Smartwatch diagnosis of atrial fibrillation in patient with embolic stroke of unknown source: A case report

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Introduction

Atrial fibrillation (AF), the most common arrhythmia seen in clinical practice, is projected to affect 6–12 million Americans by the year 2050. The cornerstone of management of AF revolves around prevention of stroke, as close to 25% of ischemic strokes in the United States are secondary to AF. However, in some cases the etiology of ischemic strokes may not always be apparent, as AF is frequently paroxysmal in nature.

Embolic stroke of unknown significance (ESUS) is a type of ischemic stroke in an embolic distribution where the cause of the stroke cannot be determined, and represents around 17% of all ischemic strokes. Patients without a clear source of stroke undergo workup that typically includes a transthoracic echocardiography, transesophageal echocardiography, and telemetry monitoring before receiving a diagnosis of ESUS. Some groups have advocated that in patients with ESUS anticoagulation should be started without a definitive diagnosis of AF, given the high prevalence of AF in this patient population. However, multiple trials have shown that empiric anticoagulation is not superior to antiplatelet therapy at preventing future strokes in patients with ESUS and is associated with an increase in bleeding.

Many devices are available for ambulatory cardiac rhythm monitoring, including extended ambulatory electrocardiography (ECG) monitoring, event monitoring, and ambulatory continuous telemetry. These devices are not invasive, but they are limited in duration. The CRYSTAL-AF study demonstrated that implantable loop recorders (ILRs) are better able to detect AF compared to standard telemetry monitoring. In the era of digital medicine, direct-to-consumer devices that enable patients to independently record ECG strips have provided an alternative to traditional monitors with the advantage of accessibility, unlimited wear time, and ease of use. Herein, we present a patient who was diagnosed with ESUS and was referred to electrophysiology for consideration of implating an ILR to rule out AF.

Case report

A 70-year-old woman with past medical history of hypertension and hyperlipidemia presented to the electrophysiology clinic for consideration of ILR implantation. The patient presented to the emergency room 4 months prior with symptoms of profound dizziness and left eye ptosis. She had a computed tomography of the head, which was negative for any acute intracranial process. Given mild symptoms and a low stroke scale, thrombolytics were not administered. The patient underwent magnetic resonance imaging, which showed small subacute infarcts involving the cerebellum. She underwent workup including a computed tomography angiography of the head and neck, which was unrevealing, and a transthoracic and transesophageal echocardiogram, which did not reveal any evidence of a patent foramen ovale or cause of her stroke. Her LDL was 145 mg/dL and so the patient was given aspirin and statin therapy for secondary prevention. She underwent a 30-day ambulatory cardiac telemetry recorder, which did not reveal any episodes of AF. Given that no other cause could be identified, she was referred to electrophysiology for consideration of an ILR implantation.

Upon interviewing of the patient during her electrophysiology clinic visit, patient noted that she knew we are trying to rule out AF as a cause of her stroke. She has heard about the Apple™ Watch and its ability to detect AF and therefore she purchased one on her own. In retrospect, she occasionally felt palpitations but was not certain of her symptoms. She felt similar palpitations while wearing the ambulatory monitor that did not correlate with any episodes of AF. Over a course of 3 weeks after purchasing the watch, she received a notification about irregular pulse detections through the watch and the app on her phone that these could be possible AF. As instructed, she recorded a rhythm strip (Figure 1). She thought nothing of it at the time but brought her watch to the clinic visit. These were reviewed by the staff electrophysiologist, who agreed that her rhythm tracings represented AF (Figure 2). In fact, she had more than 1 detection and the recordings were of excellent quality, and no further monitoring was necessary to establish a diagnosis of AF. Given her
Figure 1  A: Main page notification about irregular heart rhythm. B: Irregular heart notification types. C: Description of irregular heart rhythm. D: Tracings of irregular heart rhythm.
An elevated CHA2DS2-VASC score of 5 (age, female, previous stroke, and hypertension), the patient was started on a direct oral anticoagulant, and the aspirin was stopped. The smartwatch reading, which was further confirmed by her electrophysiologist, had successfully detected her AF as the likely cause of her stroke. An ILR was not necessary given the AF confirmation, the patient had an etiology for her ischemic stroke, and the correct therapy was implemented to prevent further strokes.

Discussion

Even after a patient presents with a stroke and goes through extensive workup during their hospitalization, the exact etiology of their stroke may be unknown in up to 20%–40% of cases. The American Heart Association / American Stroke guidelines state that it is reasonable to complete 30-day extended cardiac monitoring in patients with ESUS, especially those with risk factors, to detect AF. The EMBRACE randomized trial showed that 30-day event extended cardiac monitoring was able to detect AF in 16.1% of patients compared to 3.2% in the standard-of-care arm in cryptogenic stroke patients above the age of 55. The CRYSTAL-AF trial showed that ILRs play an important role and can better detect AF than following patients by recording ambulatory ECGs or symptoms. However, ILRs come at a high cost and have a definite battery life, and even though low risk, implantation is not a risk-free procedure. Wearables have the advantage of being less expensive and easier to understand and use. However, a major limitation of many direct-to-consumer ECG recordings is the on-demand nature of the recordings that are usually triggered by the patient’s symptoms, risking missing asymptomatic episodes. The coupling of wrist bands or watches that continuously check for pulse irregularities through photoplethysmogram (PPG) technology using different algorithms coupled with notification to the patient to record an ECG strip on demand offer the potential of more thorough monitoring.

Few devices were introduced to the market that use these combined features. The Kardiaband was the first accessory to a smartwatch to obtain US Food & Drug Administration clearance. Its algorithm depends on using PPG and pedometer to continuously assess pulse rate and the activity level and if there is any discrepancy detected, the app alerts the patient to record their rhythm by placing their thumb on a sensor embedded in the band. The newer generation of Apple Watch can detect irregularities in the pulse using an optical sensor PPG and proprietary algorithm that opportunistically checks for heart rate and irregularities; if certain criteria are met, the app alerts the patient about irregular heart rhythm. The user then records an ECG rhythm strip directly on the same watch by placing the finger on a sensor embedded in the digital crown. In the Apple Heart Study, 0.5% of all users received a notification of irregular heart rhythm, but the study was conducted with an older-generation watch and did not have the ability to record ECG, and therefore the AF diagnosis relied on a subsequent ECG patch that was sent to those who received the notification. In our case, the patient bought an Apple Watch on her own, and she was successfully alerted to record her rhythm when irregular heart rhythm was detected and was able to save recordings for review by the electrophysiologist to diagnose AF. While this was an insightful case as to the advancement of digital medicine, ILRs are still the gold standard for providing true continuous monitoring.

The Apple Watch uses photoplethysmography (PPG) technology to detect pulse irregularities and notify the user if there are any abnormalities. The user can then record an ECG strip on-demand by placing their thumb on a sensor embedded in the digital crown. This feature has been shown to detect irregular heart rhythms in a significant number of users, offering a non-invasive and convenient method for monitoring heart health.
increasing, it represents a paradigm shift in patients taking action into their own hands. The popularity of devices is continuously rising, as seen by a recent Gallup poll that revealed that close to 20% of Americans wear a fitness tracker or smartwatch, with the use especially higher in those who are younger (<55 years of age) and higher income level. This brings up the potential drawbacks to these devices, as they require a certain knowledge of electronic devices, ability to use these devices and their software, and disposable income, as these devices (unlike ILRs) are not usually reimbursed by patients’ insurance companies. However, as these devices may save insurance companies money, especially in preventative cardiology, they will be increasingly reimbursed.

**Conclusion**

A patient was successfully diagnosed with AF as the likely cause of her stroke after having undergone extensive negative workup. This diagnosis was made by her consumer wearable digital device, which alerted the patient to record ECG signals, and was later verified by her electrophysiologist. The patient was started on anticoagulation to prevent further strokes, and ILR was not needed. Future studies should examine the role of these devices in patients who are at a higher risk of having AF or where a diagnosis of AF would change their management, as these devices are easier to use and more accessible to patients than traditional ECG monitoring devices.

**Disclosures**

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