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Mini Review

The place of digital devices and artificial intelligence in cardiac arrhythmia management: new advances, practical guides, and promising prospects.

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Summary

Developing digital devices and remote technologies for the diagnosis and management of arrhythmias are revolutionizing cardiologist clinical practice and decision-making. Electrocardiogram (ECG) and plethysmography (PPG)-based devices are widely used to assess cardiac rhythm. Artificial intelligence (AI) enabled devices may contribute to early detection and monitoring of atrial fibrillation (AF), long QT syndrome (LQTS), as well as QTc related adverse drug events. Some other devices such as contactless rhythm monitoring may be useful in ambulatory cardiac arrhythmia mass screening.

Keywords

Digital device ;Arrhythmia ;Atrial fibrillation ;Artificial intelligence ;Review.

Rapidly developing technologies and increased demand for the use of digital devices over the past decades contributed to considerable changes in arrhythmias management. A resolution of the 71st WHO World Health Assembly urged to prioritize the development and greater the use of digital technologies in health to promote health coverage and advance the sustainable development goals [1]. According to several surveys conducted with the help of Heart Rhythm Society communities, mobile smartwatch and non-smartwatch ECG devices were prescribed by 80% of cardiac electrophysiology professionals (EP). In COVID-19 pandemic era, the use of video-telehealth increased 10-fold [2]. The European Heart Rhythm Association (EHRA) published a recent practical user guide for digital cardiologic technologies. PPG and ECG-based devices were introduced for the screening of Atrial fibrillation (AF) and ventricular tachycardia (VT)[3]. The available data on digital devices including smartwatches, ECG patches, chest straps, mHealth and smartphones applications contributed considerably to the assessment of cardiac rhythm abnormalities. These devices may be ECG-based or non-ECG based. The choice depends on the duration of the symptomatic episodes. Up to date, the 12-lead ECG is the gold standard for the diagnosis of arrhythmias. However, ECG- or PPG-based device can be useful if 12-lead ECG is not available. Holter ECG is recommended for recurrent arrhythmia episodes. ECG-patch in turn-weekly or monthly and implantable loop recorder (ILR) may be of great aid in such clinical situations. PPG recordings may be of low sensitivity in the assessment short arrhythmias and are still used to document normal rhythm and normal heart rate [3]. Diagnostic confirmation needs always a 12-lead ECG or an ECG-based device. Around 37.5 AF cases are diagnosed around the world. An increase of 33% over the last 20 years was observed. The prevalence may double in Europe by 2060 [4]. Up to 50 TO 87% of AF patients are initially asymptomatic [5]. Early detection of AF allows to initiate AF management in the appropriate moments. This may reduce the mortality related to several associated cardiovascular syndrome [6]. Digital devices may contribute to stroke risk assessment of, symptoms-rhythm correlation, and management of concomitant risk factors. This offers a multifunctional management approach for these patients.

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However, it should be noted that both PPG-based and single-lead ECG devices may be of low diagnostic sensitivity in regular tachyarrhythmias. Systematic screening for AF in high cardiovascular risk population may reduce stroke incidence [7]. AF is seen in almost 10% of the patients of more than 80 years old. Systematic screening approach should be implemented also for patients with past stroke history and in case of multiple associated comorbidity factors. Wearable devices can be considered first in these cases [8]. New mHealth approach provides an effective implementation of digital technologies allowing wait-and-see strategy during peri-cardioversion [9]. The management of recent AF require immediate restoration of sinus rhythm by pharmacologic or electrical cardioversion. However, the results of rate control versus acute cardioversion (trial-7 ACWAS) study showed that spontaneous resolution of recent-onset AF may be obtained in more than 90% of cases in delayed cardioversion group which makes the Wait and see strategy and objective alternative. This does not apply to patients in whom the duration of atrial fibrillation is unknown. Regardless of whether a rate or rhythm control strategy is selected, the patient's risk for stroke needs always to be estimated and anticoagulation initiated, if appropriate [10]. According to the iHEART study, the use of mHealth improved the detection recurrent atrial arrhythmias after AF ablation [11]. Pilot study showed that using smartphone ECG with a cloud-based platform for three months following AF ablation is non inferior to the standard monitoring plan [12].

AI-enabled mECG device are effective alternative to ECG-based screening of several other kinds of arrhythmia such as LQTS. With this monitoring techniques, QTc values are almost equal to those obtained from a standard 12-lead ECG [13]. QTc monitoring is useful to prevent QTc-related adverse drug events. QTc prolonging drugs account for 3% of prescriptions worldwide and the number of patients undergoing multiple QTc-prolonging treatments is rapidly increasing [14]. Moreover, some individuals have potentially proarrhythmic common genetic variants associated with 8-fold increased risk of drug-induced LQTS/ torsade de pointe (TdP) (p.Asp85Asn-KCNE1 variant is present in 1% European origin individuals and has p.Ser1103Tyr-SCN5A in up to 8% of African individuals)[15]. The future of QTc monitoring is 6-lead ECG device that was approved for measurement of QTc intervals [16] and AI-enabled mECG device with AI-deep neural network (DNN) that detects QTc values ≥500 ms and predicts accurately the QTc of a standard 12-lead ECG [16,17]. According to the available data, the rate of dropout using health technology is about 44%. The systematic review of 33 studies showed that the most frequent reasons for dropout included technical malfunction and difficulties in the convenience and accessibility. Most of the enrolled patients preferred standard tools and did not trust the new alternatives [18]. Other barriers to the implementation of AI-enabled devices were the cost and insurance reimbursement issues. Personalization and demonstrating flexibility, as well as clarity of delivered message may facilitate the implementation of intelligent remote measurement technologies.

perspectives of digital technology are contactless rhythm monitoring for the assessment of sudden cardiac arrest risk and mass AF screening on ambulatory basis.

Video plethysmography correlates with contact PPG . The first study demonstrated the feasibility of AF detection with a high accuracy in a group of patients with a single camera [19]. Moreover, there is technology for accurate detecting cardiac arrest through identifying cardiac arrest-associated agonal breathing instances using commodity smart devices [20].

Key takeaways

- **The implementation of new technologies specially AI-enabled devices determines rapid improvement of the algorithms of automated interpretations of single-lead ECG and PPG.**
- **AI-enabled mECG device–based QTc monitoring, contactless rhythm monitoring for mass AF screening and assessment of sudden cardiac arrest risk are nowadays real eHealth perspectives.**
- **Early detection of AF using digital devices allows early non-invasive management.**
- **For successful implementation of telecare technologies , raising digital health literacy among patients is crucial.**
- **Clarifications on legal aspects regarding the collection or processing of personal data is required for smooth digital health implementation.**
- **Implementing low-cost screening PPG Apps followed by confirmation with patch ECGs might balance the cost/effectiveness scheme for these new devices .**

Conflict of interest: none

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