



# Case Report Apple Watch for Pulse Rate Assessment Detects Unidentified Paroxysmal Atrial Fibrillation

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**Abstract:** Consumer rhythm-monitoring devices, such as the Apple Watch, are becoming more readily available. Irregular pulses can be detected using an optical sensor that is built into the wearable device. The Apple Watch (Apple Inc., Cupertino, CA, USA) is a class II medical device with pulse rate and electrocardiography (ECG) monitoring capabilities. Here, we report a case in which an arrhythmia that was conventionally perceived but undiagnosed was identified as an atrial fibrillation by the self-acquisition of the ECG data using an Apple Watch.

Keywords: Apple Watch; wearable sensor; pulse rate; arrhythmia; atrial fibrillation; case report

# 1. Introduction

The Apple Watch (Apple Inc., Cupertino, CA, USA) is a class II medical device with pulse rate and electrocardiography (ECG) monitoring capabilities [1,2]. Consumer rhythmmonitoring devices, such as the Apple Watch, have become increasingly accessible. The Apple Watch detects the pulse waves on the wrist using an optical heart rate sensor and measures the fluctuations in the pulse interval at rest. The system notifies the user when an irregular pulse is detected [3,4]. Since the diagnosis of arrhythmia and the subsequent treatment plan depend entirely on symptomatic ECG findings, the use of an Apple Watch, which enables the diagnosis of arrhythmia in the symptomatic state during normal life, may significantly impact the future treatment of arrhythmia. Here, we report a case in which an arrhythmia, of which the patient was aware but had not yet received a definitive diagnosis of, was identified as a paroxysmal atrial fibrillation (AF) using an Apple Watch.

# 2. Case Presentation

A 59-year-old man taking medication for hypertension and hyperlipidemia had experienced occasional short-lasting arrhythmias for approximately 15 years. However, a 12-lead electrocardiogram, which was a part of his annual physical examination, indicated that there was no arrhythmia. The patient's awareness of the arrhythmia had ceased in the previous five years. The patient also had an untreated sleep apnea syndrome. Finally, he had been aware of an irregular heartbeat for approximately three months.

The patient was working on his personal computer in his office when he became aware of the arrhythmia and simultaneously received a notification from his Apple Watch that he was experiencing a tachycardia exceeding 120 bpm (Figure 1). The patient's pulse rate exceeded 150 bpm, and he activated the ECG app on his Apple Watch to obtain a series of ECG tracings. (Figure 2: 30-s ECG that was collected during an arrhythmic attack; Figure 3: 30-s ECG that was collected at the time of the arrhythmia; Figure 4: 30-s ECG that was collected 30 min after the arrhythmic attack). The patient was aware of the arrhythmia for approximately 3 min. A loss of consciousness did not occur. The arrhythmia resolved without any intervention having been performed such as the Valsalva maneuver or a carotid massage.



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Figure 1. Pulse rate chart recorded using the iPhone.



**Figure 2.** Paroxysmal atrial fibrillation was detected during the arrhythmic attack. The first 1 min of an electrocardiogram that was collected immediately after notification of the tachycardic episode. 25 mm/s, 10 mm/mV, iOS v.15.4.1, Apple Watch 4.2, algorithm v.1.



**Figure 3.** Paroxysmal atrial fibrillation was detected during the arrhythmic attack. Electrocardiogram that was collected during the second minute after notification of the tachycardic episode. 25 mm/s, 10 mm/mV, iOS v15.4.1, Apple Watch 4.2, algorithm ver. 1.s.



**Figure 4.** Electrocardiogram collected at 30 min after cessation of the arrhythmia. 25 mm/s, 10 mm/mV, iOS v.15.4.1, Apple Watch 4.2, algorithm v.1.

The ECG charts, which were converted to PDF files, were submitted to a cardiologist, who diagnosed the patient with a paroxysmal AF.

## 3. Discussion

The Apple Watch has a background check function for high and low pulse rates, and the irregular pulse rate notification feature checks for an irregular pulse, which is indicative of an AF [5,6]. The irregular pulse notification function uses an optical pulse rate sensor to detect the pulse waves at the wrist and measure the fluctuations in the resting pulse rate interval. When the algorithm detects repeated irregular pulse rates, which is a possible sign of an AF, the user receives a notification, and the date, time, and heart rate are recorded in the healthcare application on the paired iPhone. The ECG app, which is available on Apple Watch Series 4 and its subsequent models, records a single-lead ECG that is similar to the I-lead ECG using an electric pulse rate sensor in the digital crown and a crystal on the back of Apple Watch Series 4 and its subsequent models. The electrical signals that are acquired by the watch are transmitted to the paired iPhone, and a 30-s continuous ECG is made available as a PDF file. The single-lead ECG provides information on the heart rate and the heart rhythm, and these can be used to classify an AF [1]. In the prospective single-group Apple Heart Study, 34% of the individuals who received an arrhythmia notification were later diagnosed with an AF, with a positive predictive value of 0.84. These estimates may help the providers better understand the implications of irregular pulse notifications when patients present themselves for clinical care [1,6–8].

Upon complaining of symptoms or the awareness of an arrhythmia, the patient was subjected to Holter ECG testing for 24-48 h for an objective diagnosis or hospitalized for several days to monitor whether the symptom were considered to be caused by a dangerous arrhythmia that could result in the loss of consciousness or death. However, hospitalization and wearing a Holter ECG for 48 h is extremely burdensome for the patients that are of working age, and in many cases, the diagnosis is not made due to a lack of time that is used for monitoring. Devices that overcome the shortcomings of conventional Holter ECGs are also being developed. One such device is the Zio Patch<sup>TM</sup>. The Zio Patch<sup>TM</sup> is a device that can be worn continuously for two weeks to get a more accurate picture of heart activity, and has the ability to add event tags by pressing a button on the surface of the device when the subject detects an abnormality, which has been reported to improve the diagnosis rate of atrial fibrillation [9]. However, there are many cases in which the diagnosis is not made because the patient is asymptomatic during the test period. The failure to reach a diagnosis may result in missed opportunities for appropriate therapeutic interventions to be performed and, consequently, a sudden death. Since the diagnosis of an arrhythmia and the subsequent treatment plan depend entirely on the symptomatic ECG findings, the use of an Apple Watch, which enables the diagnosis of an arrhythmia in the symptomatic state during normal life, may significantly impact the future treatment of an arrhythmia. The

problem with the Apple Watch at present is that the operation of its recording feature is somewhat complicated for those who are not familiar with it. However, this will be easily resolved by the future refinement of the device.

The data from the test results that we can see as healthcare professionals are limited to the data that are collected during a patient's hospital visit. However, devices such as smartwatches and smartphones continue to accumulate data outside of the hospital while they are being worn. The significant difference is that the healthcare data still lack a unified medical meaning and interpretation, while the ECG tracings can be treated as established data. Sudden death is becoming an increasing problem in today's aging society. This sudden death is usually preceded by the loss of consciousness, and the loss of consciousness while driving can cause serious accidents involving many surrounding vehicles and people. These are most often caused by cardiovascular diseases, such as a myocardial infarction, and they are associated ventricular arrhythmias. However, it is extremely difficult to determine the risk of sudden death especially when the person has never been aware of the symptom. If the wearable devices have the ability to detect and automatically record dangerous arrhythmias or significant ST-T changes, it will be possible to diagnose potential cardiovascular diseases in advance. In the near future, it is possible that the wearable devices such as the Apple Watch will become an indispensable piece in the medical diagnosis process, and they may even lead to a diagnostic revolution.

### 4. Conclusions

We reported a case in which an arrhythmia that was conventionally perceived but undiagnosed was identified as an atrial fibrillation by the self-acquisition of ECG data using an Apple Watch.

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