single-center noncomparative study evaluating the feasibility and diagnostic yield of a continuous recording device with longer recording period (Zio Patch) for patients with risk factors for AF.[64,] The study included 75 patients older than age 55 years with at least 2 risk factors for AF (coronary disease, heart failure, hypertension, diabetes, or sleep apnea), without a history of prior AF, stroke, TIA, implantable pacemaker or defibrillator, or palpitations or syncope in the prior year. Of the 75 subjects, 32% had a history of significant valvular disease and 9.3% had prior valve replacement. Most subjects (97%) were considered at moderate- to high-risk of stroke (CHA_2DS_2-VASc scores ≥2). After a mean follow-up of 7.6 days, AF was detected in 4 (5.3%) subjects, all of whom had CHA_2DS_2-VASc scores of 2 or greater. All patients with AF detected had an initial episode within the first 48 hours of monitoring. Five patients had detected episodes of atrial tachyarrhythmias lasting at least 60 seconds.

Heckbert et al (2018) reported results of an ancillary study of the Multi-Ethnic Study of Atherosclerosis (MESA), designed to determine the prevalence of AF, atrial flutter, and other arrhythmias in participants 45 to 84 years of age and free of clinically recognized cardiovascular disease.[65,] A total of 1122 participants completed 1 or 2 monitoring episodes using the Zio Patch. The mean age of participants at the time of monitoring was 75 (standard deviation, 8) years. Among the 804 participants with no prior history of clinically recognized AF/flutter, 32 (4.0%) had AF/flutter detected during the monitoring period, representing a new diagnosis. Among the 32 individuals with AF/flutter detected, the arrhythmia was detected at device activation or during the initial 24 hours in 15 (47%), during the second 24 hours in 5 (16%), and during days 3 to 12 of monitoring in 12 (38%).

Steinhubl et al (2018) conducted a RCT with a concurrent observational study (mSToPS) to evaluate home-based cardiac monitoring with the iRhythm Zio.[63,] Individuals from a US health plan were randomized to monitoring initiated immediately after study recruitment (n=1364) versus active monitoring after 4 months (n=1291). A cohort of patients (n=3476) without monitoring, matched by age, sex, and CHA_2DS_2-VASc score were part of a concurrent observational study. The primary endpoint was newly diagnosed AF at 4 months among those actively monitored at initiation versus those just beginning the monitoring. The secondary endpoint was newly diagnosed AF at 1 year among the actively monitored groups combined versus the matched observational controls. For the primary endpoint, at 4 months follow-up, 3.9% of the immediate group and 0.9% of the delayed group had newly diagnosed AF (absolute difference, 3.0%; 95% CI , 1.8% to 4.1%). For the secondary endpoint, at 1 year follow-up, 6.7 per 100 person-years in the monitored group and 2.6 per 100 person-years in the control group had newly diagnosed AF. At 1 year, patients who were actively monitored were more likely to

initiate anticoagulants, and have more cardiology visits and more primary care visits. There were no differences in emergency room visits or hospitalizations between the monitored and unmonitored groups after 1 year.

Steinhubl et al (2021) reported 3-year outcomes for the observational cohort.[66,] At the end of 3 years, AF was newly diagnosed in 11.4% (n=196) of those actively monitored versus 7.7% (n = 261) in observational controls (p<.01). The rate of the combined endpoint of death, stroke, systemic emboli and myocardial infarction was 3.6 per 100 person-years (95% CI, 3.1 to 5.1) in actively monitored individuals and 4.5 (95% CI, 4.0 to 5.0) in the observational cohort (adjusted HR, 0.79 ; p=.02). Rates of hospitalizations for bleeding were 0.32 per 100 person-years in the actively monitored cohort versus 0.71 per 100 person-years in the control cohort (adjusted Incidence Rate Ratio, 0.47; p<.01). Among the screened cohort with incident AF, one-third were diagnosed through screening. Clinical events were common in the 4 weeks surrounding a diagnosis, and the study authors noted that although the clinical event rate was lower in the actively monitored cohort, the difference in detection rates at 3 years indicated that screening did not diagnose AF prior to the development of complications, and so the influence of screening on health outcomes is unclear. In addition to its potential for bias in unmeasured confounders, this study was limited by its use of claims data for outcome measurement.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Randomized Controlled Trials

Seven RCTs have compared long-term ambulatory event monitoring to usual care in asymptomatic individuals at higher risk (Tables 8 and 9).[57,58,59,60,62,61,67,]

Halcox et al (2017) conducted an RCT (REmote HEArt Rhythm Sampling using the AliveCor heart monitor to scrEen for Atrial Fibrillation, REHEARSE AF) which screened patients for AF using the AliveCor Kardia monitor (n=500) or routine care (n=501).[57,] Patients were 65 years and older, asymptomatic, with CHA_2DS_2-VASc scores of 2 or higher. Patients randomized to the Kardia monitor arm undertook twice-weekly, 30-second single-lead ECG recordings and uploaded the information to a secure server. Analysis was performed using an automated software system and forwarded to a physiologist reading service. Abnormal ECG readings were sent to cardiologists. Appropriate care was arranged when arrhythmias were detected. Patients in the routine care arm were followed by their general practitioners. All patients were contacted at 12, 32, and 52 weeks. At 52-week follow-up, 19 patients in the Kardia monitor arm and 5 patients in the routine care arm were diagnosed with AF (HR, 3.9; 95% CI, 1.4 to 10.4; p=.007). There were no significant differences in the rates of mortality; stroke, TIA, or spontaneous embolism; deep vein thromboembolism or pulmonary embolism; or other cardiovascular events between groups. The trial was not powered to detect clinical outcomes and was of insufficient duration to draw conclusions on health outcomes.

An RCT reported by Gladstone et al (2021) evaluated screening for AF with continuous ambulatory monitoring (the Zio XT patch worn for up to 4 weeks) compared to standard care (routine clinical follow-up plus a pulse check and heart auscultation at baseline and 6 months) in 876 asymptomatic adults over age 75 years with hypertension and without known AF.[58,] The

primary outcome was AF detected by continuous monitoring or clinically within 6 months. At 6-month follow-up, AF was detected in 23 of 434 participants (5.3%) in the screening group, compared to 2 of 422 (0.5%) in the control group (relative risk, 11.2; 95% CI, 2.7 to 47.1; p=.001; absolute difference, 4.8%; 95% CI, 2.6% to 7.0%; p<.001; number needed to screen, 21). Anticoagulant treatment was initiated in 4.1% of the screening group compared to 0.9% of the control group (relative risk, 4.4; 95% CI, 1.5 to 12.8; p=.007; absolute difference, 3.2%; 95% CI, 1.1% to 5.3%; p=.003). During the 6-month study period, 1 participant died (control group; cardiovascular death) and 2 participants had an ischemic stroke (both in the screening group). One patient had a TIA (screening group). The trial was not powered to detect clinical outcomes and was of insufficient duration to draw conclusions on health outcomes.

Svendsen et al (2021) reported results of the LOOP trial.[59,] Results are shown in Table 10. Screening with an ILR resulted in an increase in AF detection and anticoagulation initiation but no significant reduction in the risk of stroke or systemic arterial embolism (Table 10). A higher-than-anticipated proportion of participants in the control group were diagnosed with AF (12.2% compared with anticipated 3.0%), indicating that control group participants could have been more likely to consult their physician. Additionally, AF episodes detected in the control group are likely to have lasted longer than AF detected by monitors, increasing the probability of detection and potentially decreasing the protective effect of anticoagulant treatment. In a post hoc analysis of the LOOP trial focused on stroke severity and prior stroke history, Diederichsen et al (2023) found that screening did not result in a significant decrease in ischemic (HR, 0.76; 95% CI, 0.57 to 1.03; p=.07) or severe (HR, 0.69; 95% CI, 0.44 to 1.09; p=.11) strokes compared with usual care.[68,] In an exploratory subgroup analysis of participants without prior stroke, the HRs were 0.68 (95% CI, 0.48-0.97; p=.04) and 0.54 (95% CI, 0.30-0.97; p=.04), respectively, indicating a possible reduction in these outcomes among individuals without prior stroke. In another subgroup analysis of the LOOP trial also reported by Diederichsen et al (2023), screening led to an increase in bradyarrhythmia diagnoses and pacemaker implantations compared with usual care but no change in the risk of syncope (HR, 0.83; 95% CI, 0.56 to 1.22; p=.34) or sudden death (HR, 1.11; 95% CI, 0.64 to 1.90; p=.71).[69,]

Svennberg et al (2021) conducted a multicenter, open-label, RCT of AF screening in older adults.[60,] Patients were identified from a prospective national registry and invited to participate. Of the individuals invited for screening, 51.3% chose to participate, which involved using a handheld, single-lead ECG twice daily for 2 weeks. No information about race or ethnicity was provided, except that 20% of patients were born outside of Sweden. The primary endpoint was a composite of stroke (ischemic or hemorrhagic), systemic embolism, bleeding requiring hospitalization, and all-cause death. Results are shown in Table 10. The median follow-up was 6.9 years; at that time, the number of primary outcome events in the screening group was 5.45 events per 100 person-years versus 5.68 events per 100 person-years in the control group (HR, 0.96; 95% CI, 0.92 to 1.00; p=.045). There were no differences between groups in the secondary outcomes.

Kemp Gundmundsdottir et al (2024) conducted an RCT among older adults to determine the efficacy of 2 weeks of AF screening stratified based on N-terminal pro-B-type natriuretic peptide (NT-proBNP) levels.[62,] Patients were identified from a prospective national registry and invited to participate. No information about race or ethnicity of the included population was provided, but about 22% of patients were born outside of Sweden. Results are shown in Table 10. After 5 years, the rate of AF detection and anticoagulant use were similar between patients who

underwent screening and patients who received usual care. After a median of 5.1 years of follow-up, the primary outcome (stroke or systemic embolism) was similar between groups (HR, 0.96; 95% CI, 0.86 to 1.06). The risk of stroke or systemic embolism was higher among patients who were considered high risk based on NT-proBNP levels compared to patients who were considered low risk based on NT-proBNP levels (p=.001).

Lopes et al (2024) conducted an RCT that evaluated ECG screening on AF detection and stroke risk in older adults.[61,] Racial and ethnic background of the included patients was mainly White (88%) and Black (7.1%). Patients who received a single-lead continuous ECG patch monitor (Zio XT) for 14 days were compared to patients who received usual care. Results are shown in Table 10. After a median follow-up of 15.3 months, there was no difference in the risk of first stroke requiring hospitalization (HR, 1.10; 95% CI, 0.69 to 1.75) or bleeding requiring hospitalization (HR, 0.87; 95% CI, 0.60 to 1.26) between groups. The outcomes may be affected by a lack of power, since trial enrollment was stopped early due to the COVID-19 pandemic.

Murphy et al (2025) conducted an RCT in which 488 patients aged ≥55 years at risk for AF (based on CHA_2DS_2-VASc score) received immediate or delayed ELR monitoring, then crossed over to the other group.[67,] Almost all patients in the trial were of Irish ethnicity. New AF was detected in 6.6% of patients during the screening period and 1% of patients during the usual care period (difference, 5.53%; 95% CI, 3.2% to 7.9%; p<.001). All patients with AF were started on anticoagulation therapy.

Study limitations are summarized in Tables 11 and 12. Three of the 7 trials were of insufficient duration and power to draw conclusions on health outcomes. In the LOOP trial, no participants were lost to follow-up and the median follow-up duration was 64.5 months (IQR, 59.3 to 69.8 months), however only 16.4% of participants were still followed up for the primary outcome at the 6-year follow-up, and the study authors note that results at this timepoint should be interpreted with caution. Results of the GUARD-AF study should be interpreted with caution because the trial was terminated early. No study included blinded outcome assessment, and their relevance is limited due to a lack of racial diversity in the study populations.

Table 8. Randomized Controlled Trials of Ambulatory Event Monitoring Versus Usual Care- Characteristics

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					Ambulatory Event Monitoring	**Usual Care**
Halcox et al (2017)[57,] REHEARSE-AF ISRCTN10709813	UK	1	2015 to 2017	65 years and older, asymptomatic, with CHA_2DS_2-VASc scores of 2 or higher.	N=500 Kardia monitor arm undertook twice-weekly, 30-second single-lead ECG recordings and uploaded the information to a secure	N=501 Followed by general practitioners

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					server. Analysis was performed using an automated software system and forwarded to a physiologist reading service. Abnormal ECG readings were sent to cardiologists. Appropriate care was arranged when arrhythmias were detected	
Gladstone et al (2021)[58,] SCREEN-AF NCT02392754	Canada and Germany	Multiple	2015 to 2019	Asymptomatic adults over age 75 with hypertension and without known AF	N=434 Zio XT patch worn for up to 4 weeks	N=422 Standard care (routine clinical follow-up plus a pulse check and heart auscultation at baseline and 6 months)
Svendsen et al (2021)[59,] LOOP NCT02036450	Denmark	4	2014 to 2016	Eligibility criteria: Ages 70 to 90 years, with at least 1 of 4 conditions: hypertension, diabetes, previous stroke, or heart failure Exclusions: AF, a history of AF, a pacemaker, anticoagulation medicine, or contraindication to anticoagulation.	N=1501 Continuous ECG monitoring via automated remote transmissions from an implantable loop recorder with daily physician review of all transmissions. If AF lasting at least 6 min was detected, the participant was contacted	N=4503 Annual interview with a study nurse and standard contact with the participant's general practitioner

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
					and initiation of oral anticoagulation was recommended Median duration of monitoring was 39.3 months (IQR, 36.8 to 41.5).	
Svennberg et al (2021)[60,] STROKESTOP NCT01593553	Sweden	Multiple	2012 to 2014	Age 75 to 76 years, living near Halland or Stockholm	N=7165 ECG screening using a handheld device (Zenicor II), 2 times daily for 2 weeks	N=13,996 No additional screening
Kemp Gundmundsdottir et al (2024)[62,] STROKESTOP II NCT02743416	Sweden	Multiple	2016 to 2018	Born in 1940 or 1941, living near Stockholm	N=6843 ECG screening using a handheld device, 4 times daily for 2 weeks (patients with sinus rhythm on ECG but considered high risk based on NT-proBNP levels ≥125 ng/L)	N=13,884 No additional screening (patients with sinus rhythm on ECG but considered low risk due to NT-proBNP levels <125 ng/L)
Lopes et al (2024)[61,] GUARD-AF NCT04126486	United States	149	2019 to 2020 (terminated prematurely due to COVID-19 pandemic)	Eligibility criteria: Aged ≥70 years in primary care Exclusions: a history of AF, anticoagulation, or contraindication to anticoagulation,	N=5952 Continuous ECG patch (Zio XT monitor) screening for 14 days	N=5953 Usual care

Study; Trial	Countries	Sites	Dates	Participants	Interventions	
				implanted cardiac device, allergy to adhesives		
Murphy et al (2025)[67,] R-BEAT NCT03911986	Ireland	NR	2018 to 2023	Eligibility criteria: 55 years and older, asymptomatic, with CHA_2DS_2-VASc scores of 2 or higher. Exclusions: a history of AF, anticoagulation, or contraindication to anticoagulation	N=224 (patients served as their own controls) Immediate external loop recorder (R-Test) screening, worn for 1 week	N=224 (patients served as their own controls) Delayed external loop recorder (R-Test) screening, worn for 1 week

AF: atrial fibrillation; ECG: electrocardiogram; IQR: interquartile range; NT-proBNP: N-terminal pro-B-type natriuretic peptide.

Table 9. Diagnostic Yield of Atrial Fibrillation in Randomized Controlled Trials

Study	Intervention	Control	Relative Risk (95% CI)	P-Value
Halcox et al (2017)[57,]	19/500 (3.8%)	5/501 (1.0%)	HR 3.9 (1.4 to 10.4)	.007
Gladstone et al (2021)[58,]	23/434 (5.3%)	2/422 (0.5%)	RR 11.2 (2.7 to 47.1)	.001
Svendsen et al (2021)[59,]	477/1501 (31.8%)	550/4503 (12.2%)	HR 3.17 (2.81 to 3.59)	<.0001
Svennberg et al (2021)[60,]	14.0%	12.8%	NR	.005
Kemp Gundmundsdottir et al (2024)[62,]	24/307 (7.8%)	72/531 (13.6%)	NR	NR
Lopes et al (2024)[61,]	260 (5%)	175 (3.3%)	Absolute risk increase 0.017	NR
Murphy et al (2025)[67,]	32/488 (6.6%)	5/488 (1)	OR 65 (7.02 to 601.1)	<.001

CI: confidence interval; HR: hazard ratio; OR: odds ratio; RR: relative risk.

Table 10. Management Changes and Health Outcomes Reported in the Randomized Controlled Trials

Study	Oral anti coagulation	Primary endpoint (combined stroke or systemic arterial embolism)	Combined secondary endpoint ischemic stroke, transient ischemic attack, or systemic arterial embolism	Combined secondary endpoint stroke, systemic arterial embolism, or cardiovascular death	Cardiovascular death	All-cause death
Svendsen et al (2021)[59,] LOOP NCT02036450						
Implantable loop recorder	445/1501 (29.7%)	67/1501 (4.5%)	96/1501 (6.4%)	104/1501 (6.9%)	43/1501 (2.9%)	168/1501 (11.2%)
Usual Care	591/4503 (13.1%)	251/4503 (5.6%)	316/4503 (7.0%)	376/4503 (8.3%)	157/4503 (3.5%)	507/4503 (11.3%)
HR (95% CI)	2.72 (2.41 to 3.08)	0.80 (0.61 to 1.05)	0.92 (0.73 to 1.15)	0.83 (0.67 to 1.04)	0.83 (0.59 to 1.16)	1.00 (0.84 to 1.19)
p-value	<.0001	.11	.47	.10	.27	1.00
Svennberg et al (2021)[60,] STROKESTOP NCT01593553						
Screening	3.7%	372 events/47,203 years at risk	N/A	N/A	1211 events/86,930 years at risk	3177 events/86,930 years at risk
Usual care	NR	874 events/84,514 years at risk	N/A	N/A	1197 events/86,614 years at risk	3287 events/86,614 years at risk
HR (95% CI)	NR	0·76 (0·67 to 0·85)	N/A	N/A	1·01 (0·93 to 1·09)	0·96 (0·92 to 1·01)
p-value	NR	<.0001	N/A	N/A	.87	.12
Kemp Gundmundsdottir et al (2024)[62,]						

Study	Oral anti coagulation	Primary endpoint (combined stroke or systemic arterial embolism)	Combined secondary endpoint ischemic stroke, transient ischemic attack, or systemic arterial embolism	Combined secondary endpoint stroke, systemic arterial embolism, or cardiovascular death	Cardiovascular death	All-cause death
STROKESTOP II NCT02743416						
Screening	NR	673 events/68,093 years at risk	N/A	N/A	851 events/69,379 years at risk	2126 events/69,379 years at risk
Usual care	NR	706 events/68,373 years at risk	N/A	N/A	797 events/69,811 years at risk	2078 events/69,811 years at risk
HR (95% CI)	NR	0.96 (0.86 to 1.06)	N/A	N/A	1.07 (0.98 to 1.18)	1.03 (0.97 to 1.09)
p-value	NR	.412	N/A	N/A	.174	.348
Lopes et al (2024)[61], GUARD-AF NCT04126486		First stroke requiring hospitalization				
Screening	59.3%	0.7%	N/A	N/A	N/A	2.1%
Usual care	48.1%	0.6%	N/A	N/A	N/A	2.3%
HR (95% CI)	NR	1.10 (0.69 to 1.75)	N/A	N/A	N/A	NR
p-value	NR	NR	N/A	N/A	N/A	NR

CI: confidence interval; HR: hazard ratio; N/A: not applicable; NR: not reported.

Table 11. Study Relevance Limitations

Study	Population[a]	Intervention[b]	Comparator[c]	Outcomes[d]	Duration of Follow-up[e]
Halcox et al (2017)[57,]	4. Race not reported; majority of participants were of White European ethnicity				1. 1 year insufficient duration to draw conclusions on health outcomes.
Gladstone et al (2021)[58,]	4. 94% White, 1.5% Black				1. 6 months was insufficient duration to draw conclusions on health outcomes.
Svendsen et al (2021)[59,]	4. Race not reported; Danish population might not be relevant to US population		3. Study participation could have biased control group participants and/or their physicians to screen for AF.		3. Only 16.4% of participants were still followed up for the primary outcome at year 6.
Svennberg et al (2021)[60,]					
Kemp Gundmundsdottir et al (2024)[62,]					
Lopes et al (2024)[61,]					
Murphy et al (2025)[67,]					1. One week screening duration may have been insufficient.

AF: atrial fibrillation.
The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Population key: 1. Intended use population unclear; 2. Study population is unclear; 3. Study population not representative of intended use; 4, Enrolled populations do not reflect relevant diversity; 5. Other.
[b] Intervention key: 1. Not clearly defined; 2. Version used unclear; 3. Delivery not similar intensity as comparator; 4. Not the intervention of interest (e.g., proposed as an adjunct but not tested as such); 5: Other.
[c] Comparator key: 1. Not clearly defined; 2. Not standard or optimal; 3. Delivery not similar intensity as intervention; 4. Not delivered effectively; 5. Other.

[d] Outcomes key: 1. Key health outcomes not addressed; 2. Physiologic measures, not validated surrogates; 3. Incomplete reporting of harms; 4. Not establish and validated measurements; 5. Clinically significant difference not prespecified; 6. Clinically significant difference not supported; 7. Other.
[e] Follow-Up key: 1. Not sufficient duration for benefit; 2. Not sufficient duration for harms; 3. Other.

Table 12. Study Design and Conduct Limitations

Study	Allocation[a]	Blinding[b]	Selective Reporting[c]	Data Completeness[d]	Power[e]	Statistical[f]
Halcox et al (2017)[57,]		1. Not blinded			4. Not powered to detect differences in health outcomes	
Gladstone et al (2021)[58,]		1. Not blinded			4. Not powered to detect differences in health outcomes	
Svendsen et al (2021)[59,]		1. Not blinded				
Svennberg et al (2021)[60,]	4. Patients could choose whether to participate	1. Not blinded				
Kemp Gundmundsdottir et al (2024)[62,]	4. Patients could choose whether to participate	1. Not blinded				
Lopes et al (2024)[61,]		1. Not blinded				
Murphy et al (2025)[67,]		1. Only outcome assessors were blinded			4. Not powered to detect differences in health outcomes	

The study limitations stated in this table are those notable in the current review; this is not a comprehensive gaps assessment.
[a] Allocation key: 1. Participants not randomly allocated; 2. Allocation not concealed; 3. Allocation concealment unclear; 4. Inadequate control for selection bias; 5. Other.
[b] Blinding key: 1. Participants or study staff not blinded; 2. Outcome assessors not blinded; 3. Outcome assessed by treating physician; 4. Other.
[c] Selective Reporting key: 1. Not registered; 2. Evidence of selective reporting; 3. Evidence of selective publication; 4. Other.
[d] Data Completeness key: 1. High loss to follow-up or missing data; 2. Inadequate handling of missing data; 3. High number of crossovers; 4. Inadequate handling of crossovers; 5. Inappropriate exclusions; 6. Not intent to treat analysis (per protocol for noninferiority trials); 7. Other.

[e] Power key: 1. Power calculations not reported; 2. Power not calculated for primary outcome; 3. Power not based on clinically important difference; 4. Other.
[f] Statistical key: 1. Analysis is not appropriate for outcome type: (a) continuous; (b) binary; (c) time to event; 2. Analysis is not appropriate for multiple observations per patient; 3. Confidence intervals and/or p values not reported; 4. Comparative treatment effects not calculated; 5. Other.

Section Summary: Long-term Ambulatory Cardiac Monitoring for Asymptomatic Patients

Multiple observational studies showed that use of ambulatory monitors would result in higher AF detection compared with routine care. Randomized controlled trials found higher AF detection and initiation of anticoagulants with monitoring. The RCTs (LOOP, STROKESTOP, and STROKESTOP II trials) with sufficient statistical power and duration to evaluate health outcomes have not consistently found a difference between monitoring and standard care on the primary endpoint of combined stroke or systemic arterial embolism. A small systematic review found that long-term ambulatory event monitoring reduced the risk of stroke or systemic embolism compared to no screening, but there was no difference when only trials that used external cardiac monitoring were evaluated.

IMPLANTABLE LOOP RECORDERS FOR PATIENTS WITH SYMPTOMS OF ARRHYTHMIA

Clinical Context and Test Purpose

This section discusses the use of ILR, with a focus on clinical situations when use of an ILR at the beginning of a diagnostic pathway is indicated. It is expected that a longer period of monitoring with any device category is associated with a higher diagnostic yield. A progression in diagnostics, from an external event monitor to ILR, in cases where longer monitoring is needed, is considered appropriate. However, there may be situations where it is sufficiently likely that long-term monitoring will be needed and that an ILR as an initial strategy may be reasonable.

The purpose of ILRs in individuals with signs or symptoms suggestive of arrhythmia with infrequent symptoms is to provide an alternative method of arrhythmia detection.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with signs or symptoms suggestive of arrhythmia with infrequent symptoms.

Interventions

The intervention of interest is an ILR. ILRs store electrical cardiac activity data. When activated (by patient or automatically), the cardiac activity is recorded from the memory loop. ILRs are implanted under the skin in the precordial area.

Comparators

Comparators of interest include no additional evaluation, standard care, or external AEMs. External AEMs may be patient- or auto-activated. Patient-activated devices are applied to the skin in the precordial area by the patient when symptoms are developing. Continuous event monitoring devices are worn continuously and are recording activity continuously, storing data longer than the Holter monitor.

Outcomes
The general outcome of interest is diagnostic yield of the ILRs in detecting arrhythmias. Accurate detection of arrhythmias may be used to inform management decisions of individuals with infrequent symptoms.

Study Selection Criteria
For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.
- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

REVIEW OF EVIDENCE

Systematic Reviews
Solbiati et al (2017) conducted a systematic review and meta-analysis on the diagnostic yield of ILRs in patients with unexplained syncope.[70,] The literature search, conducted through November 2015, identified 49 studies, published between 1998 and 2015, enrolling a total of 4381 patients. The methodologic quality of the studies was assessed using QUADAS and QUADAS-2. The diagnostic yield of ILR, defined as the proportion of patients in which ILR was useful in determining a syncope diagnosis was 44% (95% CI, 40% to 48%; I^2=80%). Diagnoses included arrhythmic syncope, ventricular arrhythmia, supraventricular arrhythmia, and bradyarrhythmia. Reviewers noted that an important analytic limitation was the considerable heterogeneity among studies, partly because definitions of syncope and methods to assess unexplained syncope were inconsistent.

Burkowitz et al (2016) conducted a systematic review and meta-analysis of ILRs in the diagnosis of syncope and the detection of AF.[71,] For syncope diagnosis, the review identified 3 RCTs comparing ILRs with a conventional diagnosis strategy (Holter monitoring). In pooled analysis, an ILR diagnosis strategy was associated with a higher likelihood of the endpoint of diagnostic yield (relative risk, 4.17; 95% CI, 2.57 to 6.77; I^2=14%). The RCTs (Da Costa et al [2013],[72,] Farwell et al [2004],[73,] and Krahn et al [2001][74,]) are described below.

Afzal et al (2015) reported on a systematic review and meta-analysis of studies comparing ILRs with wearable AEMs for prolonged outpatient rhythm monitoring after cryptogenic stroke.[75,] Reviewers included 16 studies (N=1770 patients): 3 RCTs and 13 observational studies. For ILR-monitored patients, the median monitoring duration was 365 days (range, 50 to 569 days), while for wearable device-monitored patients, the median monitoring duration was 14 days (range, 4 to 30 days). Compared with wearable AEMs, ILRs were associated with significantly higher rates of AF detection (23.3% vs. 13.6%; odds ratio, 4.54; 95% CI, 2.92 to 7.06; p<.05).

Randomized Controlled Trials

Podoleanu et al (2014) reported on results of an open-label RCT comparing 2 strategies for evaluating syncope : an experimental strategy involving the early use of an ILR and a conventional evaluation strategy excluding an ILR (see Table 13).[76,] The trial included patients who had a single syncope (if severe and recent) or at least 2 syncopes in the past 12 months. The syncope had to be unexplained at the end of clinical examination and who had a workup with 12-lead ECG, echocardiography, and head-up tilt-test. Patients randomized to ILR received the Reveal or Reveal Plus device. After 14 months of follow-up, a definitive cause of syncope was established more frequently in the ILR group than in the standard care group (see Table 14). Arrhythmic causes of syncope in the ILR group included 2 (5%) cases of atrioventricular block, 4 (10%) cases of sinus node disease, 1 (2.5%) case of AF, 1 (2.5%) case of ventricular fibrillation, and 3 (8%) other tachycardias. In the conventionally managed group, 8 patients had a diagnosis of presumed reflex syncope.

Da Costa et al (2013) compared use of an ILR with a conventional follow-up strategy in 78 patients with a first episode of syncope (Table 13).[72,] A significant number of patients had cardiomyopathy (23%), AF (15.4%), and/or bundle branch block (58%) on ECG. Twenty-one (27%) patients had at least one arrhythmia detected, with a significant difference in the detection rate for the ILR group compared with the conventional follow-up group (see Table 14).

Giada et al (2007) conducted an RCT assessing 2 diagnostic strategies in 50 patients with infrequent (≤1 episode per month) unexplained palpitations: an ILR strategy (n=26) and a conventional strategy (n=24) including 24-hour Holter, 4 weeks of ambulatory ECG monitoring with an external recorder, and an electrophysiologic study if the 2 prior evaluations were negative) (see Table 13).[77,] Prior cardiac evaluation in eligible patients included standard ECG and echocardiography. Rhythm monitoring was considered diagnostic when a symptom-rhythm correlation was demonstrated during spontaneous palpitations that resembled pre-enrollment symptoms. In the conventional strategy group, a diagnosis was made in 5 (21%) subjects, after a mean time to diagnosis of 36 days, based on external ECG monitoring in 2 subjects and electrophysiologic studies in 3 subjects. In the ILR group, a diagnosis was made in 19 subjects after a mean time to diagnosis of 279 days (Table 14).

Farwell et al (2004) reported on an RCT comparing the diagnostic yield of an ILR (Reveal Plus) with a conventional diagnostic strategy in 201 patients with unexplained syncope (Table 13).[73,] Eligible patients were evaluated at a single institution for recurrent syncope and had no definitive diagnosis after a basic initial workup (including 12-lead ECG, Holter monitoring in patients with suspected cardiac syncope, upright cardiac sinus massage, and tilt-table testing). At last follow-up, more loop recorder patients had an ECG diagnosis than control patients (HR for ECG diagnosis, 8.93; 95% CI, 3.17 to 25.19; p<.001) (see Table 14). Seven of the loop recorder patients were diagnosed with the device's auto-trigger feature. In the loop recorder group, 34 patients had an ECG-directed therapy initiated (vs. 4 in the control group; HR, 7.9; 95% CI, 2.8 to 22.3). No device-related adverse events were reported.

An earlier RCT by Krahn et al (2001) compared a conventional monitoring strategy (ELR monitoring for 2 to 4 weeks, followed by tilt-table and electrophysiologic testing) with at least 1 year of monitoring using an ILR in 60 subjects with unexplained syncope (n=30 per group) (Table 13).[74,] Eligible patients had a previous clinical assessment, at least 24 hours of continuous

ambulatory monitoring or inpatient telemetry, and a transthoracic echocardiogram. A diagnosis was made in 20% of those in the conventional monitoring arm and in 52% of those in the ILR arm (see Table 14).

Table 13. Summary of Randomized Controlled Trial Characteristics for Implantable Loop Recorders for Arrhythmia

					Interventions (n)	
Study	**Country**	**Sites**	**Dates**	**Participants**	**Active**	**Comparator**
Podoleanu et al (2014)[76,]	France	13	2004-2008	Single recent syncope or 2 in past 12 months	ILR (39)	Standard (39)
Da Costa et al (2013)[72,]	France	Multiple, NS	2005-2010	Single syncope	ILR (41)	Standard (37)
Giada et al (2007)[77,]	Italy	Multiple, NS	NR	Unexplained palpitations	ILR (26)	Standard (24)
Farwell et al (2004)[73,]	England	1	2000-2001	≥2 unexplained syncope in past 12 months	ILR (103)	Standard (98)
Krahn et al (2001)[74,]	England	1	NR	Single or recurrent unexplained syncope	ILR (27)	ELR (30)

ELR: external loop recorder; ILR: implantable loop recorder; NR: not reported; NS: not specified.

Table 14. Summary of Randomized Controlled Trial Results for Implantable Loop Recorders for Arrhythmia

Study	**FU**	**Diagnosis Made, n (%)**			**Additional Findings**
		ILR	**Standard**	**p-value**	
Podoleanu et al (2014)[76,]	14 months	18 (46)	2 (5)	<.001	• Advanced cardiology tests performed less frequently in ILR group versus standard (p=.05) • No difference in quality of life
Da Costa et al (2013)[72,]	27 months[a]	15 (37)	4 (11)	.02	• Earlier diagnosis in ILR group permitted earlier pacemaker implantation. However, earlier implantation did not improve survival (potentially due to small sample).
Giada et al (2007)[77,]	≥12 months	19 (73)	5 (21)	<.001	• 9 of 19 patients with negative results with standard care crossed over to ILR and 6 of them received a diagnosis
Farwell et al (2004)[73,]	≥6 months	34 (33)	4 (4)	<.001	• ECG-directed therapy was initiated quicker in the ILR group

Study	FU	Diagnosis Made, n (%)			Additional Findings
					• No difference in syncopal episodes, mortality, or quality of life
Krahn et al (2001)[74,]	12 months	14 (52)	6 (20)	.012	• Crossover offered to patients with negative results • 1 of 6 switching to ELR was diagnosed and 8 of 13 switching to ILR was diagnosed (p=.07)

ECG: electrocardiogram; ELR: external loop recorder; FU: follow-up; ILR: implantable loop recorder.
[a] Mean.

Observational Studies

Multiple observational studies compared the diagnostic yield of ICMs to the Holster monitor and reported high rates of arrhythmia detection.[78,79,80,81,82,83,] Several observational studies reported management outcomes following diagnoses, such as anticoagulation initiation or cardiac procedures.[84,85,86,87,88,]

Safety of Implantable Loop Recorders

Mittal et al (2015) reported on safety outcomes related to the use of an ILR, based on data from 2 studies, the Reveal LINQ Usability study and the Reveal LINQ Registry.[89,] The Usability study enrolled 151 patients at 16 European and Australian centers; adverse events were reported for the first month of follow-up. The Registry is a multicenter postmarketing surveillance registry, with a planned enrollment of at least 1200 patients. At the time of analysis, 161 patients had been enrolled. For Registry patients, all adverse events were recorded when they occurred. The device is inserted with a preloaded insertion tool via a small skin incision. In the Usability study, 1 serious adverse event was recorded (insertion site pain); in the Registry study, 2 serious adverse events were recorded (1 case each of insertion site pain and insertion site infection). The rates of infection and procedure-related serious adverse events in the Usability study were 1.3% and 0.7%, respectively, and 1.6% and 1.6%, respectively, in the Registry study.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. No RCTs providing evidence for clinical utility were identified.

CHAIN OF EVIDENCE

Section Summary: Implantable Loop Recorders for Patients with Symptoms of Arrhythmia

Several RCTs have reported high rates of arrhythmia detection with the use of ILRs compared with external event monitoring or Holter monitoring. These studies support the use of a progression in diagnostics from an external event monitor to ILR when longer monitoring is needed. Some available trials evaluating the detection of AF after ablation procedures or in

patients with cryptogenic stroke used ILRs as an initial ambulatory monitoring strategy, after a negative Holter monitor. Many observational studies reported the initiation of treatment (for example, anticoagulation therapy or pacemaker implantation) following the confirmation of diagnoses with the ILR. Because these treatments are known to be effective, it can be concluded that long-term monitoring with ILRs will improve health outcomes.

MOBILE CARDIAC OUTPATIENT TELEMETRY FOR PATIENTS WITH SYMPTOMS OF ARRHYTHMIA

Clinical Context and Test Purpose

This section addresses whether the addition of real-time MCOT to ambulatory cardiac monitoring is associated with improved outcomes. Two factors must be addressed in evaluating MCOT: (1) the inherent detection capability of the monitoring devices and (2) whether the real-time transmission and interpretation of data confers an incremental health benefit. The proposed addition of real-time monitoring suggests that there may be a subset of individuals who require immediate intervention when an arrhythmia is detected. Because it is not clear which individuals comprise that subset, or whether identification of those individuals in the outpatient setting leads to improved outcomes (eg, reduced risks of sudden cardiac death), the evaluation of the second factor requires studies that directly assess outcomes, not just arrhythmia detection rates.

The purpose of outpatient cardiac telemetry in individuals with signs or symptoms suggestive of arrhythmia is to provide an alternative method of transmitting electrical cardiac activity data to healthcare providers.

The following PICO was used to select literature to inform this review.

Populations

The relevant population of interest is individuals with signs or symptoms suggestive of arrhythmia.

Interventions

The therapy being considered is MCOT system which transmits ambulatory cardiac monitoring data in real-time to healthcare providers.

Comparators

The comparator of interest is ambulatory cardiac monitoring alone.

Outcomes

The general outcome of interest is the incremental benefit of transmitting the ambulatory cardiac monitoring data in real-time.

Study Selection Criteria

For the evaluation of clinical validity of auto-activated or patient-activated external ambulatory event monitoring for patients with arrhythmia symptoms, studies that met the following criteria were considered:

- To assess the clinical validity, studies should report sensitivity, specificity, positive and negative predictive values. Alternatively, studies reporting on diagnostic yield are informative.

- To assess the clinical utility, studies should demonstrate how results of the tests impacted treatment decisions and overall management of the patient.

Clinically Valid
A test must detect the presence or absence of a condition, the risk of developing a condition in the future, or treatment response (beneficial or adverse).

REVIEW OF EVIDENCE

Randomized Controlled Trials
An RCT by Rothman et al (2007) compared MCOT with standard event monitors (Table 15).[90,] This trial involved 305 patients randomized to the LOOP recorder or to MCOT (CardioNet) and monitored for up to 30 days. Patients were recruited from 17 centers. Investigators and patients were not blinded to randomization assignment. Monitor strips and diagnoses were reviewed by an electrophysiologist blinded to the monitoring device assignment. Most patients in the LOOP recorder group had a patient-triggered event monitor. Only a subset of patients (n=50) had auto-trigger devices, thus precluding comparison between MCOT and auto-trigger devices. Analyses were conducted on patients completing at least 25 days of monitoring. The primary endpoint was either confirmation or exclusion of arrhythmic cause of the patient's symptoms. Arrhythmias were classified as either clinically significant or clinically insignificant. The diagnostic endpoint (confirmation or exclusion of arrhythmic cause of symptoms) was significantly different between the 2 groups (Table 16). The difference in rates was primarily due to detection of asymptomatic (not associated with simultaneous symptoms) arrhythmias in the MCOT group, symptoms consisting of rapid AF and/or flutter (15 patients vs. 1 patient), and ventricular tachycardia defined as more than 3 beats and rate greater than 100 (14 patients vs. 2 patients). These differences were thought to be clinically significant rhythm disturbances and the likely causes of the patients' symptoms. In this trial, median time to diagnosis in the total study population was 7 days in the MCOT group and 9 days in the LOOP group (Table 16). The trialists did not comment on the clinical impact (changes in management) of these findings in patients for whom the rhythm disturbance did not occur simultaneously with symptoms.

Table 15. Summary of Randomized Controlled Trial Characteristics

Study	Countries	Sites	Dates	Participants	Interventions		Duration
					Active	Comparator	
Rothman et al (2007)[90,]	United States	17	NR	Patients with a high clinical suspicion of a malignant arrhythmia, with syncope, presyncope, or severe palpitations, and a nondiagnostic 24-hour Holter test	Mobile automated cardiac outpatient telemetry (CardioNet) n=134	Patient-activated external looping event monitor n=132	Confirmation of a diagnosis, up to 30 days

NR: not reported.

Table 16. Summary of Randomized Controlled Trial Results

Study	Confirmation or Exclusion of Arrhythmic Cause of Symptoms, n (%)	Confirmation or Exclusion of Arrhythmic Cause of Symptoms in Subgroup with Syncope, n (%)	Confirmation or Exclusion of Arrhythmic Cause of Symptoms in Subgroup Autotriggered Recorder, n (%)	Time to Diagnosis, median (95% CI)
Rothman et al (2007)[90,]	263	113	50	263
MCOT	117 (88.0)	55 (88.7)	21 (87.5)	7 (4 to 11)
LOOP	98 (75.4)	35 (68.6)	12 (46.2)	9 (7 to 15)
p-value	.008	.008	.002	NR

CI: confidence interval; LOOP: looping event monitor; MCOT: mobile cardiac outpatient telemetry; NR: not reported.

OBSERVATIONAL STUDIES

Arrhythmia Detection

Derkac et al (2017) retrospectively reviewed the BioTelemetry database of patients receiving ambulatory ECG monitoring, selecting patients prescribed MCOT (n=69,977) and patients prescribed AT-LER, an auto-trigger looping event recorder (n=8513).[91,] Patients were diagnosed with palpitations, syncope and collapse, AF, tachycardia, and/or TIA. Patients given the MCOT were monitored for an average of 20 days and patients given the AT-LER were monitored an average of 27 days. The diagnostic yield using MCOT was significantly higher than that using AT-LER for several events: 128% higher for AF, 54% higher for bradycardia, 17% higher for ventricular pause, 80% higher for SVT, and 222% higher for ventricular tachycardia. Mean time to diagnosis for each asymptomatic arrhythmia was shorter for patients monitored by MCOT than by AT-LER. There was no discussion of management changes or health outcomes based on monitoring results.

Kadish et al (2010) evaluated the frequency with which events transmitted by MCOT represented emergent arrhythmias, thereby indirectly assessing the clinical utility of real-time outpatient monitoring.[92,] Medical records from 26,438 patients who had undergone MCOT during a 9-month period from a single service provider were retrospectively examined. During a mean monitoring period of 21 days, 21% (5459) had an arrhythmic event requiring physician notification. Of these, 1% (260) had an event that could be considered potentially emergent. These potentially emergent events included 120 patients with wide-complex tachycardia, 100 patients with sinus pauses of 6 seconds or longer, and 42 with sustained bradycardia at less than 30 beats per minute.

A number of uncontrolled case series have reported on arrhythmia detection rates of MCOT.[93,94,95,96,] One study (Joshi et al [2005]) described the outcomes of a consecutive case series of 100 patients.[93,] Included patients had the following symptoms: palpitations (47%), dizziness (24%), or syncope (19%). Patients being evaluated for the efficacy of drug treatment (25%) were also included. Clinically significant arrhythmias were detected in 51% of patients, but half of these patients were asymptomatic. The authors commented that the automatic detection

resulted in an increased diagnostic yield, but there was no discussion of its unique features (i.e., the real-time analysis, transmission, and notification of arrhythmia).

Atrial Fibrillation Detection

In the largest study evaluating the diagnostic yield of MCOT for AF, Favilla et al (2015) evaluated a retrospective cohort of 227 patients with cryptogenic stroke or TIA who underwent 28 days of monitoring with MCOT.[97,] AF was detected in 14% (31/227) of patients, of whom 3 reported symptoms at the time of AF. Oral anticoagulation was initiated in 26 (84%) patients diagnosed with AF. Of the remaining 5 (16%) not on anticoagulation therapy, 1 had a prior history of gastrointestinal bleeding, 3 were unwilling to accept the risk of bleeding related to the use of anticoagulants, and 1 failed to follow-up.

Miller et al (2013) retrospectively analyzed paroxysmal AF detection rates among 156 patients evaluated with MCOT within 6 months of a cryptogenic stroke or TIA.[33,] Over a median 21-day period of MCOT monitoring (range, 1 to 30 days), AF was detected in 17.3% of patients. Mean time to first occurrence of AF was 9 days (range, 1 to 21 days).

Tayal et al (2008) retrospectively analyzed patients with cryptogenic stroke who had not been diagnosed with AF by standard monitoring.[96,] In this study, 13 (23%) of 56 patients with cryptogenic stroke had AF detected by MCOT. Twenty-seven asymptomatic AF episodes were detected in the 13 patients; 23 of them were less than 30 seconds in duration. In contrast, Kalani et al (2015) reported a diagnostic yield for AF of 4.7% (95% CI, 1.5% to 11.9%) in a series of 85 patients with cryptogenic stroke.[98,] In this series, 82.4% of patients had completed transesophageal echocardiography, cardiac magnetic resonance imaging, or both, with negative results. Three devices were used and described as MCOT devices: 34% received LifeStar ACT ambulatory cardiac telemetry, 41% received the LifeStar AF Express autodetect looping monitor, and 25% received the Cardiomedix cardiac event monitor. While the authors reported that there was a system in place to transmit the data for review, it is unclear whether data were sent in "real-time."

Narasimha et al (2018) published results of a study in which 33 patients wore both an ELR and a Kardia monitor to screen for AF during a period of 14 to 30 days.[99,] Patients were 18 years or older, had palpitations less often than daily but more frequently than several times per month, and prior nondiagnostic ECGs. Exclusion criteria included myocardial infarction within the last 3 months, history of ventricular tachycardia/fibrillation, unstable angina, and syncope. Study personnel viewed the Kardia monitor recordings once daily and a physician was contacted if a serious or sustained arrhythmia was detected. Patients were also monitored by the ELR company, which notified a physician on call when necessary. All 33 patients had a diagnosis using the Kardia monitor and 24 patients received a diagnosis using the ELR (p=.001).

Dorr et al (2019) compared the diagnostic accuracy of a smartwatch system with cardiologists' interpretation of an ECG in the diagnostic accuracy to detect AF.[100,] The smartwatch system uses an algorithm to enable rhythm analysis of the photoplethysmographic signals. The population consisted of 508 hospitalized patients who had interpretable ECG and photoplethysmographic recordings. The photoplethysmographic algorithm compared with the cardiologists' diagnoses had a sensitivity of 94% and a specificity of 98%. A limitation of the study was that many of the recordings were excluded due to insufficient signal quality (148 of 672). The investigators

concluded that detection of AF is feasible with a smartwatch, though signal quality issues need to be resolved and a broader population needs to be tested.

Post-Transcatheter Aortic Valve Replacement

Beccarino et al (2024) conducted a multicenter study investigating a 30-day MCOT protocol initiative after transcatheter aortic valve replacement (TAVR) to evaluate its utility in detecting conduction disturbances and tachyarrhythmias in 693 patients without pre-existing or in-hospital cardiac implantable devices.[101,] The primary outcomes included post-discharge permanent pacemaker (PPM) implantation, detection of actionable arrhythmias, and effects on length of hospital stay. 21 patients required PPM placement, 8 of which had no conduction abnormality on initial or discharge ECG. MCOT monitoring detected new AF or flutter in 59 (8.6%) patients. Prior to the MCOT initiative, 1281 patients underwent TAVR over a one-year period. Patients in the MCOT initiative group had a statistically significant shorter length of hospital stay than the pre-initiative group (2.5 ± 4.5 vs. 3.0 ± 3.8 days; p<.001). Limitations included the nonrandomized design, outcome assessment limited to 30 days, potential missed events due to imperfect monitoring compliance, confounding from evolving TAVR practices and technologies, and potential influences from the COVID-19 era on hospitalization practices.

Nuche et al (2024) conducted a multicenter observational study evaluating continuous ambulatory ECG monitoring to detect subclinical new-onset AF after transcatheter aortic valve implantation (TAVI) in 700 patients without prior AF or in-hospital arrhythmias.[102,] The primary outcomes included the incidence, predictors, and clinical significance of subclinical AF. New-onset AF was identified in 7% of patients, with a median time to first episode of 2 days (IQR: 1 to 6), a median total AF duration of 185 minutes (IQR: 43 to 421), a longest AF episode of 138 minutes (IQR: 48.9 to 505.6), and an AF burden of 0.7% (IQR: 0.3 to 2.8). In the logistic regression analysis, the baseline mean transaortic gradient was the only independent predictor of new-onset AF, with a statistically significant association in both univariable analysis (OR: 1.04 per mmHg; 95% CI: 1.01 to 1.06; p=.005) and multivariable analysis (OR: 1.04 per mmHg; 95% CI: 1.01 to 1.06; p=.006). Limitations included heterogeneous patient selection across centers, retrospective analysis of prospectively collected data, variable clinical decision-making regarding anticoagulation, disruptions in follow-up related to the COVID-19 pandemic, exclusion of pacemaker patients leading to selection bias, and incomplete long-term arrhythmia surveillance.

Muntané-Carol et al (2021) conducted a prospective multicenter study investigating 14-day ambulatory electrocardiographic monitoring after minimalist TAVR in 459 consecutive patients without pre-existing or in-hospital pacemakers.[103,] The primary outcomes included the incidence and timing of delayed high-degree atrioventricular block (HAVB) or complete heart block (CHB). Delayed HAVB or CHB occurred in 21 (4.6%) patients at a median of 5 days post-procedure (IQR: 4 to 6), leading to pacemaker implantation in 17 (81%) patients. Limitations noted by the authors included the nonrandomized design, lack of a central ECG adjudication system, use of two different monitoring devices, small sample size of self-expanding valve recipients, and insufficient statistical power to identify independent predictors of late conduction disturbances.

Clinically Useful

A test is clinically useful if the use of the results informs management decisions that improve the net health outcome of care. The net health outcome can be improved if patients receive correct therapy, or more effective therapy, or avoid unnecessary therapy, or avoid unnecessary testing.

Direct Evidence

Direct evidence of clinical utility is provided by studies that have compared health outcomes for patients managed with and without the test. Because these are intervention studies, the preferred evidence would be from RCTs. No RCTs were identified that evaluated the management of patients with and without mobile cardiac monitoring.

Norlock et al (2024) conducted an observational study of claims data to identify patients who were monitored with MCOT or ILR after hospitalization for stroke.[104,] Among the 2244 included patients, hospital readmission was lower with MCOT versus ILR (30.2% vs. 35.4%; HR, 1.23; 95% CI, 1.04 to 1.46). Average costs over 18 months were also lower in the MCOT group. There was no difference in mortality between groups (HR, 1.30; 95% CI, 1.00 to 1.69).

Chain of Evidence

Indirect evidence on clinical utility rests on clinical validity. Evidence for clinical validity consists of one RCT and several observational studies. The RCT reported a larger proportion of patients receiving a diagnosis in the MCOT group compared with the LOOP group, though time to diagnosis was not significantly different. In addition, no studies demonstrated an incremental benefit of the real-time transmission and interpretation of data compared with the usual monitoring timeline.

Section Summary: Mobile Cardiac Outpatient Telemetry for Patients with Symptoms of Arrhythmia

The available evidence has suggested that MCOT is likely to be at least as good at detecting arrhythmias as ambulatory event monitoring. Compared with ambulatory event monitoring, MCOT is associated with the theoretical advantage of real-time monitoring, permitting for emergent intervention for potentially life-threatening arrhythmias. One study reported that 1% of arrhythmic events detected on MCOT during a mean monitoring period of 21 days per patient could be considered potentially emergent. However, no randomized studies were identified that addressed whether the use of MCOT is associated with differences in the management of or outcomes after these potentially emergent events; one observational study reported a benefit of MCOT on hospital readmission in patients with prior stroke. The addition of real-time monitoring to outpatient ambulatory monitoring is considered an enhancement to existing technology. Currently, the evidence does not demonstrate a clinically significant incremental benefit for MCOT.

SUMMARY OF EVIDENCE

Ambulatory Event Monitoring

For individuals who have signs and/or symptoms suggestive of arrhythmia(s) who receive patient- or auto-activated external ambulatory event monitoring or continuous ambulatory monitoring storing information for more than 48 hours, the evidence includes prospective and retrospective studies reporting on the diagnostic yield. Relevant outcomes are overall survival (OS) and morbid events. The randomized controlled trail (RCT) and the observational studies have consistently shown that continuous monitoring with longer recording periods detects more arrhythmias than 24- or 48-hour Holter monitoring. Particularly for patients who, without the more prolonged monitoring, would only undergo shorter term monitoring, the diagnostic yield is likely to identify arrhythmias that may have therapeutic implications. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have atrial fibrillation (AF) following ablation who receive long-term ambulatory cardiac monitoring, the evidence includes one RCT comparing ambulatory event monitoring with standard care and several observational studies. Relevant outcomes are OS, morbid events, medication use, and treatment-related morbidity. The RCT evaluating a long-term monitoring strategy after catheter ablation for AF reported significantly higher rates of AF detection. The available evidence has suggested that long-term monitoring for AF postablation is associated with improved outcomes. However, the specific type of monitoring associated with the best outcomes is not established, because different long-term monitoring devices were used across the studies. Trials demonstrating improved outcomes have used event monitors or implantable monitors. In addition, there are individual patient considerations that may make one type of monitor preferable over another. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who have cryptogenic stroke with a negative standard workup for AF who receive long-term ambulatory cardiac monitoring, the evidence includes systematic reviews of RCTs comparing ambulatory event monitoring with standard care. Relevant outcomes are OS, morbid events, medication use, and treatment-related morbidity. RCTs evaluating a long-term AF monitoring strategy poststroke have reported significantly higher rates of AF detection with longer term ambulatory monitoring. The available evidence has suggested that long-term monitoring for AF after cryptogenic stroke is associated with improved outcomes, but the specific type of monitoring associated with the best outcomes is not established because different long-term monitoring devices were used across the studies. Trials demonstrating improved outcomes have used event monitors or implantable monitors. In addition, there are individual patient considerations that may make one type of monitor preferable over another. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

For individuals who are asymptomatic with risk factors for AF who receive long-term ambulatory cardiac monitoring or implantable monitoring, the evidence includes a systematic review, RCTs and observational studies. Relevant outcomes are OS, morbid events, medication use, and treatment-related morbidity. Multiple observational studies showed that use of ambulatory monitors would result in higher AF detection compared with routine care. Randomized controlled trials found higher AF detection and initiation of anticoagulants with monitoring, but adequately powered trials have not consistently reported a benefit between monitoring and standard care in stroke or systemic embolism outcomes. A small systematic review found that long-term ambulatory event monitoring reduced the risk of stroke or systemic embolism compared to no screening, but there was no difference when only trials that used external cardiac monitoring were evaluated. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

Implantable Loop Recording

For individuals who have signs and/or symptoms suggestive of arrhythmia with infrequent symptoms who receive patient- or auto-activated implantable ambulatory event monitoring, the evidence includes RCTs comparing implantable loop recorders (ILRs) with shorter term monitoring, usually 24- to 48-hour Holter monitoring, and many observational studies. Relevant outcomes are OS, morbid events, medication use, and treatment-related morbidity. Studies assessing prolonged ILRs in patients have reported high rates of arrhythmia detection compared with shorter external event or Holter monitoring. These studies have supported the use of a

progression in diagnostics from an external event monitor to ILR when longer monitoring is needed. The evidence is sufficient to determine that the technology results in an improvement in the net health outcome.

Outpatient Cardiac Telemetry
For individuals who have signs and/or symptoms suggestive of arrhythmia who receive outpatient cardiac telemetry, the evidence includes an RCT and nonrandomized studies evaluating rates of arrhythmia detection using outpatient cardiac telemetry. Relevant outcomes are OS and morbid events. The available evidence has suggested that outpatient cardiac telemetry is at least as good at detecting arrhythmias as ambulatory event monitoring. However, prospective studies have not evaluated whether the real-time monitoring feature of outpatient cardiac telemetry leads to reduced cardiac events and mortality. The evidence is insufficient to determine that the technology results in an improvement in the net health outcome.

SUPPLEMENTAL INFORMATION

The purpose of the following information is to provide reference material. Inclusion does not imply endorsement or alignment with the evidence review conclusions.

Clinical Input From Physician Specialty Societies and Academic Medical Centers
While the various physician specialty societies and academic medical centers may collaborate with and make recommendations during this process, through the provision of appropriate reviewers, input received does not represent an endorsement or position statement by the physician specialty societies or academic medical centers, unless otherwise noted.

2025 Input
Clinical input was sought to help determine whether the use of mobile cardiac outpatient telemetry for individuals with signs and/or symptoms suggestive of arrhythmia would provide a clinically meaningful improvement in net health outcome and represents generally accepted medical practice in selected patients. In response to requests, clinical input was received from 3 respondents, including 2 specialty society-level responses and 1 clinical health system response.

For individuals who experience infrequent symptoms (less frequently than every 48 hours) suggestive of cardiac arrhythmias (i.e., severe palpitations, dizziness, or clinically significant presyncope or syncope) who receive outpatient cardiac telemetry, clinical input supports this use provides a clinically meaningful improvement in net health outcomes and indicates this use is consistent with generally accepted medical practice in a subgroup of appropriately selected individuals when any of the conditions below are met:

- Evaluation of recurrent unexplained clinically significant presyncope, syncope, severe palpitations or dizziness when:
    - Symptoms are thought to be due to a cardiac arrhythmia as the most likely diagnosis; AND
    - Holter monitor and/or external AEM has been nondiagnostic or contraindicated; AND
    - There is documentation that real-time monitoring is essential for patient safety and will lead to immediate clinical changes such as medication or other emergent procedures; OR
- Evaluation of cryptogenic stroke thought to be caused by atrial fibrillation, with non-diagnostic 24- to 48-hour Holter monitor or 48-hour telemetry.

Further details from clinical input are included in the Appendix.

2014 Input
In response to requests, input was received from 3 physician specialty societies and 4 academic medical centers (3 reviews) while this policy was under review in 2014. Input was obtained to provide information on mobile cardiac outpatient telemetry and new devices. There was no consensus whether mobile cardiac outpatient telemetry is medically necessary. While reviewers agreed that mobile cardiac outpatient telemetry is comparable to event monitors for arrhythmia detection, they did not agree on whether the real-time monitoring provides incremental benefit over external event monitors or is associated with improved health outcomes compared with external event monitors. There was consensus on the medical necessity of externally worn event monitors with longer continuous recording periods as an alternative to Holter monitors or event monitors. For implantable memory loop devices that are smaller than older-generation devices, there was consensus that these devices improve the likelihood of obtaining clinically useful information due to improved ease of use, but there was no consensus that such devices improve clinical outcomes and are medically necessary.

2009 Input
In response to requests, input was received from one physician specialty society and 4 academic medical centers (5 reviews) while this policy was under review in 2009. There were differences among reviewers on outpatient cardiac telemetry, with some reviewers concluding it had a role in certain subsets of patients (eg, in those with sporadic atrial fibrillation [AF]). Other reviewers commented that the value of this technology should be considered in both providing a diagnosis and in making treatment decisions. At times, excluding arrhythmia as a cause of a patient's symptoms is an important finding.

Practice Guidelines and Position Statements
Guidelines or position statements will be considered for inclusion in 'Supplemental Information' if they were issued by, or jointly by, a US professional society, an international society with US representation, or National Institute for Health and Care Excellence (NICE). Priority will be given to guidelines that are informed by a systematic review, include strength of evidence ratings, and include a description of management of conflict of interest.

American Academy of Neurology
In 2014 (reaffirmed 2022), the American Academy of Neurology updated its guidelines on the prevention of stroke in patients with nonvalvular AF (NVAF).[105,] These guidelines made the following recommendations on the identification of patients with occult NVAF:

- "Clinicians might obtain outpatient cardiac rhythm studies in patients with cryptogenic stroke without known NVAF, to identify patients with occult NVAF (Level C).
- Clinicians might obtain cardiac rhythm studies for prolonged periods (e.g., for 1 or more weeks) instead of shorter periods (e.g., 24 hours) in patients with cryptogenic stroke without known NVAF, to increase the yield of identification of patients with occult NVAF (Level C)."

American Heart Association, American College of Cardiology, et al
The American College of Cardiology (ACC), the American Heart Association (AHA), the American College of Clinical Pharmacy (ACCP), and the Heart Rhythm Society (HRS) (2023) updated

guidelines initially issued in 2014[4,] on the management of patients with AF. [106,]Table 17 summarizes guideline-recommended monitoring.

The ACC/AHA/HRS (2017) collaborated on guidelines on the evaluation and management of patients with syncope[107,] and patients with ventricular arrhythmias[108,]. Cardiac monitoring recommendations are summarized below in Tables 17 and 18.

Table 17. Cardiac Monitoring Recommendations, AHA/ACC/HRS

Recommendation	COR[a]	LOE[b]
Choice of a specific cardiac monitor should be determined on the basis of frequency and nature of syncope events.[107,]	I	C-EO
To evaluate selected ambulatory patients with syncope of suspected arrhythmic etiology, the following external cardiac monitoring approaches can be useful: Holter monitor, transtelephonic monitor, external loop recorder, patch recorder, and mobile cardiac outpatient telemetry.[107,]	IIa	B-NR
To evaluate selected ambulatory patients with syncope of suspected arrhythmic etiology, an implantable cardiac monitor can be useful.[107,]	IIa	B-R
Ambulatory electrocardiographic monitoring is useful to evaluate whether symptoms including palpitations, presyncope, or syncope, are caused by ventricular arrhythmia.[108,]	I	B-NR
In patients with stroke or TIA of undetermined cause, initial cardiac monitoring and, if needed, extended monitoring with an implantable loop recorder are reasonable to improve detection of AF.[106,]	2a	B-R

ACC: American College of Cardiology; AF: atrial fibrillation; AHA: American Heart Association; COR: class of recommendation; HRS: Heart Rhythm Society; LOE: level of evidence; TIA: transient ischemic attack.
[a] COR definitions: I: strong recommendation; IIa or 2a: benefit probably exceeds risk (moderate).
[b] LOE definitions: B-NR: moderate level based on well-executed nonrandomized studies; B-R: moderate level based on randomized trials; C-EO: consensus of expert opinion based on clinical experience.

Table 18. Patient Selection Recommendations by Cardiac Rhythm Monitor, AHA/ACC/HRS

Type of Monitor	Patient Selection
Holter monitor	• Symptoms frequent enough to be detected within 24 to 72 hours
Patient-activated event monitor	• Frequent spontaneous symptoms likely within 2 to 6 weeks • Limited use when syncope associated with sudden incapacitation
External loop recorder (patient or auto-triggered)	• Frequent spontaneous symptoms likely to occur within 2 to 6 weeks
External patch recorder	• Alternative to external loop recorder • Leadless, so more comfortable, resulting in improved compliance • Offers only 1-lead recording
Mobile cardiac outpatient telemetry	• Spontaneous symptoms related to syncope and rhythm correlation • High-risk patients needing real-time monitoring
Implantable cardiac monitor	• Recurrent, infrequent, unexplained syncope

ACC: American College of Cardiology; AHA: American Heart Association; HRS: Heart Rhythm Society.

International Society for Holter and Noninvasive Electrocardiology/Heart Rhythm Society

The International Society for Holter and Noninvasive Electrocardiology and the HRS (2017) issued a consensus statement on ambulatory electrocardiogram and external monitoring and telemetry.[109,] Below are 2 summary tables from the consensus statement, detailing advantages and limitations of ambulatory electrocardiogram techniques (see Table 19) and recommendations for the devices that are relevant to this evidence review (see Table 20).

Table 19. Advantages and Limitations of Ambulatory Electrocardiogram Techniques, International Society for Holter and Noninvasive Electrocardiology/HRS

ECG Monitoring Technique	Advantages	Limitations
Holter monitoring	• Records and documents continuous 3- to 32-lead ECG signal simultaneously with biologic signals during normal daily activities • Physicians familiar with analysis software and scanning services	• Frequent noncompliance with symptom logs and event markers • Frequent electrode detachments • Signal quality issues due to skin adherence, tangled wires, dermatitis • Absence of real-time data analysis • Poor patient acceptance of electrodes
Patch ECG monitors	• Long-term recording of ≥14 days • Excellent patient acceptance	• Limited ECG from closely spaced electrodes, lacking localization of arrhythmia origin • Inconsistent ECG quality due to body type variations
External loop recorders	• Records only selected ECG segments marked as events either automatically or manually by patient • Immediate alarm generation on event detection	• Single-lead ECG, lacking localization of arrhythmia origin • Cannot continuously document cardiac rhythm • Requires patient to wear electrodes continuously
Event recorders	• Records only selected ECG segments after an event is detected by patient • Immediate alarm generation at event detected by patient • Well-tolerated by patient	• Single-lead ECG, lacking localization of arrhythmia origin • Cannot continuously document cardiac rhythm • Diagnostic yield dependent on patient ability to recognize correct symptom
Mobile cardiac telemetry	• Multilead, so higher sensitivity and specificity of arrhythmia detection • Streams data continuously; can be programmed to autodetect and autosend events at prescribed time intervals • Immediate alarm generation on event without patient interaction	• Long-term patient acceptance is reduced due to requirement of daily electrode changes

ECG: electrocardiogram; HRS: Heart Rhythm Society.

Table 20. Select Recommendations for Ambulatory Electrocardiogram and External Monitoring or Telemetry, International Society for Holter and Noninvasive Electrocardiology/HRS

Recommendation	COR[a]	LOE[b]
Selection of ambulatory ECG		
Holter monitoring when symptomatic events anticipated within 48 hours	I	B-NR
Extended ambulatory ECG (15 to 30 days) when symptomatic events are not daily or are uncertain	I	B-R
Continuous monitoring (1 to 14 days) to quantify arrhythmia burden and patterns	I	B-NR
Specific conditions for use of ambulatory ECG		
Unexplained syncope, when tachycardia suspected	I	B-R
Unexplained palpitation	I	B-R
Detection of atrial fibrillation, triggering arrhythmias, and postconversion pauses	IIa	B-NR
Cryptogenic stroke, to detect undiagnosed atrial fibrillation	I	B-R

COR: class of recommendation; ECG: electrocardiogram; HRS: Heart Rhythm Society; LOE: level of evidence.
[a] COR definitions: I: strong recommendation; IIa: benefit probably exceeds risk.
[b] LOE definitions: B-NR: moderate level based on well-executed nonrandomized studies; B-R: moderate level based on randomized trials.

U.S. Preventive Services Task Force Recommendations

In 2022, the U.S. Preventive Services Task Force updated its recommendation on Screening for Atrial Fibrillation and concluded, "For adults 50 years or older who do not have signs or symptoms of atrial fibrillation: The current evidence is insufficient to assess the balance of benefits and harms of screening for AF (Grade: I statement)."[110,]

Ongoing and Unpublished Clinical Trials

Some currently unpublished trials that might influence this review are listed in Table 21.

Table 21. Summary of Key Trials

NCT No.	Trial Name	Planned Enrollment	Completion Date
Ongoing			
NCT06763549[a]	COR-INSIGHT: Optimizing Cardiovascular and Cardiopulmonary Outcomes with AI-Driven Multiplexed Indications from the COR ECG Wearable	15,000	Apr 2026
NCT06519747	Enhanced DETECTion of PeriOperative Atrial Fibrillation After Noncardiac Surgery with Continuous Electrocardiographic Monitoring (DETECT-POAF)	750	Dec 2026
NCT06564012	Wearable Cardiac Monitor to Enhance Detection of Arrhythmia Recurrence After Catheter Ablation of Atrial Fibrillation (WEAR-HF)	100	Dec 2026
NCT06542770	Subtle Ultrasound Atrial Anomalies Predicts the Early Diagnosis of Silent Atrial Fibrillation Detected by Implantable	100	Dec 2024

NCT No.	Trial Name	Planned Enrollment	Completion Date
	Cardiac Monitor in Patients With Cryptogenic Stroke. A Randomized Trial (CRIPTO-FAST)		
NCT05957315	Mobile Cardiac Outpatient Telemetry for Unexplained Syncope: Time to Treatment, Arrhythmia Diagnosis and Outcome	160	Oct 2025
NCT04371055	Intensive Heart Rhythm Monitoring to Decrease Ischemic Stroke and Systemic Embolism - the Find-AF 2 Study	5227 (actual)	Dec 2026
NCT03940066	Evaluation of Ambulatory Monitoring of Patients After High-risk Acute Coronary Syndrome Using Two Different Systems: Biomonitor-2 and Kardia Mobile	169 (actual)	Jun 2024 (actual)
Unpublished			
NCT02786940	Remote Cardiac Monitoring of Higher-Risk Emergency Department Syncope Patients after Discharge (REMOSYNC)	99	Apr 2020
NCT03541616	Prevalence of Subclinical Atrial Fibrillation in High Risk Heart Failure Patients and Its Temporal Relationship With Hospital Readmission for Heart Failure (PROTECT-HF)	242	Mar 2023

NCT: national clinical trial.
[a] Denotes industry involvement

CODING

The following codes for treatment and procedures applicable to this policy are included below for informational purposes. This may not be a comprehensive list of procedure codes applicable to this policy.

Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

The code(s) listed below are medically necessary ONLY if the procedure is performed according to the "Policy" section of this document.

CPT/HCPCS	
Ambulatory Event Monitors	
33285	Insertion, subcutaneous cardiac rhythm monitor, including programming
33286	Removal, subcutaneous cardiac rhythm monitor
93268	External patient and, when performed, auto activated electrocardiographic rhythm derived event recording with symptom-related memory loop with remote download capability up to 30 days, 24-hour attended monitoring; includes transmission, review and interpretation by a physician or other qualified health care professional
93270	External patient and, when performed, auto activated electrocardiographic rhythm derived event recording with symptom-related memory loop with remote download capability up to 30 days, 24-hour attended monitoring; recording (includes connection, recording, and disconnection)
93271	External patient and, when performed, auto activated electrocardiographic rhythm derived event recording with symptom-related memory loop with remote download capability up to 30 days, 24-hour attended monitoring; transmission and analysis
93272	External patient and, when performed, auto activated electrocardiographic rhythm derived event recording with symptom-related memory loop with remote download capability up to 30 days, 24-hour attended monitoring; review and interpretation by a physician or other qualified health care professional
0650T	Programming device evaluation (remote) of subcutaneous cardiac rhythm monitor system, with iterative adjustment of the implantable device to test the function of the device and select optimal permanently programmed values with analysis, review and report by a physician or other qualified health care professional
C1764	Event recorder, cardiac (implantable)
E0616	Implantable cardiac event recorder with memory, activator, and programmer
Outpatient Continuous Cardiac Telemetry (MCOT)	
93228	External mobile cardiovascular telemetry with electrocardiographic recording, concurrent computerized real time data analysis and greater than 24 hours of accessible ECG data storage (retrievable with query) with ECG triggered and patient selected events transmitted to a remote attended surveillance center for up to 30 days; review and interpretation with report by a physician or other qualified health care professional

CPT/HCPCS	
93229	External mobile cardiovascular telemetry with electrocardiographic recording, concurrent computerized real time data analysis and greater than 24 hours of accessible ECG data storage (retrievable with query) with ECG triggered and patient selected events transmitted to a remote attended surveillance center for up to 30 days; technical support for connection and patient instructions for use, attended surveillance, analysis and transmission of daily and emergent data reports as prescribed by a physician or other qualified health care professional
Continuous Recording Monitoring (more than 48 hours)	
93241	External electrocardiographic recording for more than 48 hours up to 7 days by continuous rhythm recording and storage; includes recording, scanning analysis with report, review and interpretation
93242	External electrocardiographic recording for more than 48 hours up to 7 days by continuous rhythm recording and storage; recording (includes connection and initial recording)
93243	External electrocardiographic recording for more than 48 hours up to 7 days by continuous rhythm recording and storage; scanning analysis with report
93244	External electrocardiographic recording for more than 48 hours up to 7 days by continuous rhythm recording and storage; review and interpretation
93245	External electrocardiographic recording for more than 7 days up to 15 days by continuous rhythm recording and storage; includes recording, scanning analysis with report, review and interpretation
93246	External electrocardiographic recording for more than 7 days up to 15 days by continuous rhythm recording and storage; recording (includes connection and initial recording)
93247	External electrocardiographic recording for more than 7 days up to 15 days by continuous rhythm recording and storage; scanning analysis with report
93248	External electrocardiographic recording for more than 7 days up to 15 days by continuous rhythm recording and storage; review and interpretation
93297	Interrogation device evaluation(s), (remote) up to 30 days; implantable cardiovascular physiologic monitor system, including analysis of 1 or more recorded physiologic cardiovascular data elements from all internal and external sensors, analysis, review(s) and report(s) by a physician or other qualified health care professional
93298	Interrogation device evaluation(s), (remote) up to 30 days; subcutaneous cardiac rhythm monitor system, including analysis of recorded heart rhythm data, analysis, review(s) and report(s) by a physician or other qualified health care professional

REVISIONS	
01-28-2011	Updated Description section
	Updated Rationale section
	In Coding section: ▪ Added CPT Codes: 33282, 33284 ▪ Deleted CPT Codes: 93224, 93225, 93226, 93227, 93230, 93231, 93232, 93233, 93235, 93236, 93237 ▪ Added Diagnosis Code: 426.9
	Updated References section
02-26-2013	Description section updated.
	In Policy section: ▪ Format updated. ▪ In Item A, inserted "the following situations:" to read "diagnostic alternative to Holter monitoring in the following situations:" ▪ In Item A, #2, added "Patients with atrial fibrillation who have been treated with catheter ablation, and in whom discontinuation of systemic anticoagulation is being considered." ▪ In Item C, removed "as a diagnostic alternative in patients who experience infrequent symptoms (less frequently than 48 hours) suggestive of cardiac arrhythmias (i.e., palpitations, dizziness, presyncope, or syncope); this is considered not medically necessary because the clinical (health) outcomes with this technology have not been shown to be superior to other available approaches, yet outpatient cardiac telemetry is generally more costly than those alternative approaches." ▪ Added "Item D. Continuous ambulatory monitors that record and store information for more than 48 hours are considered experimental / investigations." ▪ In Item E, added "including outpatient cardiac telemetry," to read "Other uses of ambulatory event monitors, including outpatient cardiac telemetry…" ▪ In Item E, added "medication for patients with cryptogenic stroke," to read monitoring effectiveness of antiarrhythmic medications for patients with cryptogenic stroke,…"
	Rationale section updated.
	In Coding section: ▪ Updated coding nomenclature ▪ Added HCPCS codes: 0295T, 0296T, 0297T, 0298T
	Reference section updated.
09-05-2013	In Policy section: ▪ In Item B, inserted "including cryptogenic stroke," to read "may be considered medically necessary only in the small subset of patients, including cryptogenic stroke, who experience…"
	In Coding section: ▪ Added ICD-10 Diagnosis *(Effective October 1, 2014)*
	Updated Reference section
04-15-2014	Description section updated
	In Policy section: ▪ In Item B removed "Holter monitor and" to read, "…only in the small subset of patients, including cryptogenic stroke, who experience recurrent symptoms so infrequently that a prior trial of other external ambulatory event monitors has been unsuccessful." ▪ In Item D revised wording from "…for more than 48 hours…" to read "…for periods longer than 48 hours…"

REVISIONS	
	▪ In Item E removed "…for patients with cryptogenic stroke," to read "…including but not limited to monitoring effectiveness of antiarrhythmic medications and detection of myocardial ischemia by detecting ST segment changes."
	Rationale section updated
	In Coding section: ▪ Coding instructions updated
	References updated
09-03-2014	Description section updated
	In Policy section: ▪ Revised policy position on MCOT from not medically necessary to medically necessary adding to Item A, "external ambulatory event monitors," and "or outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT)" to read, "The use of patient-activated external ambulatory event monitors, auto-activated external ambulatory event monitors, or outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT) may be considered medically necessary as a diagnostic alternative to Holter monitoring in the following situations:" ▪ Added to Item A the new indication of, "3. Patients with cryptogenic stroke who have a negative standard work-up for atrial fibrillation including a 24-hour Holter monitor." ▪ Removed "Outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT) is considered not medically necessary."
	Rationale section updated
	References updated
02-04-2015	Updated Rationale section.
	Updated References section.
11-12-2015	Updated Description section.
	In Policy section: ▪ In Item A, added "continuous ambulatory monitors that record and store information for periods longer than 48 hours as a diagnostic alternative to patient-activated or auto-activated external ambulatory event monitors" to read, "The use of patient-activated or auto-activated external ambulatory event monitors, external ambulatory event monitors, continuous ambulatory monitors that record and store information for periods longer than 48 hours as a diagnostic alternative to patient-activated or auto-activated external ambulatory event monitors, or outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT) may be considered medically necessary as a diagnostic alternative to Holter monitoring in the following situations:" ▪ In Item C, removed "including" and added "implantable ambulatory event monitors, and" and "continuous" to read, "Other uses of ambulatory event monitors, implantable ambulatory event monitors, and outpatient continuous cardiac telemetry, are considered experimental/investigational, including, but not limited to, monitoring effectiveness of antiarrhythmic medications and detection of myocardial ischemia by detecting ST segment changes."
	Updated Rationale section.
	Updated References section.
05-01-2016	Updated Description section.
	In Policy section: ▪ Added Policy Guidelines.
	In Coding section: ▪ Added CPT code 93298, 93299, and 93799.

REVISIONS	
	▪ Added coding bullet, "The King of Hearts monitor should be billed with CPT code: 93799."
07-22-2016	Revised title from "Ambulatory Event Monitors and Mobile Outpatient Cardiac Telemetry" to "Ambulatory Event Monitors and Mobile Cardiac Outpatient Telemetry"
	Updated Description section.
	In Policy section: ▪ In Item A, removed "external ambulatory event monitors" to read "The use of patient-activated or auto-activated external ambulatory event monitors, continuous ambulatory monitors that record and store information for periods longer than 48 hours as a diagnostic alternative to patient-activated or auto-activated external ambulatory event monitors, or outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT) may be considered medically necessary as a diagnostic alternative to Holter monitoring in the following situations:" ▪ In Item A 3, added "(see Policy Guidelines)" to read "Patients with cryptogenic stroke who have had a negative standard work-up for atrial fibrillation including a 24-hour Holter monitor (see Policy Guidelines)." ▪ In Item B, added "in the following situations" to read "The use of implantable ambulatory event monitors, either patient-activated or auto-activated, may be considered medically necessary in the following situations:" ▪ In Item B 1, removed "only" and "including cryptogenic stroke" to read "In the small subset of patients who experience recurrent symptoms so infrequently that a prior trial of other external ambulatory event monitors has been unsuccessful." ▪ Added Item B 2, "In patients who require long-term monitoring for atrial fibrillation or possible atrial fibrillation (see Policy Guidelines)." ▪ In Policy Guidelines 1, added "93297" to read "When 33282 is considered not medically necessary, 93297, 93298 and 93299 will also be considered not medically necessary." ▪ Added Policy Guidelines 2 and 3.
	Updated Rationale section.
	In Coding section: ▪ Added CPT code: 93297.
	Updated References section.
10-26-2016	In Policy section: ▪ In Policy Guidelines Item 1, added "CPT code" and "CPT codes" to read, "When CPT code 33282 is considered not medically necessary, CPT codes 93297, 93298 and 93299 will also be considered not medically necessary."
	Updated References section.
07-11-2017	Updated Description section.
	Updated Rationale section.
	Updated References section.
01-01-2018	In Coding section: ▪ Added CPT codes: 0497T, 0498T. ▪ Removed ICD-9 codes.
07-23-2018	Updated Description section.
	In Policy section: ▪ In Item C, added "monitoring asymptomatic patients with risk factors for arrhythmia" to read, "Other uses of ambulatory event monitors, implantable ambulatory event monitors, and outpatient continuous cardiac telemetry, are considered experimental / investigational, including, but not limited to, monitoring asymptomatic patients with

REVISIONS	
	risk factors for arrhythmia, monitoring effectiveness of antiarrhythmic medications, and detection of myocardial ischemia by detecting ST segment changes."
	Updated Rationale section.
	In Coding section: ▪ Added HCPCS codes: C1764, E0616.
	Updated References section.
01-01-2019	In Policy section: ▪ Updated Policy Guidelines.
	In Coding section: ▪ Added new CPT codes: 33285, 33286. ▪ Revised nomenclature to CPT codes: 93297, 93298, 93299. ▪ Removed deleted CPT codes: 33282, 33284. ▪ Updated coding bullets.
06-19-2019	Updated Description section.
	Updated Rationale section.
	Updated References section.
10-01-2019	In Coding section: ▪ Added ICD10 Codes: I48.20, I48.21 ▪ Removed ICD10 Code: I48.2
01-01-2020	In Coding section: ▪ Added HCPCS Code: G2066 ▪ Deleted CPT Code: 93299
02-09-2021	Updated Description section
	Updated Rationale section
	Updated References section
03-18-2021	In Coding section: • Added CPT codes 93241, 93242, 93243, 93244, 93245, 93246, 93247, and 93248 • Removed CPT codes 0295T, 0296T, 0297T, 0298T
07-02-2021	Updated Rationale section
	In the Code section ▪ Added Code 0650T (effective 07-01-2021)
	Updated References section
07-01-2022	Updated Description Section
	Updated Rationale Section
	Updated Coding Section ▪ Converted ICD-10 codes to ranges
	Updated References Section
01-03-2023	Updated Coding Section ▪ Removed Deleted codes 0497T and 0498T
06-27-2023	Updated Description Section
	Updated Rationale Section
	Updated Coding Section ▪ Removed code 93799 ▪ Removed ICD-10 Codes
	Updated References Section
06-27-2024	Updated Description Section
	Updated Rationale Section
	Updated Coding Section ▪ Removed Deleted code G2066

REVISIONS	
	Updated References Section
11-26-2025	Updated Description Section
	Updated Rationale Section
	Updated Reference Section
Posted: 05-14-2026 Effective: 06-15-2026	Updated Description Section
	Updated Policy Section ▪ Section A: o Removed: "as a diagnostic alternative to patient-activated or auto-activated external ambulatory event monitors, or outpatient continuous cardiac telemetry (also known as mobile cardiac outpatient telemetry or MCOT)" ▪ Added Section C: C. The use of outpatient cardiac telemetry (also known as mobile cardiac outpatient telemetry) as a diagnostic alternative to AEMs in individuals who experience infrequent symptoms (less frequently than every 48 hours) suggestive of cardiac arrhythmias (i.e., palpitations, dizziness, presyncope, syncope) may be considered medically necessary when any of the following criteria are met: 1. Evaluation of recurrent unexplained episodes of presyncope, syncope, palpitations or dizziness when: a. Symptoms are thought to be due to a cardiac arrhythmia; AND b. Holter monitor and/or external AEM has been nondiagnostic or contraindicated; AND c. There is documentation that real-time monitoring is essential for patient safety and will lead to immediate clinical changes such as medication or other emergent procedures; OR 2. Evaluation of cryptogenic stroke thought to be caused by atrial fibrillation, with non-diagnostic 24- to 48-hour Holter monitor or 48-hour telemetry.
	Updated Rationale Section
	Updated Reference Section

REFERENCES

1. Moya A, Sutton R, Ammirati F, et al. Guidelines for the diagnosis and management of syncope (version 2009). Eur Heart J. Nov 2009; 30(21): 2631-71. PMID 19713422
2. National Institute for Health and Care Excellence (NICE). Transient loss of consciousness ('blackouts') in over 16s [CG109]. 2023; https://www.nice.org.uk/guidance/cg109. Accessed December 8, 2025.
3. Raviele A, Giada F, Bergfeldt L, et al. Management of patients with palpitations: a position paper from the European Heart Rhythm Association. Europace. Jul 2011; 13(7): 920-34. PMID 21697315
4. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. Circulation. Dec 02 2014; 130(23): 2071-104. PMID 24682348
5. Mittal S, Movsowitz C, Steinberg JS. Ambulatory external electrocardiographic monitoring: focus on atrial fibrillation. J Am Coll Cardiol. Oct 18 2011; 58(17): 1741-9. PMID 21996384

6. Christensen LM, Krieger DW, Højberg S, et al. Paroxysmal atrial fibrillation occurs often in cryptogenic ischaemic stroke. Final results from the SURPRISE study. Eur J Neurol. Jun 2014; 21(6): 884-9. PMID 24628954
7. Hoefman E, Bindels PJ, van Weert HC. Efficacy of diagnostic tools for detecting cardiac arrhythmias: systematic literature search. Neth Heart J. Nov 2010; 18(11): 543-51. PMID 21113379
8. Farris GR, Smith BG, Oates ET, et al. New atrial fibrillation diagnosed by 30-day rhythm monitoring. Am Heart J. Mar 2019; 209: 29-35. PMID 30639611
9. Turakhia MP, Hoang DD, Zimetbaum P, et al. Diagnostic utility of a novel leadless arrhythmia monitoring device. Am J Cardiol. Aug 15 2013; 112(4): 520-4. PMID 23672988
10. Barrett PM, Komatireddy R, Haaser S, et al. Comparison of 24-hour Holter monitoring with 14-day novel adhesive patch electrocardiographic monitoring. Am J Med. Jan 2014; 127(1): 95.e11-7. PMID 24384108
11. Solomon MD, Yang J, Sung SH, et al. Incidence and timing of potentially high-risk arrhythmias detected through long term continuous ambulatory electrocardiographic monitoring. BMC Cardiovasc Disord. Feb 17 2016; 16: 35. PMID 26883019
12. Wineinger NE, Barrett PM, Zhang Y, et al. Identification of paroxysmal atrial fibrillation subtypes in over 13,000 individuals. Heart Rhythm. Jan 2019; 16(1): 26-30. PMID 30118885
13. Go AS, Reynolds K, Yang J, et al. Association of Burden of Atrial Fibrillation With Risk of Ischemic Stroke in Adults With Paroxysmal Atrial Fibrillation: The KP-RHYTHM Study. JAMA Cardiol. Jul 01 2018; 3(7): 601-608. PMID 29799942
14. Bolourchi M, Batra AS. Diagnostic yield of patch ambulatory electrocardiogram monitoring in children (from a national registry). Am J Cardiol. Mar 01 2015; 115(5): 630-4. PMID 25591894
15. Eisenberg EE, Carlson SK, Doshi RH, et al. Chronic ambulatory monitoring: results of a large single-center experience. J Innovations Cardiac Rhythm Manage. Nov 2014;5:1818-1823.
16. Schreiber D, Sattar A, Drigalla D, et al. Ambulatory cardiac monitoring for discharged emergency department patients with possible cardiac arrhythmias. West J Emerg Med. Mar 2014; 15(2): 194-8. PMID 24672611
17. Mullis AH, Ayoub K, Shah J, et al. Fluctuations in premature ventricular contraction burden can affect medical assessment and management. Heart Rhythm. Oct 2019; 16(10): 1570-1574. PMID 31004780
18. Reed MJ, Grubb NR, Lang CC, et al. Diagnostic yield of an ambulatory patch monitor in patients with unexplained syncope after initial evaluation in the emergency department: the PATCH-ED study. Emerg Med J. Aug 2018; 35(8): 477-485. PMID 29921622
19. Eysenck W, Freemantle N, Sulke N. A randomized trial evaluating the accuracy of AF detection by four external ambulatory ECG monitors compared to permanent pacemaker AF detection. J Interv Card Electrophysiol. Apr 2020; 57(3): 361-369. PMID 30741360
20. Kabali C, Xie X, Higgins C. Long-Term Continuous Ambulatory ECG Monitors and External Cardiac Loop Recorders for Cardiac Arrhythmia: A Health Technology Assessment. Ont Health Technol Assess Ser. 2017; 17(1): 1-56. PMID 28194254
21. Balmelli N, Naegeli B, Bertel O. Diagnostic yield of automatic and patient-triggered ambulatory cardiac event recording in the evaluation of patients with palpitations, dizziness, or syncope. Clin Cardiol. Apr 2003; 26(4): 173-6. PMID 12708623

22. Ermis C, Zhu AX, Pham S, et al. Comparison of automatic and patient-activated arrhythmia recordings by implantable loop recorders in the evaluation of syncope. Am J Cardiol. Oct 01 2003; 92(7): 815-9. PMID 14516882
23. Reiffel JA, Schwarzberg R, Murry M. Comparison of autotriggered memory loop recorders versus standard loop recorders versus 24-hour Holter monitors for arrhythmia detection. Am J Cardiol. May 01 2005; 95(9): 1055-9. PMID 15842970
24. Dagres N, Kottkamp H, Piorkowski C, et al. :Influence of the duration of Holter monitoring on the detection of arrhythmia recurrences after catheter ablation of atrial fibrillation: implications for patient follow-up. Int J Cardiol. Mar 18 2010; 139(3): 305-6. PMID 18990460
25. Pokushalov E, Romanov A, Corbucci G, et al. Ablation of paroxysmal and persistent atrial fibrillation: 1-year follow-up through continuous subcutaneous monitoring. J Cardiovasc Electrophysiol. Apr 2011; 22(4): 369-75. PMID 20958836
26. Chao TF, Lin YJ, Tsao HM, et al. CHADS(2) and CHA(2)DS(2)-VASc scores in the prediction of clinical outcomes in patients with atrial fibrillation after catheter ablation. J Am Coll Cardiol. Nov 29 2011; 58(23): 2380-5. PMID 22115643
27. Kapa S, Epstein AE, Callans DJ, et al. Assessing arrhythmia burden after catheter ablation of atrial fibrillation using an implantable loop recorder: the ABACUS study. J Cardiovasc Electrophysiol. Aug 2013; 24(8): 875-81. PMID 23577826
28. Verma A, Champagne J, Sapp J, et al. Discerning the incidence of symptomatic and asymptomatic episodes of atrial fibrillation before and after catheter ablation (DISCERN AF): a prospective, multicenter study. JAMA Intern Med. Jan 28 2013; 173(2): 149-56. PMID 23266597
29. Themistoclakis S, Corrado A, Marchlinski FE, et al. The risk of thromboembolism and need for oral anticoagulation after successful atrial fibrillation ablation. J Am Coll Cardiol. Feb 23 2010; 55(8): 735-43. PMID 20170810
30. Gumbinger C, Krumsdorf U, Veltkamp R, et al. Continuous monitoring versus HOLTER ECG for detection of atrial fibrillation in patients with stroke. Eur J Neurol. Feb 2012; 19(2): 253-7. PMID 21895885
31. Lazzaro MA, Krishnan K, Prabhakaran S. Detection of atrial fibrillation with concurrent holter monitoring and continuous cardiac telemetry following ischemic stroke and transient ischemic attack. J Stroke Cerebrovasc Dis. Feb 2012; 21(2): 89-93. PMID 20656504
32. Cotter PE, Martin PJ, Ring L, et al. Incidence of atrial fibrillation detected by implantable loop recorders in unexplained stroke. Neurology. Apr 23 2013; 80(17): 1546-50. PMID 23535493
33. Miller DJ, Khan MA, Schultz LR, et al. Outpatient cardiac telemetry detects a high rate of atrial fibrillation in cryptogenic stroke. J Neurol Sci. Jan 15 2013; 324(1-2): 57-61. PMID 23102659
34. Ho JS, Ho ES, Yeo LL, et al. Use of wearable technology in cardiac monitoring after cryptogenic stroke or embolic stroke of undetermined source: a systematic review. Singapore Med J. Jul 01 2024; 65(7): 370-379. PMID 38449074
35. Sposato LA, Cipriano LE, Saposnik G, et al. Diagnosis of atrial fibrillation after stroke and transient ischaemic attack: a systematic review and meta-analysis. Lancet Neurol. Apr 2015; 14(4): 377-87. PMID 25748102
36. Kishore A, Vail A, Majid A, et al. Detection of atrial fibrillation after ischemic stroke or transient ischemic attack: a systematic review and meta-analysis. Stroke. Feb 2014; 45(2): 520-6. PMID 24385275

37. Kamel H, Navi BB, Elijovich L, et al. Pilot randomized trial of outpatient cardiac monitoring after cryptogenic stroke. Stroke. Feb 2013; 44(2): 528-30. PMID 23192756
38. Higgins P, MacFarlane PW, Dawson J, et al. Noninvasive cardiac event monitoring to detect atrial fibrillation after ischemic stroke: a randomized, controlled trial. Stroke. Sep 2013; 44(9): 2525-31. PMID 23899913
39. Sinha AM, Diener HC, Morillo CA, et al. Cryptogenic Stroke and underlying Atrial Fibrillation (CRYSTAL AF): design and rationale. Am Heart J. Jul 2010; 160(1): 36-41.e1. PMID 20598970
40. Sanna T, Diener HC, Passman RS, et al. Cryptogenic stroke and underlying atrial fibrillation. N Engl J Med. Jun 26 2014; 370(26): 2478-86. PMID 24963567
41. Brachmann J, Morillo CA, Sanna T, et al. Uncovering Atrial Fibrillation Beyond Short-Term Monitoring in Cryptogenic Stroke Patients: Three-Year Results From the Cryptogenic Stroke and Underlying Atrial Fibrillation Trial. Circ Arrhythm Electrophysiol. Jan 2016; 9(1): e003333. PMID 26763225
42. Gladstone DJ, Spring M, Dorian P, et al. Atrial fibrillation in patients with cryptogenic stroke. N Engl J Med. Jun 26 2014; 370(26): 2467-77. PMID 24963566
43. Kaura A, Sztriha L, Chan FK, et al. Early prolonged ambulatory cardiac monitoring in stroke (EPACS): an open-label randomised controlled trial. Eur J Med Res. Jul 26 2019; 24(1): 25. PMID 31349792
44. Ritter MA, Kochhäuser S, Duning T, et al. Occult atrial fibrillation in cryptogenic stroke: detection by 7-day electrocardiogram versus implantable cardiac monitors. Stroke. May 2013; 44(5): 1449-52. PMID 23449264
45. Etgen T, Hochreiter M, Mundel M, et al. Insertable cardiac event recorder in detection of atrial fibrillation after cryptogenic stroke: an audit report. Stroke. Jul 2013; 44(7): 2007-9. PMID 23674523
46. Tung CE, Su D, Turakhia MP, et al. Diagnostic Yield of Extended Cardiac Patch Monitoring in Patients with Stroke or TIA. Front Neurol. 2014; 5: 266. PMID 25628595
47. Rosenberg MA, Samuel M, Thosani A, et al. Use of a noninvasive continuous monitoring device in the management of atrial fibrillation: a pilot study. Pacing Clin Electrophysiol. Mar 2013; 36(3): 328-33. PMID 23240827
48. Savelieva I, Camm AJ. Clinical relevance of silent atrial fibrillation: prevalence, prognosis, quality of life, and management. J Interv Card Electrophysiol. Jun 2000; 4(2): 369-82. PMID 10936003
49. Israel CW, Grönefeld G, Ehrlich JR, et al. Long-term risk of recurrent atrial fibrillation as documented by an implantable monitoring device: implications for optimal patient care. J Am Coll Cardiol. Jan 07 2004; 43(1): 47-52. PMID 14715182
50. Page RL, Wilkinson WE, Clair WK, et al. Asymptomatic arrhythmias in patients with symptomatic paroxysmal atrial fibrillation and paroxysmal supraventricular tachycardia. Circulation. Jan 1994; 89(1): 224-7. PMID 8281651
51. Hart RG, Pearce LA, Rothbart RM, et al. Stroke with intermittent atrial fibrillation: incidence and predictors during aspirin therapy. Stroke Prevention in Atrial Fibrillation Investigators. J Am Coll Cardiol. Jan 2000; 35(1): 183-7. PMID 10636278
52. Hohnloser SH, Pajitnev D, Pogue J, et al. Incidence of stroke in paroxysmal versus sustained atrial fibrillation in patients taking oral anticoagulation or combined antiplatelet therapy: an ACTIVE W Substudy. J Am Coll Cardiol. Nov 27 2007; 50(22): 2156-61. PMID 18036454

53. Ganesan AN, Chew DP, Hartshorne T, et al. The impact of atrial fibrillation type on the risk of thromboembolism, mortality, and bleeding: a systematic review and meta-analysis. Eur Heart J. May 21 2016; 37(20): 1591-602. PMID 26888184
54. Fitzmaurice DA, Hobbs FD, Jowett S, et al. Screening versus routine practice in detection of atrial fibrillation in patients aged 65 or over: cluster randomised controlled trial. BMJ. Aug 25 2007; 335(7616): 383. PMID 17673732
55. Langén V, Winstén AK, Airaksinen KEJ, et al. Clinical outcomes of atrial fibrillation screening: a meta-analysis of randomized controlled trials. Ann Med. Dec 2025; 57(1): 2457522. PMID 39862317
56. Benito L, Coll-Vinent B, Gómez E, et al. EARLY: a pilot study on early diagnosis of atrial fibrillation in a primary healthcare centre. Europace. Nov 2015; 17(11): 1688-93. PMID 26071233
57. Halcox JPJ, Wareham K, Cardew A, et al. Assessment of Remote Heart Rhythm Sampling Using the AliveCor Heart Monitor to Screen for Atrial Fibrillation: The REHEARSE-AF Study. Circulation. Nov 07 2017; 136(19): 1784-1794. PMID 28851729
58. Gladstone DJ, Wachter R, Schmalstieg-Bahr K, et al. Screening for Atrial Fibrillation in the Older Population: A Randomized Clinical Trial. JAMA Cardiol. May 01 2021; 6(5): 558-567. PMID 33625468
59. Svendsen JH, Diederichsen SZ, Højberg S, et al. Implantable loop recorder detection of atrial fibrillation to prevent stroke (The LOOP Study): a randomised controlled trial. Lancet. Oct 23 2021; 398(10310): 1507-1516. PMID 34469766
60. Svennberg E, Friberg L, Frykman V, et al. Clinical outcomes in systematic screening for atrial fibrillation (STROKESTOP): a multicentre, parallel group, unmasked, randomised controlled trial. Lancet. Oct 23 2021; 398(10310): 1498-1506. PMID 34469764
61. Lopes RD, Atlas SJ, Go AS, et al. Effect of Screening for Undiagnosed Atrial Fibrillation on Stroke Prevention. J Am Coll Cardiol. Nov 19 2024; 84(21): 2073-2084. PMID 39230544
62. Kemp Gudmundsdottir K, Svennberg E, Friberg L, et al. Randomized Invitation to Systematic NT-proBNP and ECG Screening in 75-Year-Olds to Detect Atrial Fibrillation: STROKESTOP II. Circulation. Dec 03 2024; 150(23): 1837-1846. PMID 39217615
63. Steinhubl SR, Waalen J, Edwards AM, et al. Effect of a Home-Based Wearable Continuous ECG Monitoring Patch on Detection of Undiagnosed Atrial Fibrillation: The mSToPS Randomized Clinical Trial. JAMA. Jul 10 2018; 320(2): 146-155. PMID 29998336
64. Turakhia MP, Ullal AJ, Hoang DD, et al. Feasibility of extended ambulatory electrocardiogram monitoring to identify silent atrial fibrillation in high-risk patients: the Screening Study for Undiagnosed Atrial Fibrillation (STUDY-AF). Clin Cardiol. May 2015; 38(5): 285-92. PMID 25873476
65. Heckbert SR, Austin TR, Jensen PN, et al. Yield and consistency of arrhythmia detection with patch electrocardiographic monitoring: The Multi-Ethnic Study of Atherosclerosis. J Electrocardiol. 2018; 51(6): 997-1002. PMID 30497763
66. Steinhubl SR, Waalen J, Sanyal A, et al. Three year clinical outcomes in a nationwide, observational, siteless clinical trial of atrial fibrillation screening-mHealth Screening to Prevent Strokes (mSToPS). PLoS One. 2021; 16(10): e0258276. PMID 34610049
67. Murphy R, Waters R, Murphy A, et al. Risk-based screening for the evaluation of atrial fibrillation in general practice (R-BEAT): a randomized cross-over trial. QJM. Mar 01 2025; 118(3): 166-173. PMID 39786890
68. Diederichsen SZ, Frederiksen KS, Xing LY, et al. Severity and Etiology of Incident Stroke in Patients Screened for Atrial Fibrillation vs Usual Care and the Impact of Prior Stroke: A

Post Hoc Analysis of the LOOP Randomized Clinical Trial. JAMA Neurol. Oct 01 2022; 79(10): 997-1004. PMID 36036546
69. Diederichsen SZ, Xing LY, Frodi DM, et al. Prevalence and Prognostic Significance of Bradyarrhythmias in Patients Screened for Atrial Fibrillation vs Usual Care: Post Hoc Analysis of the LOOP Randomized Clinical Trial. JAMA Cardiol. Apr 01 2023; 8(4): 326-334. PMID 36790817
70. Solbiati M, Casazza G, Dipaola F, et al. The diagnostic yield of implantable loop recorders in unexplained syncope: A systematic review and meta-analysis. Int J Cardiol. Mar 15 2017; 231: 170-176. PMID 28052814
71. Burkowitz J, Merzenich C, Grassme K, et al. Insertable cardiac monitors in the diagnosis of syncope and the detection of atrial fibrillation: A systematic review and meta-analysis. Eur J Prev Cardiol. Aug 2016; 23(12): 1261-72. PMID 26864396
72. Da Costa A, Defaye P, Romeyer-Bouchard C, et al. Clinical impact of the implantable loop recorder in patients with isolated syncope, bundle branch block and negative workup: a randomized multicentre prospective study. Arch Cardiovasc Dis. Mar 2013; 106(3): 146-54. PMID 23582676
73. Farwell DJ, Freemantle N, Sulke AN. Use of implantable loop recorders in the diagnosis and management of syncope. Eur Heart J. Jul 2004; 25(14): 1257-63. PMID 15246645
74. Krahn AD, Klein GJ, Yee R, et al. Randomized assessment of syncope trial: conventional diagnostic testing versus a prolonged monitoring strategy. Circulation. Jul 03 2001; 104(1): 46-51. PMID 11435336
75. Afzal MR, Gunda S, Waheed S, et al. Role of Outpatient Cardiac Rhythm Monitoring in Cryptogenic Stroke: A Systematic Review and Meta-Analysis. Pacing Clin Electrophysiol. Oct 2015; 38(10): 1236-45. PMID 26172621
76. Podoleanu C, DaCosta A, Defaye P, et al. Early use of an implantable loop recorder in syncope evaluation: a randomized study in the context of the French healthcare system (FRESH study). Arch Cardiovasc Dis. Oct 2014; 107(10): 546-52. PMID 25241220
77. Giada F, Gulizia M, Francese M, et al. Recurrent unexplained palpitations (RUP) study comparison of implantable loop recorder versus conventional diagnostic strategy. J Am Coll Cardiol. May 15 2007; 49(19): 1951-6. PMID 17498580
78. Ciconte G, Saviano M, Giannelli L, et al. Atrial fibrillation detection using a novel three-vector cardiac implantable monitor: the atrial fibrillation detect study. Europace. Jul 01 2017; 19(7): 1101-1108. PMID 27702865
79. Nölker G, Mayer J, Boldt LH, et al. Performance of an Implantable Cardiac Monitor to Detect Atrial Fibrillation: Results of the DETECT AF Study. J Cardiovasc Electrophysiol. Dec 2016; 27(12): 1403-1410. PMID 27565119
80. Sanders P, Pürerfellner H, Pokushalov E, et al. Performance of a new atrial fibrillation detection algorithm in a miniaturized insertable cardiac monitor: Results from the Reveal LINQ Usability Study. Heart Rhythm. Jul 2016; 13(7): 1425-30. PMID 26961298
81. Hanke T, Charitos EI, Stierle U, et al. Twenty-four-hour holter monitor follow-up does not provide accurate heart rhythm status after surgical atrial fibrillation ablation therapy: up to 12 months experience with a novel permanently implantable heart rhythm monitor device. Circulation. Sep 15 2009; 120(11 Suppl): S177-84. PMID 19752365
82. Hindricks G, Pokushalov E, Urban L, et al. Performance of a new leadless implantable cardiac monitor in detecting and quantifying atrial fibrillation: Results of the XPECT trial. Circ Arrhythm Electrophysiol. Apr 2010; 3(2): 141-7. PMID 20160169

83. Ziegler PD, Rogers JD, Ferreira SW, et al. Real-World Experience with Insertable Cardiac Monitors to Find Atrial Fibrillation in Cryptogenic Stroke. Cerebrovasc Dis. 2015; 40(3-4): 175-81. PMID 26314298
84. Edvardsson N, Garutti C, Rieger G, et al. Unexplained syncope: implications of age and gender on patient characteristics and evaluation, the diagnostic yield of an implantable loop recorder, and the subsequent treatment. Clin Cardiol. Oct 2014; 37(10): 618-25. PMID 24890550
85. Bhangu J, McMahon CG, Hall P, et al. Long-term cardiac monitoring in older adults with unexplained falls and syncope. Heart. May 2016; 102(9): 681-6. PMID 26822427
86. Maines M, Zorzi A, Tomasi G, et al. Clinical impact, safety, and accuracy of the remotely monitored implantable loop recorder Medtronic Reveal LINQTM. Europace. Jun 01 2018; 20(6): 1050-1057. PMID 29016753
87. Magnusson PM, Olszowka M, Wallhagen M, et al. Outcome of implantable loop recorder evaluation. Cardiol J. 2018; 25(3): 363-370. PMID 28840588
88. Katapadi A, Chelikam N, Garg J, et al. Dynamic data-driven management of atrial fibrillation with implantable cardiac monitors: The MONITOR AF study. Heart Rhythm. Dec 2025; 22(12): 3050-3056. PMID 39826639
89. Mittal S, Sanders P, Pokushalov E, et al. Safety Profile of a Miniaturized Insertable Cardiac Monitor: Results from Two Prospective Trials. Pacing Clin Electrophysiol. Dec 2015; 38(12): 1464-9. PMID 26412309
90. Rothman SA, Laughlin JC, Seltzer J, et al. The diagnosis of cardiac arrhythmias: a prospective multi-center randomized study comparing mobile cardiac outpatient telemetry versus standard loop event monitoring. J Cardiovasc Electrophysiol. Mar 2007; 18(3): 241-7. PMID 17318994
91. Derkac WM, Finkelmeier JR, Horgan DJ, et al. Diagnostic yield of asymptomatic arrhythmias detected by mobile cardiac outpatient telemetry and autotrigger looping event cardiac monitors. J Cardiovasc Electrophysiol. Dec 2017; 28(12): 1475-1478. PMID 28940881
92. Kadish AH, Reiffel JA, Clauser J, et al. Frequency of serious arrhythmias detected with ambulatory cardiac telemetry. Am J Cardiol. May 01 2010; 105(9): 1313-6. PMID 20403485
93. Joshi AK, Kowey PR, Prystowsky EN, et al. First experience with a Mobile Cardiac Outpatient Telemetry (MCOT) system for the diagnosis and management of cardiac arrhythmia. Am J Cardiol. Apr 01 2005; 95(7): 878-81. PMID 15781022
94. Olson JA, Fouts AM, Padanilam BJ, et al. Utility of mobile cardiac outpatient telemetry for the diagnosis of palpitations, presyncope, syncope, and the assessment of therapy efficacy. J Cardiovasc Electrophysiol. May 2007; 18(5): 473-7. PMID 17343724
95. Saarel EV, Doratotaj S, Sterba R. Initial experience with novel mobile cardiac outpatient telemetry for children and adolescents with suspected arrhythmia. Congenit Heart Dis. 2008; 3(1): 33-8. PMID 18373747
96. Tayal AH, Tian M, Kelly KM, et al. Atrial fibrillation detected by mobile cardiac outpatient telemetry in cryptogenic TIA or stroke. Neurology. Nov 18 2008; 71(21): 1696-701. PMID 18815386
97. Favilla CG, Ingala E, Jara J, et al. Predictors of finding occult atrial fibrillation after cryptogenic stroke. Stroke. May 2015; 46(5): 1210-5. PMID 25851771
98. Kalani R, Bernstein R, Passman R, et al. Low Yield of Mobile Cardiac Outpatient Telemetry after Cryptogenic Stroke in Patients with Extensive Cardiac Imaging. J Stroke Cerebrovasc Dis. Sep 2015; 24(9): 2069-73. PMID 26139455

99. Narasimha D, Hanna N, Beck H, et al. Validation of a smartphone-based event recorder for arrhythmia detection. Pacing Clin Electrophysiol. May 2018; 41(5): 487-494. PMID 29493801
100. Dörr M, Nohturfft V, Brasier N, et al. The WATCH AF Trial: SmartWATCHes for Detection of Atrial Fibrillation. JACC Clin Electrophysiol. Feb 2019; 5(2): 199-208. PMID 30784691
101. Beccarino N, Epstein LM, Khodak A, et al. The utility and impact of outpatient telemetry monitoring in post-transcatheter aortic valve replacement patients. Cardiovasc Revasc Med. Jul 2024; 64: 15-20. PMID 38388248
102. Nuche J, Soliman F, Chavarría J, et al. New-onset atrial fibrillation detected by ambulatory ECG monitoring after transcatheter aortic valve implantation. EuroIntervention. May 10 2024; 20(9): 591-601. PMID 38726722
103. Muntané-Carol G, Okoh AK, Chen C, et al. Ambulatory Electrocardiographic Monitoring Following Minimalist Transcatheter Aortic Valve Replacement. JACC Cardiovasc Interv. Dec 27 2021; 14(24): 2711-2722. PMID 34949396
104. Norlock V, Vazquez R, Dunn A, et al. Comparing the outcomes and costs of cardiac monitoring with implantable loop recorders and mobile cardiac outpatient telemetry following stroke using real-world evidence. J Comp Eff Res. Jun 2024; 13(6): e240008. PMID 38602503
105. Culebras A, Messé SR, Chaturvedi S, et al. Summary of evidence-based guideline update: prevention of stroke in nonvalvular atrial fibrillation: report of the Guideline Development Subcommittee of the American Academy of Neurology. Neurology. Feb 25 2014; 82(8): 716-24. PMID 24566225
106. Joglar JA, Chung MK, Armbruster AL, et al. 2023 ACC/AHA/ACCP/HRS Guideline for the Diagnosis and Management of Atrial Fibrillation: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. J Am Coll Cardiol. Jan 02 2024; 83(1): 109-279. PMID 38043043
107. Shen WK, Sheldon RS, Benditt DG, et al. 2017 ACC/AHA/HRS Guideline for the Evaluation and Management of Patients With Syncope: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. Aug 01 2017; 70(5): 620-663. PMID 28286222
108. Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS guideline for management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: Executive summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. Heart Rhythm. Oct 2018; 15(10): e190-e252. PMID 29097320
109. Steinberg JS, Varma N, Cygankiewicz I, et al. 2017 ISHNE-HRS expert consensus statement on ambulatory ECG and external cardiac monitoring/telemetry. Heart Rhythm. Jul 2017; 14(7): e55-e96. PMID 28495301
110. Davidson KW, Barry MJ, Mangione CM, et al. Screening for Atrial Fibrillation: US Preventive Services Task Force Recommendation Statement. JAMA. Jan 25 2022; 327(4): 360-367. PMID 35076659
111. Centers for Medicare & Medicaid Services (CMS). National Coverage Determination (NCD) for Electrocardiographic Services (20.15). 2004; https://www.cms.gov/medicare-coverage-database/view/ncd.aspx?MCDId=16&ExpandComments=n&McdName=Thomson+Micromedex+DrugDex+%C2%AE+Compendium+Revision+Request+-+CAG-00391&NCDId=179. Accessed December 8, 2025.

OTHER REFERENCES

1. Blue Cross and Blue Shield of Kansas Cardiology Liaison Committee, (see Blue Cross and Blue Shield of Kansas Newsletter, Blue Shield Report. MAC–03-05).
2. Blue Cross and Blue Shield of Kansas Medical Advisory Committee, November 3, 2005 (see Blue Cross and Blue Shield of Kansas Newsletter, Blue Shield Report. MAC–03-05).
3. Blue Cross and Blue Shield of Kansas Medical Director, May 23, 2007.
4. Blue Cross and Blue Shield of Kansas Medical Advisory Committee (MAC), August 2, 2007.
5. Blue Cross and Blue Shield of Kansas Cardiology Liaison Committee, April 2005; May 2007; April 2010; May 2013; May 2014; July 2016, January 2020, May 2021.