Mobile Health for Cardiovascular Disease: The New Frontier for AF Management: Observations from the Huawei Heart Study and mAFA-II Randomised Trial

Yutao Guo[1] and Gregory YH Lip[1,2,3]

1. Medical School of Chinese PLA, Department of Cardiology, Chinese PLA General Hospital, Beijing, China; 2. Liverpool Centre for Cardiovascular Sciences, University of Liverpool and Liverpool Heart and Chest Hospital, Liverpool, UK; 3. Aalborg Thrombosis Research Unit, Department of Clinical Medicine, Aalborg University, Aalborg, Denmark

Disclosures: The authors have no conflicts of interest to declare.
Received: 27 March 2020 **Accepted:** 27 March 2020 **Citation:** *Arrhythmia & Electrophysiology Review* 2020;9(1):5–7.
DOI: https://doi.org/10.15420/aer.2020.12
Correspondence: Gregory YH Lip, Liverpool Centre for Cardiovascular Science, William Henry Duncan Building, 6 West Derby St, Liverpool L7 8TX, UK. E: gregory.lip@liverpool.ac.uk

Cardiovascular disease (CVD) is the leading cause of death and disease globally, representing 31% of all global deaths.[1] The traditional management of CVD has largely depended on the face-to-face clinic visits once the clinical events occurred. CVD contributes to and exacerbates the economic burden on households.[2] However, most of these complications could be avoided with early diagnosis and effective prevention or interventions.

With increasing advances in mobile health (mHealth), smart technology is emerging as a novel tool to improve disease prevention and management. Some exploring studies demonstrated that the alerts or text message intervention using mHealth technology might help patients in implementing changes in lifestyle behaviours or drug adherence.[3] However, there are many gaps in knowledge when considering mHealth for CVD management.[3,4] For example, how could wearable sensors (mobile devices) be used to improve healthcare, beside using the communication function (mobile phone) of mHealth technologies? Would mHealth-supported approaches impact on important CVD outcomes, including hospitalisations?

The Mobile Health technology for improved screening and optimising integrated care in Atrial Fibrillation (the mAFA-II programme) provides some new evidence for this.[5] The mAFA II programme included the pre-mAFA phase to investigate the incidence of AF with photoplethysmography (PPG)-based screening strategy among the general population, using Huawei smart devices (hence, called the Huawei Heart Study); and the AFA II trial, which was used to validate a holistic or integrated care approach, the Atrial Fibrillation Better Care pathway (ABC) pathway, supported by mHealth technology for the management of AF.

The ABC (AF Better Care) Pathway simplifies the management of AF, as follows ('easy as ABC…'):

- 'A' Anticoagulation to avoid stroke – anticoagulation with non-vitamin K antagonist oral anticoagulant or well-managed warfarin.
- 'B' Better symptom management with patient-centred symptom-directed shared decisions for rate or rhythm control.
- 'C' Cardiovascular risk and comorbidity management (blood pressure, sleep apnoea etc) plus lifestyle changes (weight reduction, regular exercise, reducing alcohol/stimulants, psychological morbidity, smoking cessation etc).[6,7]

AF Screening Using Smart Technology

The predictive ability of AF screening using smart technology would be influenced by several factors: monitoring technology PPG, single-lead ECG, the frequency of monitoring (single-point or twice a day etc), monitoring duration (7 days, 14 days etc), the type of smart devices (smart bands, ePatch or hand-held devices) and the patient population with different risk profiles. For a single-lead ECG-based approach to detect AF detection, there could also be the instability of signal quality of the wristband due to motion artefacts.[8,9] A lower AF burden requires a longer monitoring time.

Two large population-based smartwear studies have been published. In the Apple Heart Study: Assessment of Wristwatch-Based Photoplethysmography to Identify Cardiac Arrhythmias; (NCT03335800), 419,297 participants using Apple Watch were recruited over 8 months, and 0.52% received notifications of irregular pulse: AF was present in 34% and 84% of notifications were concordant with AF.[10] In the Huawei Heart Study, a PPG algorithm and smart devices used were validated with a total of 29,485 PPG signals before starting the mAFA II programme.[11,12] Both the pilot study and the Huawei Heart Study demonstrated a consistent predictive ability for AF of >91% with continuous monitoring mode in a real-world setting.[12,13] In the study, about one-third of AF episodes were detected over 14 days. However, the comfort factor of monitoring should be balanced with the monitoring time and type of smart device(s) used. Nearly one-third of subjects refused to use the ECG skin adhesive patch for 14-day monitoring, and some individuals reported skin irritation, resulting in early discontinuation of structured management in one study.[14] Even with a PPG technology-based wristband, more frequent monitoring

might contribute to much higher predictive ability. For example, the positive predictive value of detecting AF was 91.6% in the Huawei Heart Study with periodic measurements every 10 minutes on baseline, compared with 71.3% in the Apple Heart Study with periodic measurements every 2 hours.[13,15]

In the Huawei Heart Study, there were 0.23% of subjects with suspected AF using smart devices in the general population, with the highest proportion of AF episodes among the elderly, i.e. those aged over 65 years, with a prevalence of 2.78%.[13] This leads to more questions, for example, whether AF screening should be a population-wide approach, with associated logistic and cost issues, or should be targeted screening of patients at high risk of developing AF or those where greater efforts should be directed towards AF detection (for example, post stroke). Not only did the Huawei Heart Study demonstrate that AF screening with wearable devices was feasible, but also that the detected patients could be entered into an integrated care AF pathway to facilitate AF management. Thus, 95% of those with identified AF from the general population entered into ABC pathway management using a mobile Atrial Fibrillation Application (mAFA), and consequently 80% of high-risk patients were anticoagulated.[13]

mHealth-supported AF Integrated Care and CVD Outcomes

Subjects with identified AF were considered for entry into the mAFA-II clinical trial. The mAFA-II programme included an investigation of mHealth-supported AF management, and its impact on the composite of stroke/thromboembolism, all-cause death and rehospitalisation.[5]

Using a prospective cluster randomised trial design, the mAFA-II trial randomised AF patients to a mAFA intervention arm and usual care arm. In the mAFA intervention group, doctors used the mAFA platform to manage AF patients, providing clinical decision support tools, educational materials and patient involvement strategies with self-care protocols and structured follow-up to support implementation of the ABC pathway for AF patients.[7,16] The trial showed that an integrated care approach with mAFA intervention (easy as ABC…), supported by mobile health technology, significantly reduced the risks of rehospitalisation and the composite of stroke/thromboembolism, all-cause death and rehospitalisation care (1.9% versus usual care, 6.0%; HR 0.39; 95% CI [0.22–0.67]; p<0.001).[17] Rates of rehospitalisation were also lower with the mAFA intervention (1.2% versus 4.5%; HR 0.32; 95% CI [0.17–0.60]; p<0.001).

The mAFA programme is the first integrated programme that links AF screening with eligible patients subsequently entered into a structured care pathway with mHealth technologies, highlighting the potential application of mHealth bridging primary care to secondary care management, as well as patient empowerment.

Integrated Care for CVD: The New Frontier

Other integrated care approaches for AF management have included nurse-led integrated care, a post-discharge integrated care of home visits and 7- to 14-day Holter monitoring and AF care focused on optimising anticoagulation with trained nurses in primary care.[18–20]

There are growing challenges and opportunities on how best to apply mHealth technology into CVD prevention and management, for example how these novel technologies could be used to improve the quality of care without driving up costs and how mHealth technology could be applied into special populations, for example, in the management of the elderly, those with multimorbidity etc. Indeed, we need to know the advantages of smart technology in streamlining clinical management pathways, not only through better real-time communications but also with data-driven intelligent management.

We have no doubt that current smart devices will increasingly improve their specifications over time, providing better-quality signals and diagnostics, long battery life and improved capability for clinical settings. These would need to be balanced against management of comorbidities, costs and clinical setting. Using PPG-based heart rate and physical activity levels, artificial intelligence and machine learning can potentially be explored to diagnose AF without recoring and documenting an ECG.[21] Although there are some limitations (positive predictive value for AF episodes of 39.9%, detected AF ≥1 hour etc) in the current stage, this study highlights the potential use of artificial intelligence and smart devices in predicting the risk for subsequent AF.

Nevertheless, decision-making on holistic clinical care cannot be based on only what a smart device says. Physician-patient interactions remain central to optimal clinical management, hence our challenge is to streamline the patient pathway that bridges primary and secondary care, cardiologists and non-cardiologists, and – of course – the patient. In the case of AF, patients would present to general practitioners (often asymptomatically in the setting of a health check), hospital practitioners who may be non-cardiologists (emergency room, internal medicine, stroke wards, surgeons) and cardiologists (who may or may not be arrhythmia specialists). Ultimately, the patient may get different messages on their management from all these healthcare professionals they encounter, given the perception that AF management is difficult and complex. Using the ABC pathway above, AF management can be as 'easy as ABC…' and, even more so, supplemented by mHealth technology. ■

1. WHO. Cardiovascular diseases (CVDs). Key facts. 2017. https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds) (accessed 3 April 2020).
2. Murphy A, Palafox B, Walli-Attaei M, et al. The household economic burden of non-communicable diseases in 18 countries. *BMJ Glob Health* 2020;5:e002040. https://doi.org/10.1136/bmjgh-2019-002040; PMID: 32133191.
3. Burke LE, Ma J, Azar KM, et al. Current science on consumer use of mobile health for cardiovascular disease prevention: a scientific statement from the American Heart Association. *Circulation* 2015;132:1157–213. https://doi.org/10.1161/CIR.0000000000000232; PMID: 26271892.
4. Cowie MR, Bax J, Bruining N, et al. e-Health: a position statement of the European Society of Cardiology. *Eur Heart J* 2016;37:63–6. https://doi.org/10.1093/eurheartj/ehv416; PMID: 26303835.
5. Guo Y, Lane DA, Wang L, et al. Mobile Health (mHealth) technology for improved screening, patient involvement and optimising integrated care in atrial fibrillation: the mAFA (mAF-App) II randomised trial. *Int J Clin Pract* 2019;73:e13352. https://doi.org/10.1111/ijcp.13352; PMID: 31002434.
6. Lip GYH. The ABC pathway: an integrated approach to improve AF management. *Nat Rev Cardiol* 2017;14:627–8. https://doi.org/10.1038/nrcardio.2017.153; PMID: 28960189.
7. Lip GYH, Banerjee A, Boriani G, et al. Antithrombotic therapy for atrial fibrillation: CHEST guideline and expert panel report. *Chest* 2018;154:1121–201. https://doi.org/10.1016/j.chest.2018.07.040; PMID: 30144419.
8. Bumgarner JM, Lambert CT, Hussein AA, et al. Smartwatch algorithm for automated detection of atrial fibrillation. *J Am Coll Cardiol* 2018;71:2381–8. https://doi.org/10.1016/j.jacc.2018.03.003; PMID: 29535065.
9. Tison GH, Sanchez JM, Ballinger B, et al. Passive detection of atrial fibrillation using a commercially available smartwatch. *JAMA Cardiol* 2018;3:409–16. https://doi.org/10.1001/jamacardio.2018.0136; PMID: 29562087.
10. Perez MV, Mahaffey KW, Hedlin H, et al. Large-scale assessment of a smartwatch to identify atrial fibrillation. *N Engl J Med* 2019;381:1909–17. https://doi.org/10.1056/NEJMoa1901183; PMID: 31722151.
11. Fan YY, Li YG, Li J, et al. Diagnostic performance of a smart device with photoplethysmography technology for atrial fibrillation detection: pilot study (Pre-mAFA II Registry). *JMIR Mhealth Uhealth* 2019;7:e11437. https://doi.org/10.2196/11437; PMID: 30835243.
12. Zhang H, Zhang J, Li HB, et al. Validation of single centre pre-mobile atrial fibrillation apps for continuous monitoring of atrial fibrillation in a real-world setting: pilot cohort study. *J Med Internet Res* 2019;21:e14909. https://doi.org/10.2196/14909; PMID: 31793887.
13. Guo Y, Wang H, Zhang H et al. Mobile photoplethysmographic technology to detect atrial fibrillation. *J Am Coll Cardiol* 2019;74:2365–75. https://doi.org/10.1016/j.jacc.2019.08.019; PMID: 31487545.
14. Steinhubl SR, Waalen J, Edwards AM, et al. Effect of a home-based wearable continuous ECG monitoring patch on detection of undiagnosed atrial fibrillation: the mSToPS

randomized clinical trial. *JAMA* 2018;320:146–55. https://doi.org/10.1001/jama.2018.8102; PMID: 29998336.
15. Perez MV, Mahaffey KW, Hedlin H, et al. Large-scale assessment of a smartwatch to identify atrial fibrillation. *N Engl J Med* 2019;381:1909–17. https://doi.org/10.1056/NEJMoa1901183; PMID: 31722151.
16. Proietti M, Laroche C, Opolski G, et al. 'Real-world' atrial fibrillation management in Europe: observations from the 2-year follow-up of the EURObservational Research Programme-Atrial Fibrillation General Registry Pilot Phase. *Europace* 2017;19:722–33. https://doi.org/10.1093/europace/euw112; PMID: 27194538.
17. Guo Y, Lane DA, Wang L, et al. Mobile health technology to improve care for patients with atrial fibrillation. *J Am Coll Cardiol* 2020;75:1523–34. https://doi.org/10.1016/j.jacc.2020.01.052.
18. Hendriks JM, de Wit R, Crijns HJ, et al. Nurse-led care vs. usual care for patients with atrial fibrillation: results of a randomized trial of integrated chronic care vs. routine clinical care in ambulatory patients with atrial fibrillation. *Eur Heart J* 2012;33:2692–9. https://doi.org/10.1093/eurheartj/ehs071; PMID: 22453654.
19. Stewart S, Ball J, Horowitz JD, et al. Standard versus atrial fibrillation-specific management strategy (SAFETY) to reduce recurrent admission and prolong survival: pragmatic, multicentre, randomised controlled trial. *Lancet* 2015;385:775–84. https://doi.org/110.1016/S0140-6736(14)61992-9; PMID: 25467562.
20. van den Dries CJ, van Doorn S, Rutten FH, et al. Integrated management of atrial fibrillation in primary care: results of the ALL-IN cluster randomized trial. *Eur Heart J* 2020;ehaa055. https://doi.org/10.1093/eurheartj/ehaa055; PMID: 32112556; epub ahead of press.
21. Wasserlauf J, You C, Patel R, et al. Smartwatch performance for the detection and quantification of atrial fibrillation. *Circ Arrhythm Electrophysiol* 2019;12:e006834. https://doi.org/10.1161/CIRCEP.118.006834; PMID: 31113234.