Wearable Technologies in Cardiology: Current Evidence and Future Perspective

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In recent years, we have witnessed that digital health provided tools which changed, for some revolutionized, the medicine using conventional methods for screening, diagnosing and treating diseases. Wearable health technologies are important step for the digitalization of healthcare system which shifted the healthcare from physician-directed to consumer-directed. The market is rapidly growing and expected to exceed $34 billion by 2020 (1). Strikingly, one in six individuals in the United States is already bearing wearable technology including smartwatches and fitness trackers (2). In cardiology, these devices have involved in mainly tracking daily activities, monitoring heart rate and rhythm and measuring thoracic impedance and thoracic fluid. Although the rise of consumer-directed wearable health technologies hold potential promises for improving healthcare, little evidence is present up-to-date to support their widespread use in clinical practice. In the present review, we highlighted the current evidence for adopting wearable technologies in monitoring heart rhythm, intervening and tracking lifestyle habits and evaluating hemodynamic status.

Wearable technologies for monitoring heart rhythm

Majority of patients with cardiac rhythm disturbances have symptoms of short duration and some are entirely asymptomatic (3). In most of the cases evident arrhythmia could not be detected with conventional rhythm monitoring methods including the 12-lead surface electrocardiogram (ECG) and 24-h Holter device. Implantable loop recorder (ILR) is an alternative but it is expensive, requires invasive procedure to be implanted and does not provide real-time feedback to the patient. Although most arrhythmias often are not associated with adverse outcomes, 20% of patients who present with ischemic stroke are found to have priorly undetected atrial fibrillation (AF) (4). Thus, during recent years wearable devices had the major objective of detecting paroxysmal AF to allow initiating appropriate therapy and precluding ischemic stroke and other adverse outcomes. Most devices monitor heart rate by using photophletysmography (PPG), an optical volumetric assessment of blood volume changes in microvasculature. The major limitation of PPG-based device algorithms is the inability to provide electrocardiographic data; therefore, leading to the limited accuracy and presence of noise particularly during exercise. First prototype for wearable devices allowed monitoring heart rhythm only a brief period of time (usually symptom-directed initiation) which limits their diagnostic accuracy and prevents quantitative assessment of AF. Recent modifications and advances in technology enable continuous monitoring of heart rhythm through smartwatches such as Apple Watch (Apple inc, CA, US) and Kardia Band (AliveCor, Mountain View, CA, US). The Apple Watch Study was presented during the American College of Cardiology 68th Annual Scientific Sessions in New Orleans and revealed that Apple Watch identified irregular pulse rhythm in 0.5% among 419 297 US residents with a positive predictive value of 84%. Although the concept is encouraging, the risk/benefit ratio of screening relatively young and health individuals for AF is unknown. In addition, the benefit of anticoagulation in patients with asymptomatic AF episodes is yet to be proven.

Previous studies with implantable cardiac devices demonstrated that AF episodes >5.5h in a given day or >24h duration increased the risk of thromboembolic risk, whereas short duration of AF episodes did not (5, 6). Continuous rhythm monitoring by using smartwatches provides physicians to opportunity for quantitative assessment of AF. In their study Wasserlauf et al. showed that compared with insertable cardiac monitor, Kardio Band detected AF episodes and durations with a sensitivity of

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97.5% and 97.7 respectively (7). It is certain that in near future wearable devices including smartwatches, shirts and earrings will likely to be adopted widely by otherwise healthy individuals. Challenges remain to be solved, as there are still gaps on handling massive amount of data produced by devices, creating a potential health obsession and ensuring health policies for individual's data safety.

Monitoring daily activities

Obesity and inactivity are considered as the plague of our time and according to one report prevalence of obesity is more than 50% in some countries from Oceania, North Africa and the Middle East (8). Inactive individuals are more likely to have cardiovascular diseases (CVD) during lifetime and applying appropriate lifestyle interventions by promoting increased daily activities resulted in health benefits (9). The major barrier on adopting a healthy lifestyle is reported to be adherence in long-term. It is unfortunate that although 4 out of 5 patients with previous CVD state that they understand the importance of exercise, only 39% of them adhere to the structured exercise program (10).

Wearable devices including smartwatches and wristbands that are used for self-monitoring offer a unique opportunity for promoting exercise by tracking daily steps, setting reminder and goal for activities, enhancing gamification by using social media and mobile apps, organizing exercise program and even providing guidance for daily exercises by virtual fitness trainers. A meta-analysis of randomized clinical trials in patients with type 2 diabetes showed that pedometer use increased daily steps by 1822 per day (11). In contradiction, IDEA trial found no additional benefit of wearable devices on top of behavioral interventions regarding the weight loss at 24 months among otherwise healthy young adults (12). Before adopting daily trackers in clinical practice, several issues need to be addressed including validation in both healthy and sick population, tools to enhance adherence, data safety and most importantly defining and validating individualized activity and dietary goals.

Monitoring hemodynamic status

Patients with congestive heart failure (CHF) often present to the emergency departments or outpatient clinics with acute exacerbation of heart failure (HF) symptoms which are demonstrated to be an indicator for adverse events during long-term. Before the emergence of symptoms, many patients have the phase that is characterized by increased ventricular and pulmonary filling pressures whose identification could lead modifying HF medications which in turn could reduce HF hospitalization, healthcare costs and improve adverse outcomes.

Wearable hemodynamic monitors emerged to measure bioimpedance and remote dielectric sensing (ReDS) to notice healthcare givers and HF patients for pre-clinical changes in volume status.

Wearable bioimpedance monitors analyze transthoracic impedance (TTI) which is found to have a reasonable correlation with intrathoracic impedance (ITI). As the level of intrathoracic fluid increases, ITI drops and changes in ITI was shown to be preceding acute decompensation. Clinical studies showed contradictory results for the value of bioimpedance monitoring in detection of early signs of acute decompensation and optimization of HF treatments (13). The major challenge before the adoptation of bioimpedance monitors in clinical practice is the lack of specificity since several non-cardiac conditions could potentially cause changes in thoracic impedance and interfere with the analysis of intrathoracic fluid status. Therefore, to date most bioimpedance monitoring devices remain limited to patients with cardiac implantable electronic devices.

ReDS is the technology that non-invasively analyzes pulmonary fluid concentration by using electromagnetic energy. Studies demonstrated a good correlation with devices using ReDS and Chest CT in the quantification of pulmonary congestion (14). In patients who were recently hospitalized for acute HF decompensation, ReDS -guided HF treatment after discharge reduced the readmission rates (15). Ongoing randomized clinical trials will further help physician how to best use this technology in this population.

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