CLINICAL VIGNETTE

Wearable Devices in Arrhythmia Detection

Boris Arbit, MD and Roman Leibzon, MD

Introduction

Over the past decade, there has been an explosion of consumer devices for health and fitness tracking. Wearable technologies represent an important frontier in health evaluation, with the potential to provide health data for large segments of the population, including those not captured by conventional monitoring techniques in otherwise healthy persons. Clinical utility and application of the collected data for individual patient management remain uncertain. We present a 38-year-old male with palpitations.

Case Report

A 38-year-old male with no significant past medical history self-referred to Cardiology for evaluation of palpitations. He had a long history of palpitations which occurred approximately once every few months to once a year. He described a fluttering of his heart which lasted for a few minutes up to 30 minutes. These symptoms were associated with mild dyspnea and mild dizziness, but no syncope or chest pain. The patient presented to emergency rooms in the past with palpitations however, no arrhythmia was detected. Prior evaluation included transthoracic echocardiogram with normal systolic left ventricular function, with an ejection fraction of 55-60% and no significant valvular abnormalities. Prior seven day Holter monitor showed normal sinus rhythm with rare premature atrial contractions and rare premature ventricular contractions. Patient was seen in clinic one year later and reported an increase in palpitations. He also stated that he has purchased an Apple and was able to record his rhythm during a recent palpitation episode (Figure 1). Patient was diagnosed with Supraventricular tachycardia (SVT) based on Apple watch recordings. He was counseled regarding the condition and treatment options including abortive maneuvers and medications.

Discussion

Wearable devices along with smartphone technology have rapidly grown in popularity in developed nations, with the number of connected devices expected to increase from 526 million in 2017 to over 1.1 billion worldwide in 2022.[1]

Currently the two most clinically pertinent technologies use photoplethysmography (PPG) and portable single-lead ECG. PPG involves optical technology to assess variations in blood volume within the microvasculature,[2] effectively measuring each heart beat as a pulse. Accuracy is often limited by anatomical factors including location, ambient lighting, movement, skin color and conductivity. Fingertip PPG is highly accurate, with meta- analysis demonstrating a mean difference of 0.32 beats per minute (99% CI, − 1.25 to 0.60) compared with ECG.[3] PPG may be built into smartphones (using a light beam and a camera) or featured within wrist-worn or heart rate tracking devices. These are reasonably accurate, with correlation coefficients > 0.93 and mean absolute percentage errors ranging from 3.3% to 6.2%.[4]

The most prominent devices among consumers to use a built-in electrode system to create a single-lead ECG are the Apple Watch Series 5 (Apple Inc, Cupertino, CA)) and the AliveCor Kardia device (AliveCor Inc, Mountain View, CA). A Lead I electrocardiogram recording is created through a circuit between the detector on the watch back and the digital crown using an Apple Watch (Apple Inc.). Patient wears the watch on one hand and touches the crown of the watch with a contralateral hand, creating a vector.

Wearable technology has been adopted by consumers as means for tracking heart rate. Initially, relevant clinical uses were similar to conventional ambulatory ECG monitors and included measuring adequate rate control in atrial fibrillation (AF), and aiding the diagnosis of bradyarrhythmia or tachyarrhythmia. However, the clinical value of these devices has significantly grown with use of advanced algorithms and deep neural networks. These have allowed for detection of highly clinically relevant arrhythmias such as AF. Atrial fibrillation is a common arrhythmia, with an estimated prevalence of >3% among adults.[5] It is associated with increased morbidity and mortality with a 5-fold increased risk of stroke.[6] Subclinical AF (SCAF) represents approximately a third of the total AF population[7] and is associated with an increased risk of stroke.[8]

A University of California, San Francisco group published a multinational cardiovascular remote cohort study using an algorithm created from 9750 participants wearing smartwatches that recorded heart rate data. The deep neural network exhibited a C statistic of 0.97 (95% CI, 0.94-1.00; $P < .001$) to detect AF against the reference standard 12-lead ECG-diagnosed AF in the external validation cohort of 51 patients undergoing cardioversion; sensitivity was 98.0% and specificity was 90.2%.[9] The largest study using a wearable PPG to detect AF has been the Apple Heart Study which used a self-enrolled cohort of 419,297 people. The aim of the study was to identify irregular pulses on

PPG, and the diagnosis of AF with a confirmatory ECG patch. A total of 450 ECG patches were included based on PPG analysis by doctors, with AF documented in 34% of these patients. In patients ≥ 65 years of age, the rate of irregular heartrate notification was 3% with a positive predictive value for a final diagnosis of AF of 84 (95% CI, 0.76 to 0.92).[10] REHEARSE-AF Study was a one-year randomized controlled trial of twice-weekly monitoring with AliveCor Kardia device.[11] The study enrolled 1001 patients (500 iECG, 501 routine care). Nineteen patients in the iECG group were diagnosed with AF over the 12-month study period versus 5 in the routine care arm (hazard ratio, 3.9; 95% confidence interval=1.4–10.4; P=0.007).[11]

As we analyze the accuracy of wearable devices to detect subclinical atrial fibrillation, it is important to acknowledge the fundamental gaps that remain in our understanding of the disease. At this time, the minimum burden of AF that is associated with an increase in stroke risk, and the strategy for using oral anticoagulation is not clear.[12] We look forward to the publication of ongoing studies such as ARTESiA (Apixaban for the Reduction of Thrombo-Embolism in Patients with Device-Detected Sub-Clinical Atrial Fibrillation) trial[13] and the large scale follow-up to the REACT.COM (Rhythm Evaluation for Anticoagulation With Continuous Monitoring) trial[14] to further our understanding of this area.

Conclusion

Wearable devices have rapidly grown in popularity in developed nations. Numerous trials have shown the ability of these consumer devices to accurately detect arrhythmias. Our patient is an example of positive use of this data to improve the care of the patient. However, it is important to appreciate the limits of this technology. Further advancements of current hardware and software technology will likely advance the use of wearable devices and assist in arrhythmia detection in the future.

Figure 1.

REFERENCES

1. **Jin D, Adams H, Cocco AM, Martin WG, Palmer S**. Smartphones and wearable technology: benefits and concerns in cardiology. *Med J Aust*. 2020 Feb;212(2):54-56.e1. doi: 10.5694/mja2.50446. Epub 2019 Dec 18. PMID: 31851375.
2. **Allen J**. Photoplethysmography and its application in clinical physiological measurement. *Physiol Meas*. 2007 Mar;28(3):R1-39. doi: 10.1088/0967-3334/28/3/R01. Epub 2007 Feb 20. PMID: 17322588.

3. **De Ridder B, Van Rompaey B, Kampen JK, Haine S, Dilles T**. Smartphone Apps Using Photoplethysmography for Heart Rate Monitoring: Meta-Analysis. *JMIR Cardio*. 2018 Feb 27;2(1):e4. doi: 10.2196/cardio.8802. PMID: 31758768; PMCID: PMC6834218.
4. **Stahl SE, An HS, Dinkel DM, Noble JM, Lee JM**. How accurate are the wrist-based heart rate monitors during walking and running activities? Are they accurate enough? *BMJ Open Sport Exerc Med*. 2016 Apr 25;2(1):e000106. doi: 10.1136/bmjsem-2015-000106. PMID: 27900173; PMCID: PMC5117066.
5. **Friberg L, Bergfeldt L**. Atrial fibrillation prevalence revisited. *J Intern Med*. 2013 Nov;274(5):461-8. doi: 10.1111/joim.12114. Epub 2013 Aug 7. PMID: 23879838.
6. **Björck S, Palaszewski B, Friberg L, Bergfeldt L**. Atrial fibrillation, stroke risk, and warfarin therapy revisited: a population-based study. *Stroke*. 2013 Nov;44(11):3103-8. doi: 10.1161/STROKEAHA.113.002329. Epub 2013 Aug 27. PMID: 23982711.
7. **Camm AJ, Corbucci G, Padeletti L**. Usefulness of continuous electrocardiographic monitoring for atrial fibrillation. *Am J Cardiol*. 2012 Jul 15;110(2):270-6. doi: 10.1016/j.amjcard.2012.03.021. Epub 2012 Apr 12. PMID: 22503584.
8. **Healey JS, Connolly SJ, Gold MR, Israel CW, Van Gelder IC, Capucci A, Lau CP, Fain E, Yang S, Bailleul C, Morillo CA, Carlson M, Themeles E, Kaufman ES, Hohnloser SH; ASSERT Investigators**. Subclinical atrial fibrillation and the risk of stroke. *N Engl J Med*. 2012 Jan 12;366(2):120-9. doi: 10.1056/NEJMoa1105575. Erratum in: *N Engl J Med*. 2016 Mar 10;374(10):998. PMID: 22236222.
9. **Tison GH, Sanchez JM, Ballinger B, Singh A, Olgin JE, Pletcher MJ, Vittinghoff E, Lee ES, Fan SM, Gladstone RA, Mikell C, Sohoni N, Hsieh J, Marcus GM**. Passive Detection of Atrial Fibrillation Using a Commercially Available Smartwatch. *JAMA Cardiol*. 2018 May 1;3(5):409-416. doi: 10.1001/jamacardio.2018.0136. PMID: 29562087; PMCID: PMC5875390.
10. **Perez MV, Mahaffey KW, Hedlin H, Rumsfeld JS, Garcia A, Ferris T, Balasubramanian V, Russo AM, Rajmane A, Cheung L, Hung G, Lee J, Kowey P, Talati N, Nag D, Gummidipundi SE, Beatty A, Hills MT, Desai S, Granger CB, Desai M, Turakhia MP; Apple Heart Study Investigators**. Large-Scale Assessment of a Smartwatch to Identify Atrial Fibrillation. *N Engl J Med*. 2019 Nov 14;381(20):1909-1917. doi: 10.1056/NEJMoa1901183. PMID: 31722151.
11. **Halcox JPJ, Wareham K, Cardew A, Gilmore M, Barry JP, Phillips C, Gravenor MB**. Assessment of Remote Heart Rhythm Sampling Using the AliveCor Heart Monitor to Screen for Atrial Fibrillation: The REHEARSE-AF Study. *Circulation*. 2017 Nov 7;136(19):1784-1794. doi: 10.1161/CIRCULATIONAHA.117.030583. Epub 2017 Aug 28. PMID: 28851729.
12. **Healey JS, Wong J**. Wearable and implantable diagnostic monitors in early assessment of atrial tachyarrhythmia burden. *Europace*. 2019 Mar 1;21(3):377-382. doi: 10.1093/europace/euy246. PMID: 30418608.
13. **Lopes RD, Alings M, Connolly SJ, Beresh H, Granger CB, Mazuecos JB, Boriani G, Nielsen JC, Conen D, Hohnloser SH, Mairesse GH, Mabo P, Camm AJ, Healey JS**. Rationale and design of the Apixaban for the Reduction of Thrombo-Embolism in Patients With Device-Detected Sub-Clinical Atrial Fibrillation (ARTESiA) trial. *Am Heart J*. 2017 Jul;189:137-145. doi: 10.1016/j.ahj.2017.04.008. Epub 2017 Apr 24. PMID: 28625370.
14. **Passman R, Leong-Sit P, Andrei AC, Huskin A, Tomson TT, Bernstein R, Ellis E, Waks JW, Zimetbaum P**. Targeted Anticoagulation for Atrial Fibrillation Guided by Continuous Rhythm Assessment With an Insertable Cardiac Monitor: The Rhythm Evaluation for Anticoagulation With Continuous Monitoring (REACT.COM) Pilot Study. *J Cardiovasc Electrophysiol*. 2016 Mar;27(3):264-70. doi: 10.1111/jce.12864. Epub 2015 Nov 23. PMID: 26511221; PMCID: PMC4789135.