Received: 22 August 2020 | Revised: 6 September 2020 | Accepted: 13 September 2020

DOI: 10.1111/jocs.15094

REVIEW ARTICLE

JOURNAL OF CARDIAC SURGERY WILEY

Digital cardiovascular care in COVID-19 pandemic: A potential alternative?

Atul Kaushik DM[1] | Surendra Patel MCh[2] | Kalika Dubey MD,[3] Senior Resident

[1]Department of Cardiology, All India Institute of Medical Sciences (AIIMS), Jodhpur, India

[2]Department of Trauma and Emergency Cardiothoracic Surgery, All India Institute of Medical Sciences (AIIMS), Jodhpur, India

[3]Department of Maternal and Reproductive Health, Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS), Lucknow, India

Correspondence
Surendra Patel, MCh, Assistant Professor, Department of CTVS, All India Institute of Medical Sciences (AIIMS), Basni Industrial Area Phase II, Jodhpur, Rajasthan 342005, India.
Email: drsurendrapatel15@yahoo.com

Abstract

Background: Cardiovascular patients are at increased risk of acquiring coronavirus disease 2019 (COVID-19) infection while their visit to healthcare facilities. There is a need for alternative tools for optimal monitoring and management of cardiovascular patients in the present pandemic situation. Digital health care may prove to be a new revolutionary tool to protect cardiovascular patients from coronavirus disease by avoiding routine visits to health care facilities that are already overwhelmed with COVID-19 patients.

Methods: To evaluate the role of digital health care in the present era of the COVID-19 pandemic, we have reviewed the published literature on digital health services providing cardiovascular care.

Results and Conclusion: Digital health including telemedicine services, robotic telemedicine carts, use of artificial intelligence and machine learning, use of digital gadgets like smartwatches and web-based applications may be a safe alternative for the management of cardiovascular patients in the present pandemic situation.

KEYWORDS
artificial intelligence, cardiovascular care, COVID-19 pandemic, digital health, telemedicine

1 | INTRODUCTION

A severe acute respiratory syndrome due to coronavirus is also known as SARS-CoV-2 or coronavirus disease 2019 (COVID-19), has been first reported from Wuhan city of China in December 2019,[1] and the World Health Organization (WHO) declared it as a global pandemic on March 11th, 2020. It has posed a great challenge for the whole world in terms of the proper allocation of health resources and providing optimal cardiovascular care. Cardiovascular patients are at increased risk of acquiring COVID-19 infection and have a higher mortality and morbidity risks. It has become increasingly important to limit the exposure of novel coronavirus to both the patients and health care workers (HCWs) in this situation of the outbreak.[2] In the present era, digital health care may prove to be a new revolutionary tool to protect cardiovascular patients from coronavirus disease by avoiding their routine visits to health care facilities that are already overwhelmed with COVID-19 patients. To evaluate the role of digital health care in the present era, we have reviewed the few published literature on digital cardiovascular care.

2 | DEFINING DIGITAL HEALTH, eHEALTH, mHEALTH, TELEMEDICINE, TELEDIAGNOSIS, AND TELEMONITORING

Digital health is defined as "the uses of digital information or data and communication technologies to collect, share, and manipulate health information to improve patient health and health care delivery."[3] The World Health Organization, defined eHealth as "the use of information and communication technology in support of health and health-related fields" and mHealth (mobile health) as "the use of mobile wireless technologies for health."[4] Successful implementation of digital health requires an integrated approach from government bodies, health care institutions, researchers, pharmaceutical and technology industries, mobile

application developers, and public awareness. Digital health includes the use of telemedicine services, robotic telemedicine carts, digital health kits, smartphones and watches, different web-based applications, and the use of artificial intelligence (AI).

Telemedicine is defined as "the remote diagnosis and treatment of patients through telecommunications technology." This is not a new term and is being used to deliver health care facility to geographically remote areas where expert doctors and health care facility is not available for the last few years. By use of telemedicine services, a virtual visit is created, the patient stays at home and consultation is being done by a consultant physician or surgeon by telephonic conversation. The patient sends all his treatment and investigation reports to the doctor by the use of mobile applications and the treating physician advises the appropriate treatment. Teleconsulting is defined as "two-way communication, which may either be real-time or offline, between HCWs, professionals, and patients regarding health care and clinical procedures." Telediagnosis is a process of remote evaluation of diagnostic tests to provide access to specialized care reducing time to diagnosis and intervention and hence avoiding known complications. Telemonitoring is remote monitoring of patients' health and clinical parameters through electronic systems managed by a health care professional.[5] In the present era of the COVID-19 pandemic, digital health systems have gained popularity globally. These systems have achieved a good level of patient satisfaction. Polinski et al.,[6] reported in their study on patient satisfaction with telehealth visits and concluded that 94%–99% of patients were very satisfied with different attributes of the telehealth visits.

3 | ROLE OF DIGITAL HEALTH IN DIFFERENT SUBSETS OF CARDIOVASCULAR DISEASES

3.1 | Preventive cardiology

Health promotion and primary prevention have special importance in cardiology as it saves health care resources by reducing specialized consultations, admissions, and complications. Digital tools may play a vital role in the prevention of primary and secondary cardiac events by smoking cessation and weight loss programs, optimizing blood pressure (BP) control, improving glycemic control in diabetics, monitoring lipids and cholesterol levels, and thus reducing both morbidity and health care burden.[7] These objectives can be easily achieved through phone calls or text messages, web-based chat applications, wearable devices and sensors, applications for drug and diet adherence, and self-care.[8,9]

3.2 | Hypertension

Hypertension can be effectively managed by the use of digital BP monitors at home and then via telemedicine consultation, the dose of antihypertensive drugs can be adjusted. Home monitoring of BP and maintaining charts can be a simple method for patient-centered care and may also eliminate "white coat hypertension." Milani et al.,[10] in their study, "Improving hypertension control and patient engagement using digital tools" reported that at 90 days, 71% of patients who used digital BP monitors instead of usual care got good control of BP. Ciemins et al.,[11] in their prospective cohort study, home BP monitoring with smartphone technology improved BP control among newly diagnosed and uncontrolled hypertensive patients. Green et al.,[12] in their randomized control trial, concluded that patients who received pharmacist care through web communications had better BP control than usual care.

3.3 | Atrial fibrillation (AF) and rhythm disorders

AF is a leading cause of stroke and may affect patients with cardiovascular comorbidities leading to thromboembolic manifestations, hence making it necessary to detect conditions like "paroxysmal" AF and "silent" AF. Traditional devices are available which can diagnose AF and other abnormal rhythms like Holter monitoring, implantable loop recorders (ILRs), and external loop recorders (ELRs), but they have distinct disadvantages of being expensive, may sometimes be invasive and cumbersome. Recent advances have led to the development of wearable devices, of note is a smartwatch that is easy to wear, a simple, noninvasive tool to detect AF. The smartwatches passively detect the abnormal rhythm using photoplethysmography (PPG) coupled with the deep neural network.[13] Chan et al.,[14] in their prospective study, found smartphone camera-based PPG to be an accurate and reliable means to detect AF with a diagnostic sensitivity of 92.9%. Turakhia et al.,[15] did an app-based study in 419,043 participants, to detect arrhythmia using smartwatches (The Apple Heart Study) and concluded that it will provide estimates of irregular pulse in a broader population. Halcox et al.,[16] performed a study on Alivecor heart monitor device which can be connected to iPod via wifi and detects AF and found it to be more effective than routine cardiac care visits. Turchioe et al.,[17] in their systemic review compared mobile applications supporting PPG waveforms, out of which 42% were found to be of above-average quality using a mobile application rating scale; however, these applications may have wide variability in terms of access, quality, and functionality. These wearables and devices can reliably detect AF and may obviate the need of visiting a clinic. These applications have enormous diagnostic potential and utility in times of mitigation and restricted travel in the current pandemic situation.

3.4 | Heart failure

Digital solutions for heart failure management may range from traditional interventions like structured telephone support to newer ones like implantable and wearable devices, thus aiding in remote patient management (RPM). The term remote patient management (RPM) includes three pillars: (1) Guideline-based therapy provided by a cardiologist, physicians, and heart failure nurses; (2) Nurse-based

training of patients at home regarding how to use devices; and (3) Telemonitoring, in which the patient daily measures vital parameters and transmits them to telemedicine care unit for further necessary intervention. Anker et al.,[18] have proposed a classification system of four generations of telemedicine care in patients with heart failure.

1. Non-reactive data collection and analysis system: In which the parameters of interest are transferred to health care providers, but in this system, the care provider cannot respond immediately and data transferred is asynchronous; one example of this is an event recorder.
2. Systems with non-immediate analytical or decision-making structure: In this system data transfer is synchronous and is received by medical staff at a telemedicine care center; however, this may lead to delay due to availability at office time only.
3. Remote patient management system: These systems provide constant analytic and decision-making facilities even after office hours.
4. Fully integrated remote management system: In this system, data from invasive and non-invasive telemedical devices are linked to a telemedical platform, making them available to be analyzed by physicians. This system is an extension of the third-generation system and because of the complexity of data and subsequent therapeutic decisions, these services need the continuous presence of a physician.

European Society of Cardiology (ESC) has made consensus recommendations on the role of telemedicine in heart failure patients and suggested that home telemonitoring may be considered for patients with heart failure to reduce the risk of frequent hospitalizations, cardiovascular complications, and death.[19] Koehler et al.,[20] performed a study "Telemedical Interventional Management in Heart Failure II (TIM-HF2)" to access the impact of telemedicine on unplanned cardiovascular hospitalization and mortality in heart failure patients and concluded that remote telemonitoring including home assessment of weight, BP, electrocardiogram, and general health has significantly reduced the proportion of days lost due to unplanned hospitalization or death. Hindricks et al.,[21] conducted a randomized control trial "Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME)," in heart failure patients having implants like dual chamber pacemaker or cardiac resynchronization therapy device (CRT-D), in which telemonitoring group was found to be more effective in managing patients with arrhythmia and heart failure. There have been advances in the development of sensor devices when implanted may alert the physician remotely and may guide for the treatment. One such device is "CardioMEMS" that was evaluated in the Champion trial, which was a multicentre, randomized study, in which transmission of pulmonary artery pressure with an implanted pressure sensor had a significant long-term benefit in lowering hospital admission rates for heart failure.[22] These novel strategies are promising in terms of reducing heart failure burden and morbidity and can be utilized in RPM when health care visits are avoided.

3.5 | Cardiovascular surgical patients

Digital health and telemedicine services can cater to cardiac surgery patients right from diagnosis to post-surgery rehabilitation. The patient's history, electrocardiogram, echocardiography, and other imaging modalities and data can be remotely assessed and diagnosis can be made by experts. Remote assessment of echocardiograms has been proven useful in triage of patients requiring cardiac surgery in rural and remote areas and predicting outcomes.[23,24] Transmission of coronary angiograms can be done from remote areas to coronary artery bypass grafting (CABG) capable centers, to triage surgical candidates and to structure an optimum plan of surgery. Critically ill ischemic heart disease patients requiring CABG can be timely referred to higher centers thus preventing mortality and complications.[25] The practical applications of remotely delivered postoperative care with the help of digital tools and devices have been studied. Smartphones, digital cameras, image transmission through video conferencing, and web-based applications can reduce and identify postsurgical complications like surgical site complications, wound infections, improper healing, and removal of sutures and wires, with timely and systemic appointment given to patients especially in the current situation. Patients who have the requirement for anticoagulation especially after valve replacement and vascular surgery, digital educational programs can be structured with an emphasis on local monitoring of anticoagulation profile and early recognition of bleeding complications. McElroy et al.,[26] performed a study on the use of digital health kits to reduce the readmission rate after cardiac surgery and concluded that readmission rate for the digital health kit (DHK) group and control group were not significantly different. This study provided evidence that postoperative cardiac surgical patients can be managed by the use of digital health or telemedicine in the present time of the COVID-19 pandemic.

3.6 | Cardiac rehabilitation

Cardiac rehabilitation after acute myocardial infarction, post percutaneous intervention, after cardiac and vascular surgeries is an important aspect, but is often ignored due to costs to attend clinics, especially in the developing world. These programs have a role in improving exercise capacity, enhancing the quality of life, and reducing morbidity and mortality in cardiac patients after events or interventions. Such programs have been affected due to the patient's fear of attending hospitals for cardiac rehabilitation. Digital health and telemedicine-based programs provide an alternative yet effective solution for patients seeking cardiac rehabilitative care. Blasco et al.,[27] in a randomized control trial, found a telemonitoring-based approach to be more effective in improving cardiovascular risk profile with significantly more patients achieving BP and glycemic control and a significantly lower body mass index in acute coronary syndrome survivors. Frederix et al.,[28] in a multicentre randomized control trial, found a telerehabilitation-based program to be more effective than a center-based program alone, in terms of physical

activity and quality of life in patients of coronary artery disease and heart failure. The results of the FIT@Home study, compared center-based and telemonitoring guided home-based cardiac rehabilitation programs, found that short-term results were similar in improving exercise capacity and quality of life.[29] The use of mobile-based applications and digital health services can improve access to cardiac rehabilitation for patients who live remotely and those living in the containment zones, where travel is regulated and restricted.

4 | USE OF AI

AI is a complex structure of various computational models which constructs programs to reproduce various human tasks.[5] AI-based technology is now increasingly been applied to cardiology in terms of being a more effective, convenient, personalized, and efficient way of delivering care to cardiac patients. It will enhance patient care at every stage, from diagnosis to selection of therapy.[30] There are five basic subtypes AI that is related to health care, and they are usually interlinked with each other's and work in a coordinated manner to achieve the best results.[31]

1. Machine learning (MI): This is the most common form of AI and it works on the principle of neural networks and deep learning mechanism.
2. Natural language processing: This includes applications such as speech recognition, text analysis, translation, and other goals related to language.
3. Rule-based expert systems: These systems work on the principle of fixed rules made by the expert in that particular field and the system responds accordingly.
4. Physical robots: Surgical robots were initially approved by the United States of America in the year 2000 and are now widely used by the surgeons by performing surgeries by small incisions (minimally invasive surgery) and performing surgery with more precision by avoiding human factors like tremors.
5. Robotic process automation (RPA): This system directly does not involves robots, it is a computer program that does administrative work.

In diagnostic and interventional radiology, deep learning algorithms are used in mammography to detect breast cancer, in computed tomography (CT) to detect gastrointestinal malignancies, in chest X-ray to detect pulmonary pathology like lung nodules, etc.[32] A study conducted at the Catholic University of Leuven, Belgium, regarding the effectiveness of AI in the diagnosis of respiratory diseases showed that AI was approximately two times as accurate as pulmonologists (82% vs. 45%) in interpreting the results of respiratory diseases.[33] In the present time of the pandemic, AI may have an important role in diagnosis, screening, contact tracing, and management. Early detection and isolation of cases of COVID-19 is a vital step to contain the spread of the disease. The most commonly used technique for diagnosis of COVID-19 is real-time reverse transcription-polymerase chain reaction (RT-PCR), but as it has a sensitivity of only 60%–70% and suspected patients with negative RT-PCR are now increasingly diagnosed by use of chest CT and X-ray imaging. AI and ML are increasingly used in CT and X-ray imaging to diagnose and screen patients with COVID-19. Ardakani et al.,[34] performed a study on the role of 10 different types of neural networks used in AI in CT scan to diagnose patient with COVID-19 and concluded that ResNet-101 has the best results with sensitivity of 100%, specificity of 99.02%, and accuracy of 99.51%, followed by Xception which has a sensitivity of 98.04%, a specificity of 100%, and accuracy of 99.02%.

5 | DIGITAL SOLUTIONS TO TRACK COVID-19 CASES

Web-based technologies are also increasingly used for contact tracing of patients infected with COVID-19. Various countries have launched different types of mobile applications for this purpose. In India, the government has launched Aarogyasetu app for contact tracing of patients with COVID-19, in which a set of the questionnaire is asked regarding any symptoms of fever, cough, or respiratory difficulty, history of travel, history of contact with COVID positive case, etc. to detect and identify suspected cases. This also notifies the number of positive patients in nearby areas and identifies "hotspots." There are similar web-based applications that have been adopted by other countries like Australia has COVIDSafe app, United Kingdom has the NHS COVID-19 app, China has conjunction with Alipay, and the Stopcovid app of France, etc.[35]

6 | BARRIERS IN THE IMPLEMENTATION OF WIDESPREAD DIGITAL HEALTH SERVICES

Although there is increasing evidence of digital health in the management of a wide spectrum of cardiovascular diseases, there is still a lack of robust and emphatic guidelines for the implementation of these tools in routine practices. The development of the digital health systems is market-driven and there are some unsettled issues of patient privacy and data protection.[36] One of the major barriers is lack of resources like electronic items, smartphones, watches, desktops, etc. for widespread use, especially in developing and underdeveloped nations with most of the population lacking basic education. The patient's belief that the care delivered through digital services is less compassionate in comparison to usual care is another drawback. The other major issue is the physician's inability to examine the patient physically with these technologies and the inability to prescribe and deliver delicate interventions and medicines.[37] The other major hindrance to the adoption of these novel health services is lack of reimbursement. Eberly et al.,[38] in their study on "Telemedicine Outpatient Cardiovascular Care during the COVID-19 Pandemic" concluded that there were certain inequalities in getting appropriate telehealthcare, especially for female, non-English

speaking, older, and poorer patients. This study highlights potential barriers for patients to avail telehealthcare facilities like a poor patient who does not have a smartphone, an elderly patient who cannot use digital gadgets properly, and language barriers for non-English speaking patients. These issues should be addressed by the concerned authorities to minimize these inequalities so that maximum benefit can be achieved by the community.

7 | LIMITATIONS OF DIGITAL HEALTH CARE IN DEVELOPING COUNTRIES

The concept of Digital health in cardiovascular care may work well in the developed countries that have a fully equipped health system using AI and various mobile-based applications for RPM in the present context of the pandemic. But, this may not work well especially in developing and underdeveloped nations due to several existing challenges and barriers. One of the main barriers is lesser public expenditure on health when compared with developed countries.[39] Low literacy rates, lack of skilled and trained staff for implementation of digital health services, unavailability of digital tools and services like mobile phones, computer systems, and internet connections in rural and remote areas make these systems function suboptimally. Lack of standardization of web-based applications, poor insurance coverage, and the absence of regulatory authorities to avoid malpractice are limiting factors that affect patients' acceptance of digital health in the developing world.[40] The current situation of the COVID-19 pandemic has enormously affected the health care systems and exposed its vulnerabilities across the globe. Wider adaptation and easy accessibility to digital health in rural and remote areas in the developing world may curtail the impact of the pandemic on health care delivery in the developing nations.

8 | FUTURE IMPLICATIONS

Digital health-based cardiovascular care has gained recognition in the last decade. The role of digital health is expanding in early diagnosis, triage, preoperative workup, managing postsurgical and interventional complications, and follow-up. However, there is still a lack of real-time application of these systems in the delivery of cardiovascular care. Digital tools can broaden the sphere of catering large population living in remote areas; however, the feasibility and application merit further research. Digital health promises to be an effective complementary service in providing adequate cardiovascular care. Development in AI and virtual clinics may replace traditional clinics and methods in the future.

9 | CONCLUSIONS

The current situation of the COVID-19 pandemic has unprecedentedly affected usual cardiovascular care; on the other hand, it has allowed digital health to streamline health care delivery. Although cardiovascular delivery through digital health has its limitations, it has surfaced as an effective alternative strategy in this time of pandemic by limiting exposure of both patients and HCWs and ensuring adequate cardiovascular care at the same time.

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

AUTHOR CONTRIBUTIONS

Kalika Dubey designed the manuscript; Surendra Patel and Atul Kaushik drafted the manuscript. Atul Kaushik, Surendra Patel, and Kalika Dubey edited the manuscript and approved the final draft of the manuscript.

ORCID

Atul Kaushik http://orcid.org/0000-0001-9842-7245
Surendra Patel http://orcid.org/0000-0003-1474-6738

REFERENCES

1. Guo YR, Cao QD, Hong ZS, et al. The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak—an update on the status. *Mil Med Res*. 2020;7(1):11.
2. Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential effects of coronaviruses on the cardiovascular system: a review. *JAMA Cardiol*. 2020;10(1):10.
3. Turakhia MP, Desai SA, Harrington RA. The outlook of digital health for cardiovascular medicine: challenges but also extraordinary opportunities. *JAMA Cardiol*. 2016;1(7):743–744. https://doi.org/10.1001/jamacardio.2016.2661
4. World Health Organization. *WHO Guideline: Recommendations on Digital Interventions for Health System Strengthening*. World Health Organization, Geneva; 2019. Licence: CC BY-NC-SA 3.0 IGO.
5. Lopes MACQ, Oliveira GMM, Ribeiro ALP, et al. Guideline of the Brazilian Society of Cardiology on Telemedicine in Cardiology—2019. *Arq Bras Cardiol*. 2019;113(5):1006–1056. https://doi.org/10.5935/abc.20190205
6. Polinski JM, Barker T, Gagliano N, Sussman A, Brennan TA, Shrank WH. Patients' satisfaction with and preference for telehealth visits. *J Gen Intern Med*. 2016;31(3):269–275. https://doi.org/10.1007/s11606-015-3489-x
7. Bashshur RL, Howell JD, Krupinski EA, Harms KM, Bashshur N, Doarn CR. The empirical foundations of telemedicine interventions in primary care. *Telemed J E Health*. 2016;22(5):342–375. https://doi.org/10.1089/tmj.2016.0045
8. Gusmão LL, Ribeiro AL, Souza-Silva MVR, et al. Implementation of a text message intervention to promote behavioural change and weight loss among overweight and obese Brazilian primary care patients. *J Telemed Telecare*. 2019;25(8):476–483. https://doi.org/10.1177/1357633X18782092
9. Thangada ND, Garg N, Pandey A, Kumar N. The emerging role of mobile-health applications in the management of hypertension. *Curr Cardiol Rep*. 2018;20(9):78. https://doi.org/10.1007/s11886-018-1022-7
10. Milani RV, Lavie CJ, Bober RM, Milani AR, Ventura HO. Improving hypertension control and patient engagement using digital tools. *Am J Med*. 2017;130(1):14–20. https://doi.org/10.1016/j.amjmed.2016.07.029
11. Ciemins EL, Arora A, Coombs NC, et al. Improving blood pressure control using smart technology. *Telemed J E Health*. 2018;24(3):222–228. https://doi.org/10.1089/tmj.2017.0

12. Green BB, Cook AJ, Ralston JD. Effectiveness of home blood pressure monitoring, Web communication, and pharmacist care on hypertension control: a randomized controlled trial [published correction appears in JAMA. 2009 Nov 11;302(18):1972]. *JAMA*. 2008;299(24):2857–2867. https://doi.org/10.1001/jama.299.24.2857
13. Tison GH, Sanchez JM, Ballinger B, et al. Passive detection of atrial fibrillation using a commercially available smartwatch. *JAMA Cardiol*. 2018;3(5):409–416. https://doi.org/10.1001/jamacardio.2018.0136
14. Chan PH, Wong CK, Poh YC, et al. Diagnostic performance of a smartphone-based photoplethysmographic application for atrial fibrillation screening in a primary care setting [published online ahead of print July 21, 2016]. *J Am Heart Assoc*. 2016;5(7):e003428. https://doi.org/10.1161/JAHA.116.003428
15. Turakhia MP, Desai M, Hedlin H, et al. Rationale and design of a large-scale, app-based study to identify cardiac arrhythmias using a smartwatch: The Apple Heart Study. *Am Heart J*. 2019;207:66–75. https://doi.org/10.1016/j.ahj.2018.09.002
16. Halcox JPJ, Wareham K, Cardew A, et al. Assessment of remote heart rhythm sampling using the AliveCor heart monitor to screen for atrial fibrillation: the REHEARSE-AF study. *Circulation*. 2017;136(19):1784–1794. https://doi.org/10.1161/circulationaha.117.030583
17. Turchioe MR, Jimenez V, Isaac S, Alshalabi M, Slotwiner D, Creber RM. Review of mobile applications for the detection and management of atrial fibrillation. *Heart Rhythm O2*. 2020;1(1):35–43. https://doi.org/10.1016/j.hroo.2020.02.005
18. Anker S, Koehler F, Abraham W. Telemedicine and remote management of patients with heart failure. *Lancet*. 2011;378:731–739.
19. Seferovic PM, Ponikowski P, Anker SD, et al. Clinical practice update on heart failure 2019: pharmacotherapy, procedures, devices and patient management. An expert consensus meeting report of the Heart Failure Association of the European Society of Cardiology. *Eur J Heart Fail*. 2019;21:1169–1186.
20. Koehler F, Koehler K, Deckwart O, et al. Telemedical Interventional Management in Heart Failure II (TIM-HF2), a randomised, controlled trial investigating the impact of telemedicine on unplanned cardiovascular hospitalisations and mortality in heart failure patients: study design and description of the intervention. *Eur J Heart Fail*. 2018;20(10):1485–1493. https://doi.org/10.1002/ejhf.1300
21. Hindricks G, Taborsky M, IN-TIME study group, et al. Implant-based multiparameter telemonitoring of patients with heart failure (IN-TIME): a randomised controlled trial. *Lancet*. 2014;384:583–590.
22. Abraham WT, Stevenson LW, Bourge RC, Lindenfeld JA, Bauman JG, Adamson PB. Sustained efficacy of pulmonary artery pressure to guide adjustment of chronic heart failure therapy: complete follow-up results from the CHAMPION randomised trial. *Lancet*. 2016;387(10017):453–461. https://doi.org/10.1016/S0140-6736(15)00723-0
23. Sekar P, Vilvanathan V. Telecardiology: effective means of delivering cardiac care to rural children. *Asian Cardiovasc Thorac Ann*. 2007;15(4):320–323. https://doi.org/10.1177/021849230701500411
24. Gackowski A, Czekierda Ł, Chrustowicz A, et al. Development, implementation, and multicenter clinical validation of the TeleDICOM—advanced, interactive teleconsultation system. *J Digit Imaging*. 2011;24(3):541–551. https://doi.org/10.1007/s10278-010-9303-8
25. Bonvini RF, Caoduro L, Menafoglio A, Calanca L, von Segesser L, Gallino A. Telemedicine for cardiac surgery candidates. *Eur J Cardiothorac Surg*. 2002;22(3):377–380. https://doi.org/10.1016/S1010-7940(02)00364-0
26. McElroy I, Sareh S, Zhu A, et al. Use of digital health kits to reduce readmission after cardiac surgery. *J Surg Res*. 2016;204(1):1–7.
27. Blasco A, Carmona M, Fernández-Lozano I, et al. Evaluation of a telemedicine service for the secondary prevention of coronary artery disease. *J Cardiopulm Rehabil Prev*. 2012;32(1):25–31. https://doi.org/10.1097/HCR.0b013e3182343aa7
28. Frederix I, Hansen D, Coninx K, et al. Medium-term effectiveness of a comprehensive internet-based and patient-specific telerehabilitation program with text messaging support for cardiac patients: randomized controlled trial. *J Med Internet Res*. 2015;17(7):e185.
29. Kraal JJ, Peek N, Van den Akker-Van Marle ME, Kemps HM. Effects of home-based training with telemonitoring guidance in low to moderate risk patients entering cardiac rehabilitation: short-term results of the FIT@Home study. *Eur J Prev Cardiol*. 2014;21(2 suppl):26–31. https://doi.org/10.1177/2047487314552606
30. Johnson KW, Torres Soto J, Glicksberg BS, et al. Artificial intelligence in cardiology. *J Am Coll Cardiol*. 2018;71(23):2668–2679.
31. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. *Fut Healthc J*. 2019;6(2):94–98. https://doi.org/10.7861/futurehosp.6-2-94
32. Horgan D, Romao M, Morré SA, Kalra D. Artificial intelligence: power for civilisation—and for better healthcare. *Public Health Genomics*. 2019;22(5-6):145–161. https://doi.org/10.1159/000504785
33. Venkatesan P. 2018 Annual Congress of the European Respiratory Society. *Lancet Respir Med*. 2018;6(11):P815–P816.
34. Ardakani AA, Kanafi AR, Acharya UR, Khadem N, Mohammadi A. Application of deep learning technique to manage COVID-19 in routine clinical practice using CT images: results of 10 convolutional neural networks. *Comput Biol Med*. 2020;121:103795. https://doi.org/10.1016/j.compbiomed.2020.103795
35. Lalmuanawma S, Hussain J, Chhakchhuak L. Applications of machine learning and artificial intelligence for Covid-19 (SARS-CoV-2) pandemic: a review. *Chaos, Solitons Fractals*. 2020;139:110059. ISSN 0960-0779. https://doi.org/10.1016/j.chaos.2020
36. Saner H. Digital health implementation: how to overcome the barriers? *Eur J Prev Cardiol*. 2019;26(11):1164–1165. https://doi.org/10.1177/2047487319848222
37. Ajibade A, Younas H, Pullan M, Harky A. Telemedicine in cardiovascular surgery during COVID-19 pandemic: a systematic review and our experience. *J Card Surg*. 2020:1–12. https://doi.org/10.1111/jocs.14933
38. Eberly LA, Khatana SAM, Nathan AS, et al. Telemedicine outpatient cardiovascular care during the COVID-19 pandemic: bridging or opening the digital divide? [published online ahead of print, June 8, 2020]. *Circulation*. 2020;142:510–512. https://doi.org/10.1161/CIRCULATIONAHA.120.048185
39. Wootton R. Telemedicine and developing countries—successful implementation will require a shared approach. *J Telemed Telecare*. 2001;7(suppl 1):1–6. https://doi.org/10.1177/1357633X010070S101
40. Combi C, Pozzani G, Pozzi G. Telemedicine for developing countries: a survey and some design issues. *Appl Clin Inform*. 2016;7(4):1025–1050. https://doi.org/10.4338/ACI-2016-06-R-0089

How to cite this article: Kaushik A, Patel S, Dubey K. Digital Cardiovascular Care in COVID-19 pandemic: A potential alternative? *J Card Surg*. 2020;35:3545–3550. https://doi.org/10.1111/jocs.15094