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EDITORIAL COMMENT

Wearing Your Heart on Your Wrist

How Wearable Smart Devices Are Shaping the Landscape of Early Cardiac Arrhythmia Detection*

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Wearable "smart device" use has become increasingly popular with consumers, both domestically and globally. More than two-thirds of the U.S. population use smartphones or other smart devices, including minorities and older adults (1–3). This places mobile health (mHealth), wearable devices, smartphones, and applications in a special position to affect a wide audience. Companies such as Apple, Fitbit, Huawei, and Samsung, among many others, have developed mobile technologies such as smartwatches and mHealth apps that have evolved from heart rate to arrhythmia detection and are now widely available for consumer purchase. Prevalent mobile smart device availability and use offer unique platforms to detect rare and intermittent arrhythmias noninvasively over extended time periods or on demand using consumer rather than prescribed medical devices. Although the enthusiasm to adopt wearable and smart devices has exceeded the paucity of data demonstrating clinical benefit, a small body of research investigating their use in screening, early detection, and management of cardiac arrhythmias is rapidly expanding.

In this issue of *JACC: Case Reports*, Walsh and Lin (4) present the case of a 54-year-old woman with exertional intolerance and dyspnea presenting for evaluation of bradycardia after discovering a decrease in her heart rate as monitored on a Fitbit fitness tracker (Fitbit, San Francisco, California). This initial finding led to electrocardiographic (ECG) evidence of 2:1 atrioventricular block and prompted a battery of subsequent diagnostic tests, which ultimately led to the diagnosis and treatment of pulmonary and cardiac sarcoidosis. This case highlights the utility of a widely available consumer heart rate-monitoring technology as an initial screening tool for arrhythmias, but the investigators smartly point out that numerous ensuing diagnostic tests and multidisciplinary management were necessary to confirm the final diagnosis.

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This case is one of a growing number of reports of wearable smart devices aiding the early diagnosis of potentially life-threatening arrhythmias. In one report, a patient with palpitations and syncope was wearing an Apple Watch (Apple, Cupertino, California), which recorded an episode of ventricular tachycardia (5). In another report, heart rate information on a patient's Fitbit fitness tracker recorded the time of onset of atrial fibrillation (AF), which expedited cardioversion (6). Atrioventricular block after transcatheter aortic valve replacement has been detected by mHealth devices, prompting clinical evaluation and therapy (7).

Although these reports highlight applications of wearable devices to facilitate clinical evaluation, several recent large studies have examined the role of these devices in the early detection of arrhythmias in subclinical populations. The recently published Apple Heart Study studied the potential of the now U.S.

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Food and Drug Administration–approved Apple Watch to detect AF and atrial flutter and to return irregular rhythm results by app and telemedicine approaches (8). Subjects with self-reported existing AF or anticoagulant agent use were excluded. Subjects with urgent symptoms were instructed to seek emergency care, while those with stable symptoms were mailed an ECG patch to wear for up to 7 days. Among 419,297 subjects, irregular pulse notifications were delivered to 0.52%. Among subjects who received irregular pulse notifications, 20.8% returned ECG patches, and 34% of the returned patches yielded diagnoses of AF in 0.04% of enrolled subjects. The positive predictive value was 0.84 (95% confidence interval: 0.76 to 0.92) for receiving an irregular pulse notification and observing AF by electrocardiography.

The KardiaMobile device by AliveCor (Mountain View, California) was the first consumer mHealth device approved by the Food and Drug Administration for detection of tachyarrhythmia and bradyarrhythmia (9). KardiaMobile is a smartphone-based ECG event monitor that requires users to actively trigger recordings by placing fingers on an app-paired, portable electrode. The generated ECG rhythm strip can be sent securely to a physician for review. This device relies on user recognition of arrhythmia symptoms and initiation of ECG recordings. Nonetheless, the KardiaMobile technology allows ECG documentation of fleeting arrhythmias and may decrease time to arrhythmia diagnosis.

The Huawei Heart Study examined wearable technology (Huawei Watch GT, Honor Watch, and Honor Band 4, Huawei, Shenzhen, China) to screen for AF in 187,912 subjects in China (10). Subjects who screened positive were provided with clinical evaluation and confirmation of AF via electrocardiography or a 24-h Holter monitor. Of the 187,912 participants who used smart devices to monitor their heart rates, 0.23% participants screened positive for irregular heart rates. Of those who screened positive, 61% followed up, and 87% of participants who followed up ($n = 227$) were confirmed to have AF on electrocardiography or 24-h Holter monitoring, yielding a diagnosis of AF in 0.12% of all enrolled subjects.

Although the aforementioned case reports and large-scale studies demonstrate roles for rapidly developing mobile technology in arrhythmia detection and clinical evaluation, numerous questions arise for how physicians, providers, and health care systems will best implement these evolving technologies to optimize patient and consumer health outcomes. Will "app fatigue," as observed by high study dropout rates, limit utility? Does earlier arrhythmia detection prompt interventions that improve outcomes or more complications, anxiety, and costs? Arrhythmia and AF prevalence vary with age and cardiovascular health: will wearable mHealth devices be applied broadly, or will downstream clinical evaluation and benefit vary by population-specific prevalence and risk? Of note, the mean ages in the Apple and Huawei studies, 41 and 36 years, respectively, represent a different age profile than that of populations with clinically manifest incident and prevalent AF (8,10,11). What are the comparative and reproducible precision and accuracy of various wearable monitors and algorithms (12)? Will consumer monitors lead to increased heightened cardiac awareness that paradoxically reduces quality of life and increases health care consumption (13)? Will false-positive overnotification lead to "alarm fatigue," as described for in-hospital sudden cardiac arrests despite telemetry (14)? What are the liability implications of false-negative or discrepant results associated with adverse events? What information technology, infrastructure, personnel, and telemedicine enhancements are needed to respond to increased alert volume and best deliver results to streamline subsequent care? How will already taxed health systems with restricted resources finance downstream work flows to adapt to these technologies? How will private patient and consumer data be secured in light of security concerns of "big data" technology companies?

As wearable and mHealth technologies undergo explosive growth, so too will the need for rigorous validation and innovative implementation strategies. Although the clinical accuracy of such detection algorithms is promising, the clinical benefit of arrhythmia screening remains uncertain. The opportunities to improve health on a larger scale will require collaboration by multiple stakeholders to navigate this uncharted but exciting era integrating digital health and clinical medicine to improve the lives of patients, as demonstrated by this case, and the health of consumers.

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