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# Wearable cardiac monitors: Where do we stand?

**O**H, HOW TIME FLIES! When I started my postgraduate training a decade ago, evaluation of (most) patients with palpitations was simple: history, physical examination, and a 48-hour Holter monitor. In those days, affordable consumer-grade cardiac monitors were based solely on photoplethysmography (PPG, akin to pulse oximetry), which in its early form rarely offered actionable diagnostic information for an electrophysiologist. Instead, a clinical-grade Holter monitor was needed. Holter monitors and the related event monitors were conceptualized in the late 1940s<sup>1</sup> and commercialized in the early 1960s, but their fundamental design, management, and interpretation has changed very little over time. While not always practical for the patient, the devices represented a tried-and-true diagnostic tool for most clinicians.

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Over the past decade, marked improvement in both the quality and affordability of consumer-grade wearable monitors has changed the game completely—especially after many products acquired the ability to record single-lead electrocardiogram (ECG) tracings. This is most apparent in the outpatient electrophysiology clinic, where patients routinely hand me their phones and ask me to scroll through their ECG logs. I do this gladly, and not just to humor them. The home ECG data are incredibly helpful! Countless times, these tracings have directly affected patient management.

While Holter and event monitors continue to play a major role in patient care, the consumer-grade cardiac monitors are becoming just as important, and their value, reliability, and ubiquity will only grow. Regardless of one's technological savvy, any practicing clinician should be familiar with the most frequently used wear-

able cardiac monitors and, importantly, with the clinical evidence that supports or challenges their utility.

In this issue of the *Journal*, Mohamoud et al<sup>2</sup> provide a helpful and succinct review of the most up-to-date clinical information behind consumer-grade wearable monitors. They make it clear that the bulk of research efforts so far have focused on proving the utility of PPG-based devices as population-wide screening tools for atrial fibrillation. The 2 largest studies—the Apple Heart Study<sup>3</sup> and the Fitbit Heart Study<sup>4</sup>—together enrolled almost 1 million patients and proved that wearable monitors do indeed perform well as screening tools for atrial fibrillation.

While such information is crucial for future research efforts, it has little direct impact on the day-to-day practice of most clinicians. Indeed, Mohamoud et al<sup>2</sup> show that some nuanced but clinically crucial questions have barely been addressed. From the vantage point of a clinical electrophysiologist, I am interested in consideration of 3 dilemmas, discussed below.

## ■ DO WEARABLE CARDIAC MONITORS TRANSLATE TO STROKE PREVENTION?

The idea is simple: patients self-detect incidental atrial fibrillation on wearable cardiac monitors. After confirming the diagnosis, a physician prescribes therapeutic anticoagulation to appropriate patients (eg, after risk-stratification using the CHA<sub>2</sub>DS<sub>2</sub>-VASc<sup>5</sup> model or similar) and prevents cardioembolic events.

But we know that things are rarely so simple. For example, when patients with permanent pacemakers experience asymptomatic episodes of atrial fibrillation, their risk of stroke is indeed higher than that of the general population, but it is considerably lower than that predicted by the CHA<sub>2</sub>DS<sub>2</sub>-VASc model.<sup>6</sup> It is easy to imagine that if we extend the atrial fibrillation screening process to an even healthier population (ie,

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anyone in the general public wearing a consumer-grade monitor), the applicability of existing risk-stratification paradigms may decline even more.

In practical terms, should we start therapeutic anticoagulation in every 66-year-old man with hypertension (CHA<sub>2</sub>DS<sub>2</sub>-VASc score of 2) who walks into our office and shows us an Apple watch tracing with 15 minutes of atrial fibrillation? Additional studies are needed to address this question.

### ■ WHAT IS THE ROLE OF WEARABLE CARDIAC MONITORS FOR OTHER INDICATIONS?

As shown by Mohamoud and colleagues, most evidence for wearable monitors circles around de novo screening for atrial fibrillation. Relatively less is known about using these devices to manage patients with known atrial fibrillation. In our practice, we often ask patients to send us KardiaMobile ECG tracings once a week (or whenever the patient is symptomatic) for 3 months after undergoing catheter ablation. This approach makes intuitive sense and, in our experience, has been very effective in identifying early recurrences of atrial fibrillation. But it has never been formally studied.

The utility of cardiac wearables in the diagnosis and management of suspected short-duration arrhythmias is also unknown. Patients with symptoms caused by cardiac ectopy are often managed based on the absolute burden of premature beats. Will wearable devices help with that? What about patients with syncope? Will PPG-based wearable devices ever be able to provide sufficiently granular diagnostic information, or will clinical-grade ECG Holter devices always be necessary?

### ■ CAN WE STREAMLINE CLINICAL INTERPRETATION?

As noted, in our electrophysiology practice, established patients with arrhythmias occasionally ask to have their home device ECG tracings reviewed by a physician. Patients who require frequent ECG monitoring may also subscribe to a service that enables them to send their KardiaMobile ECG tracings directly to our device clinic, where a team of nurses and technicians

can quickly review the information. This helps ensure prompt diagnosis of arrhythmias (if present), and it improves patient satisfaction and provides reassurance. In some cases, this ECG review precludes an unnecessary office or emergency room visit. Today, the volume of such information exchange is manageable, but as more patients purchase home monitors, the availability and affordability of review services may become limited unless systemic change is implemented.

The problem of scaling is even more evident when we consider population-wide screening using consumer-grade cardiac monitors. Most wearable devices provide automatic detection of atrial fibrillation, but its clinical verification remains manual. Even if we accept the high precision of the automated diagnosis of atrial fibrillation (a positive predictive value near 98% in the FitBit Heart Study<sup>4</sup>), most clinicians would be reluctant to treat new patients based only on what their home monitor app reports. Instead, physicians typically review the primary device data manually or reassess the patient with a Holter monitor or both before moving to treatment. In some cases, this may result in a specialty (cardiology) or subspecialty (electrophysiology) referral. Like the subscription services we provide in our practice, this process may be sustainable now, but increased numbers of self-screened individuals might require a more streamlined approach. What this would look like remains to be seen, but the possibilities include workforce extension (more ECG technicians in hospital and industry) and technology so precise that manual confirmation will be unnecessary.

### ■ CLOSING THOUGHTS

Technological advances have enabled us to reimagine the diagnosis and management of cardiac arrhythmias, especially atrial fibrillation. Judicious application of these enhanced tools will require continued analysis of their potential, as well as how to manage the data they generate. ■

### ■ DISCLOSURES

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