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CASE REPORT

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Apple Watch® facilitates single-session catheter ablation of coexisting atrioventricular nodal reentrant tachycardia and atrioventricular reentrant tachycardia

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Abstract

Heart rate information from a smartwatch can facilitate the diagnosis and treatment of SVT. Benefitting from long-term HR trends, we performed successful RF catheter ablation of coexisting AVNRT and AVRT.

KEYWORDS

accessory pathway and slow pathway ablation, Apple Watch®, dual supraventricular tachycardias, heart rate trend, syncope

1 | INTRODUCTION

We report a case of a 52-year-old patient complaining of palpitations and syncope. His heart rate trends from his Apple Watch® SE suggested two types of tachycardia, and we successfully performed ablation for both of them in a single session. Our case demonstrates the cardiological potential of smartwatches.

Smartwatches such as Apple Watch® and other health monitoring devices have been increasingly popular.[1] Smartwatches with continuous pulse monitoring enable doctors to observe long-term heart rate (HR) trends. They are also patient-friendly and less invasive compared with the insertable cardiac monitor (ICM). HR trends available in smartwatches help doctors to detect tachycardia in patients with palpitations. For this reason, several recent papers report cases where recordings from smartwatches are used to diagnose cardiac arrhythmia.[2,3] Inspired by these recent efforts, we present a case in which long-term HR trends from an Apple Watch® hint at coexisting atrioventricular nodal reentrant tachycardia (AVNRT) and atrioventricular reentrant tachycardia (AVRT). AVNRT occurs in the presence of two different pathways in the AV node. AVRT happens between the physiological conduction system and a pathological accessory pathway. AVNRT and AVRT are the two most common forms of reentrant paroxysmal supraventricular reentrant tachycardias (SVT). The prevalence of coexistent AVNRT and AVRT has been reported in about 3–4% out of all patients with SVT.[4] The case that we report here illustrates the particular effectiveness of smartwatches in detecting such relatively rare cases.

2 | CASE REPORT

A 52-year-old man with hypertension presented to the hospital with a complaint of frequent episodes of palpitation and sporadic syncope.

Electrocardiogram (ECG) showed a normal sinus rhythm without preexcitation (Figure 1A). An echocardiogram revealed a structurally normal heart. ECG was not performed during his palpitation attack. His HR trend recordings from his Apple Watch® showed increases (150–180/min, green arrow in Figure 1B) and further increases in HR (180–220/min, blue arrow in Figure 1B). The former occurred when a palpitation happened, and the latter, during syncope or presyncope. His smartwatch was an Apple Watch SE®, which does not record a one-lead ECG; we could not identify the type of arrhythmia.

Electrophysiology study (EPS) and radiofrequency (RF) catheter ablation were recommended due to frequent palpitation with occasional syncope. After obtaining informed consent, EPS was performed in the patient. A quadripolar electrode catheter was positioned at the high right atrium (HRA). An octapolar electrode catheter

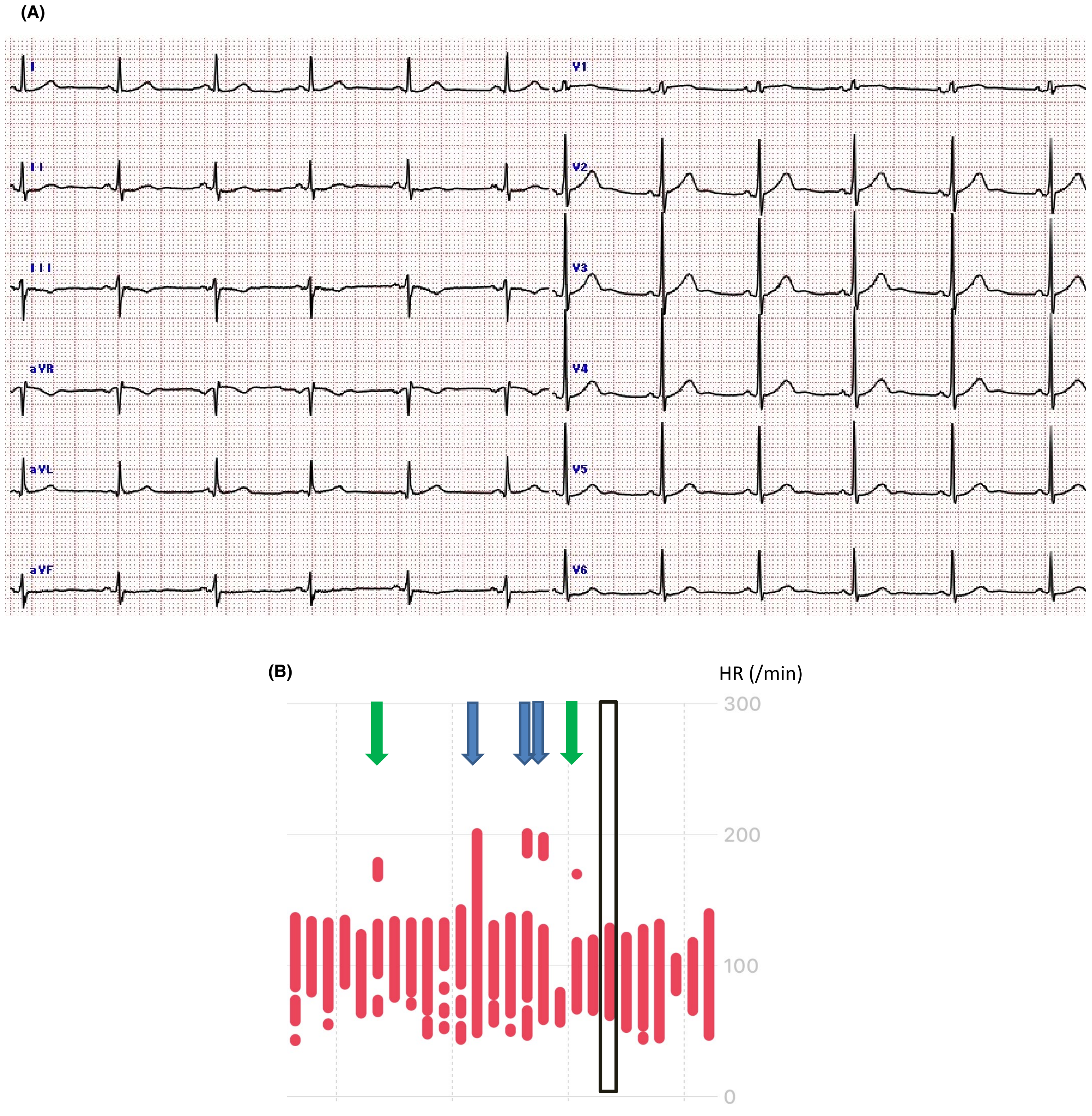

FIGURE 1 A. Baseline electrocardiogram (ECG). B. HR trend recordings from the patient's Apple Watch® over three weeks. Each red line indicates the range of the heart rates over one day. Green and blue arrows indicate tachycardia of 150–180 and 180–220 /min, respectively. The rectangle corresponds to the ablation day. Apple Watch® did not record a heart rate higher than 150 /min after the ablation day

was introduced into the coronary sinus (CS). A 14-polar electrode catheter was positioned from the right ventricle apex (RVA) to the His bundle area.

With incremental ventricular stimulation performed from RVA, the shortest VA conduction was seen in the posterolateral part of the mitral annulus. With programmed electrical stimulation performed from RVA, AVRT using a left posterolateral wall accessory pathway was induced. Shown in Figure 2A and 2B are the ECG and intracardiac electrogram during the tachycardia, respectively. There is a gap in time between the R wave and the retrograde P wave, which suggests AVRT, not AVNRT (Figure 2A). The retrograde atrial activation recorded by the CS catheter was much earlier than that recorded by the His catheter (Figure 2B). His refractory premature ventricular contraction (PVC) was delivered to differentiate between AVNRT and AVRT. Atrial activation got advanced with His refractory PVC delivery. There was nondecremental VA conduction during ventricular extrastimulation.

The HR was 150–160/min (tachycardia cycle length, TCL, of 375–400 msec (ms)), similar to the HR recorded by the Apple Watch® when the patient only had palpitations without syncope. Further, the fact that the blood pressure did not drop during the EPS is consistent with the HR increases that caused only palpitations without syncope. The shortest VA conduction was seen at CS5-6, showing compatible findings to the existence of the concealed left posterolateral wall accessory pathway (Figure 2C).

For the concealed left posterolateral wall accessory pathway, the ablation catheter was inserted into the left atrium via the Brockenbrough technique. During the AVRT, radiofrequency (RF) energy ablation was performed at the 4 o'clock position on the posterolateral wall of the mitral valve annulus where an earlier atrial activation than the retrograde atrial wave in the CS 5–6 was recorded by the ablation catheter (Figure 2C). 1.3 seconds after starting the RF ablation, the AVRT terminated (Figure 2D) and the VA conduction was blocked. The ablation lasted for 120 seconds.

During programmed atrial stimulation with single extrastimulation from the HRA catheter and CS catheter, discontinuous AV node conduction was observed (AH interval "jump" of 80 ms, suggesting dual AV node physiology). This stimulation induced a single echo beat with the earliest retrograde atrial activity to be in the His recording site, but no AVNRT was induced.

Since we could not induce the tachycardia with syncope and a rate of 180 and higher, which was found in the Apple Watch's® recordings, we proceeded with further stimulation. We conducted double premature extrastimulation and continuous atrial stimulation both in the HRA and in the CS catheter.

An SVT with an atrial cycle length of 290 ms and 1:1 AV conduction was induced in the HRA catheter by the continuous atrial stimulation with a cycle length of 400 ms.

In the ECG during this tachycardia (Figure 2E), a late r notch was observed in the terminal portion of the QRS in lead V1. Another notch was observed, and it appeared to be retrograde P waves in the terminal portion of the QRS in leads II, III, and aVF. This suggested that the mechanism of the tachycardia was common AVNRT.

We further looked at the intracardiac electrogram during the tachycardia (Figures 2F, G). The figures show the systolic blood pressure under 50 mmHg, which can trigger syncope. Similar to the previous tachycardia, His refractory PVC was delivered to differentiate between AVNRT and AVRT that is caused by a concealed septal accessory pathway. Atrial activation did not get advanced in this case with His refractory PVC delivery. In order to entrain the reentry circuit, RV was paced at 270 ms, which was 20 ms less than TCL's 290 ms. After the successful entrainment, the postpacing interval (PPI) minus the TCL was found to be 155 ms.[5] We terminated the tachycardia by continuous atrial stimulation at 220 ms because the blood pressure was too low. Afterward, we reapplied continuous ventricular stimulation with a cycle length of 270 ms and confirmed that the QRS wave's morphology during this stimulation was the same as that during the RV entrainment pacing. This result suggested that constant fusion did not happen during the RV entrainment pacing. This implies that the circuit did not include the ventricles.

These findings are all consistent with common AVNRT. Therefore, we decided to perform slow pathway ablation. We targeted the upper anterior edge of the right atrial posteroseptal CS (Figure 2H) where an appropriate A/V electrogram ratio was seen, and a fragment atrial potential (typical slow pathway potential) was observed (Figure 2I). 6 seconds after starting the RF ablation, frequent junctional beats appeared, indicative of successful RF ablation. The ablation was performed for a total of 70 seconds with 40–50 Watts and 55 °C RF energy. The effectiveness of the ablation was confirmed under the following varying conditions: single and double premature extrastimulation and continuous atrial stimulation both in the HRA and in the CS catheters under isoproterenol (ISP) administration. The ablation was in fact completely successful given that a continuous AV nodal conduction curve was present, which is much under the standard threshold of *AH interval jump and a single echo beat*.

In the three-month follow-up period, the patient was asymptomatic. Apple Watch® did not record a heart rate higher than 150/min.

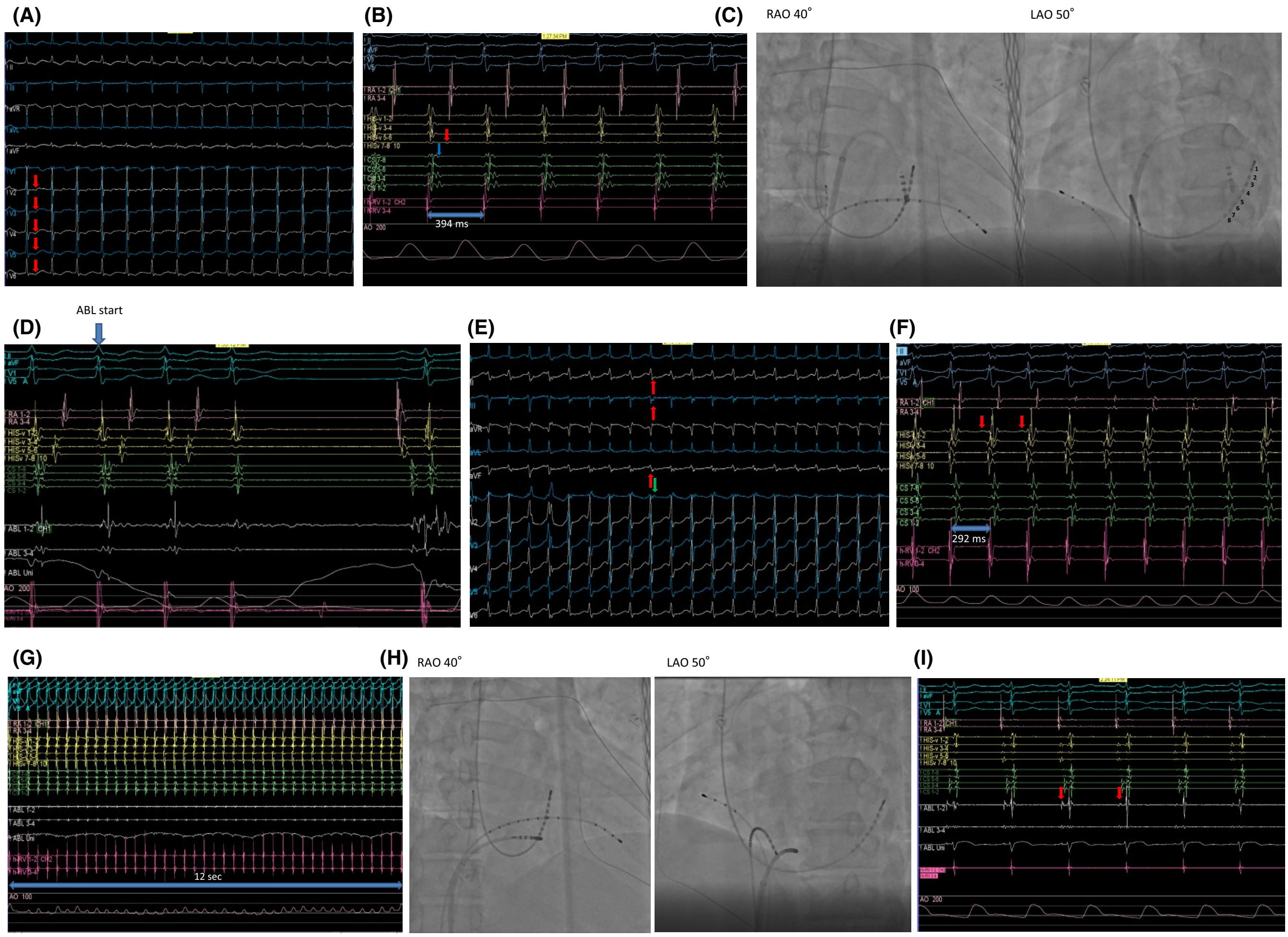

FIGURE 2 A. 12-lead ECG during the AVRT with a heart rate of 150-160/min. The retrograde P' waves (red arrow) were negative in leads II, III, and aVF, and all chest leads. B. Intracardiac electrogram during AVRT. The blood pressure did not decrease. The blue and red arrows represent the retrograde atrial activation recorded by the CS and His catheters, respectively. The former was much earlier than the latter. C. Catheter position at the successful ablation site of posterolateral accessory pathway in the fluoroscopic image. D. Early continuous VA' potential was found in the ablation catheter. 1.3 seconds after starting RF ablation at this site, the AVRT terminated via VA block. E. 12-lead electrocardiogram during the AVNRT with a heart rate higher than 200 /min. A late r notch (green arrow) was observed in the terminal portion of the QRS in lead V1. Another notch (red arrow) appeared to be a retrograde conducted P' wave in the terminal portion of the QRS in leads II, III, and aVF. F. Intracardiac electrogram during AVNRT. The red arrows indicate the His potential. G. Systolic blood pressure decreased to a level lower than 50 mm Hg. H. Catheter position at the successful ablation site of slow pathway in the fluoroscopic image. I. Intracardiac electrogram just before the slow pathway ablation started. The red arrows indicate the slow pathway potential recorded at the ablation catheter

3 | DISCUSSION

Cardiac arrhythmia is difficult to record with standard methods such as the Holter monitors and patch cardiac rhythm monitors because of their duration. For example, the Holter ECG only lasts typically for a day and a week at most, but a cardiac arrhythmia might not occur during that period. Path cardiac rhythm monitors can only record for four weeks at most. A cardiac arrhythmia might not occur during that period. On the other hand, the long-term ICM requires an invasive operation and is therefore not patient-friendly. Smartwatches such as Apple Watches® provide a long-term yet patient-friendly monitoring method.[6]

In our case, the patient was wearing an Apple Watch® of version SE, which only records HR trends. While the one-lead ECG was not available, we were able to benefit from the long-term HR trends. We found tachycardia with syncope happens when the HR is higher than 200 /min.

We first performed the left posterolateral wall accessory pathway ablation successfully. Yet, we made further steps because of the HR trends obtained from his Apple Watch®. We applied various types of stimulation such as single and double atrial premature extrastimulation and continuous atrial stimulation. As a result, we were able to induce AVNRT and conducted successful slow pathway ablation to remove it. Since the AVNRT was considered to be the cause of his syncope, it was critical to address the AVNRT in the same single session for the patient.

Our case suggests the promising potential of smartwatches that can guide doctors during medical consultation. We found that even an Apple Watch® with a limited capacity can be helpful. Available features in smartwatches vary from patient to patient or even from country to country, and our case serves as an example that we can benefit from a smartwatch even when limited features are available. Nonetheless, Apple Watches® that are series 4 or later have the capacity to record a one-lead ECG.[7] If the ECG had been recorded and two distinct types of regular narrow QRS tachycardia had been observed, we would have known that the two types are both SVT in advance. The availability of one-lead ECG recordings would open up even further potential for medical practitioners.

4 | CONCLUSION

Through our case report, we showed that information from a smartwatch can facilitate the diagnosis and treatment of SVT. We performed successful RF catheter ablation of both a concealed left posterolateral accessory pathway and coexisting slow pathway in the same single session. While our case illustrates that smartwatches serve as a convenient, useful tool, information that they record should always be critically reviewed by a cardiologist in the context of standard assessments.

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CONFLICT OF INTEREST

None declared.

AUTHOR CONTRIBUTIONS

YK wrote the manuscript and was the first operator of this ablation. JK supervised the writing of the manuscript. YS was the supervisor of this ablation. SA, HF, and TN assisted this ablation. JN supervised the project. All authors read and approved the final manuscript.

ETHICAL APPROVAL

The enrolled patient provided written informed consent. The examination was made in accordance with the approved principles. All the preparations and the equipment used are officially certified for the clinical use.

DATA AVAILABILITY STATEMENT

Data are available on request.

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