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Telecardiology in the Era of COVID-19: Slaying the Lernaen Hydra of Cardiovascular Disease with the Assistance of a Post-modern Iolaus

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ABSTRACT: The delivery of healthcare to patients with chronic non-communicable diseases has been challenging during the COVID-19 pandemic. Cardiovascular diseases constitute the leading causes of morbidity and mortality in the western world and beyond. Telecardiology services are essential for the continuity of medical care, the prevention, and early diagnosis of disease exacerbations. This is a dire need for both patients, who can experience long-term impairment and decrease in functional independence if left untreated, and healthcare systems, who cannot endure additional burden in times of crisis. The development and maintenance of effective remote care frameworks in this field is a multidisciplinary endeavor, where input and scholarly dialogue in the whole spectrum of applied sciences is valuable. In this context, the authors provide an overview of telecardiology applications, discuss its strengths and weaknesses and elaborate on strategies for safe and effective remote cardiovascular care during and beyond the COVID-19 pandemic.

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INTRODUCTION

Since time immemorial disasters and pandemics have posed unique challenges to healthcare delivery. The pandemic caused by the novel SARS-CoV-2 virus is agonizing health systems worldwide in different ways. Several studies demonstrated that the pandemic implied a severe restriction to the care of cardiac patients since the main focus has been on the acute care of people suffering from COVID-19. In particular, the care of critically ill patients in intensive care units has led to bottlenecks in hospital capacities indicating the severe hospital strain encountered. Thus, the World Health Organization and healthcare providers worldwide sought for means to translate this conundrum, with telemedicine emerging as a potential solver, capable at least partly to compensate for this public health crisis. The literal meaning of

telecardiology can be summarized as cardiology practiced from distance. This definition derives from the combination of the term cardiology with the Greek root word “tele”, which means end, far off, or distant. Nowadays, telemedicine is an emerging field, widely acknowledged during the COVID-19 pandemic, with an annual budget exceeding 18 billion dollars, whereas cardiology is treating conditions accounting for the leading morbidity and mortality rates in the western world [1,2].

While the arsenal of telehealth applications is abundant, it is important to clarify which applications are suitable for the management of cardiovascular conditions ranging from hypertension and arrhythmia to coagulation disorders. It is also pivotal to discuss the strengths and weaknesses of telecardiology in the era of COVID-19, and beyond.

APPLICATIONS OF TELECARDIOLOGY

In recent years, even before the COVID-19 pandemic, cardiologists have managed to perform a wide range of point of care examinations, including but not limited to a 12-lead electrocardiogram, blood pressure monitoring, Holter–heart rhythm monitoring, and other portable echocardiographic devices. These devices may be categorized as wearables and implanted. Wearable devices include mainly holters and serve the short-term monitoring of a patient. Implanted devices include automatic Implantable Cardiovascular Devices (AICD), Implanted Pacemakers (PM), Automatic Implantable Defibrillators (AID), and Cardiac Resynchronization Systems (CRS), which are capable not only to monitor but also to correct acute conditions. Owing to these amenities, the condition of a cardiac patient is constantly monitored, timely assistance can be provided in case of an emergency and the patient’s security and quality of life are improved [2, 3].

Nowadays, such applications can transmit information to cardiology facilities and specialists via USB, Wifi, Bluetooth, or conventional telephone lines in real-time, while data can be saved to the device memory and get transmitted later. Telecardiology can be used in pre-hospital, in-hospital, and post-hospital care. The major purpose of pre-hospital diagnosis is the early detection of acute myocardial infarction, atrial fibrillation, hypertensive crisis, and it can be carried out by the patient himself [4, 5]. The target in-hospital telemedicine is fast and provides an accurate diagnosis of diseases. The goal of post-hospital telecardiology is to monitor patients’ recovery and make sure that patients are receiving the appropriate care [6].

A Holter monitor is the most widely applicable device, especially if the patient requires observation for more than 24 hours straight. Holter is quite easy to use and does not require activation by the patient. The continuous monitoring facilitates the diagnosis of arrhythmias associated with loss of consciousness, asymptomatic arrhythmias, extrasystoles, or Prinzmetal's angina. With the usage of Holter in telemedicine, patients can easily receive teleconsultation at that very moment [7].

Telecardiology could also help to manage the major problem of polypharmacy, which is observed among 10% of the general population and up to 30% of the elderly. A recent study yielded that an application could effectively result in improving medication adherence in elderly patients with atrial fibrillation. Those individuals were less likely to experience a recurrence or complication of the disease that would render extra medication necessary [8]. Nevertheless, since more than 200,000 patients every day receive examinations via telecardiology [6], it seems natural to identify both benefits and drawbacks of this new field of medicine, which will be addressed below.

A schematic overview of the above-mentioned applications is provided in **Figure 1**.

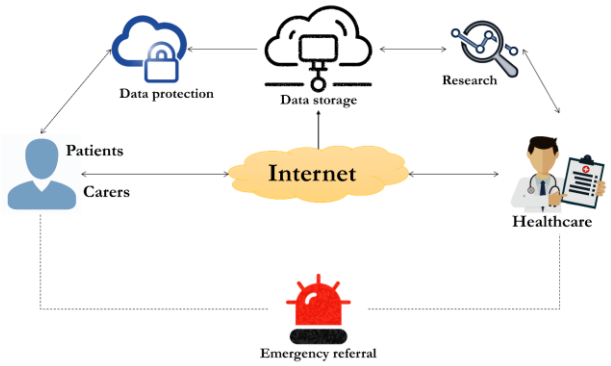

Fig. 1: Flowchart of a telecardiology network. Patients and carers are connected with healthcare facilities through the internet. Their data are stored and can be used for research purposes with the appropriate consent. Data protection is a safety valve for the patient, while emergency referrals may bypass the teleconsultation procedure.

ADVANTAGES OF TELECARDIOLOGY

Clinical medicine, healthcare systems, economy, and research take advantage of the progress in the field of telecardiology. Evidence suggests that several cases of myocardial infarction do not get a proper or on-time diagnosis in primary care or emergency facilities [9]. Telecardiology facilitates a higher level of primary care for cardiac patients since it allows physicians and patients to communicate 24/7, using smartphones or webcam-enabled computers. Clinicians are also able to communicate instantly with specialists and get a firm diagnosis for their patients [2]. Moreover, information concerning patients with portable devices such as holters and rhythm recorders can be immediately sent out to specialists who are responsible for the patients and alert them in case of an emergency [10]. In a nutshell, individual care is enhanced through telecardiological applications: patients get the right diagnosis sooner with collaborations established between primary care or emergency physicians and specialists [7].

Moreover, healthcare systems and economies greatly benefit from telecardiology. Several studies all over the globe suggest that the cost of cardiac care is greatly decreased in patients who are treated with telecardiological applications [11–14]. A

lower level of morbidity results in fewer days of hospitalization and, thus, lower workload. At the end of the day, both the cost per person and the impairment rate of the patients are decreased [6]. Nevertheless, there is yet much progress to be achieved for the development of sustainable telemedicine services in cardiology [15].

We should also consider the fact that telecardiology brings together scientists from several fields, including medicine, biology, informatics, and bioengineering. Multidisciplinary approaches are potentiated, and vast funding is allocated in this field due to its clinical effectiveness. It seems that the telecardiology research budget will exceed 5 billion dollars in 2021 [16]. Furthermore, close collaboration between academicians and industry has been enhanced, establishing a new attitude in the field of biomedical innovation [6]. The main benefit of this attitude is that new ideas can be accurately tested and reach patients faster.

Furthermore, telecardiology can provide researchers with a vast amount of data at a minimal cost. Constant monitoring of patients has already created a pool of data and metadata that can be extracted and used in synchronic and retrospective studies. Biometric features such as cardiac rhythm, pulsation, and blood pressure might be correlated to demographic, geographic, and cultural characteristics of the patients in a vast and almost automated manner [6]. Telecardiology also allows healthcare professionals in remote areas to be easily educated by academic or state institutions and ultimately update their medical knowledge. This has already been tested in India, where a large proportion of the population cannot receive cardiac care from specialists, and the results were encouraging [17]. Potential outcomes of such interventions will further expand our knowledge, ameliorate our practice and improve patients' prognosis and quality of life [2].

DRAWBACKS OF TELECARDIOLOGY

Despite the encouraging results and spectacular perspective of telecardiology, scholars have raised concerns regarding several controversial aspects of this technology. The weaknesses of telecardiology can be divided into two categories; general weaknesses of telemedicine affecting telecardiology and inherent weaknesses of telecardiology.

Data protection, low-quality doctor-patient communication, patients' compliance, and lack of digital literacy among patients and physicians are some of the most controversial aspects of telemedicine in general. The utilization of databases with a capacity of storing individual data and metadata for many years could be considered problematic in the frame of the General Data Protection Regulation (GDPR) legislation. Moreover, encouraging non-personal doctor-patient communication has a negative impact on patient psychology, according to specialists, and could result in dehumanizing the current medicine. To battle against this, many institutions implement compassionate care into the academic curricula and teach doctors to empathize with their patients. All this effort might decline if telemedicine is encouraged, not to mention the considerable difficulties healthcare professionals will face in facilitating communication with patients from a distance[3]. A deficit in communication is likely to result in lower compliance of patients and could, unfortunately, lead to the deterioration of some patients' prognosis. In addition, patients have lower chances of getting consultations from their doctors. Consequently, they cannot easily understand that they need to be sensitized towards their health, and instead of incorporating a behavior change attitude, they would become less active, putting all their confidence on the telemedical equipment.

In addition to the aforementioned drawbacks, we should not discount the indigenous weaknesses of telecardiology. To list some of them, we ought to refer to the cost, the lack of trained personnel, and the potential malfunction of particular telecardiology devices. In several countries, a considerable number of telecardiology services are not included in the national insurance system, resulting in a financial burden for the patients who opt for this kind of treatment. Furthermore, there is a deficit in trained healthcare professionals who will instruct specialists, primary care doctors, and patients concerning the appropriate use and interpretation of telecardiology devices. Speaking of devices, we ought to underline that many implantable devices and wearables are not compatible with medical examinations such as magnetic resonance imaging (MRI). Further research has to be conducted to assure the compatibility of telecardiological equipment with everyday devices, such as smartphones and laptops [7].

COVID-19 PANDEMIC AND TELECARDIOLOGY

The COVID-19 pandemic has raised questions about the feasibility of in-person visits, which should be considered a second or last option according to some scholars [18]. The inevitable suspension of all non-urgent hospitalizations and scheduled visits has resulted in several modifications in the management of patients with cardiovascular disease [19]. The evolution of telecommunications technology has led to the refinement of telemedicine and remote monitoring, and even more in pandemic times, these means should be considered a cornerstone [20]. Through telemedicine, infrastructures could remain intact, and cardiologists could be available to follow up with their patients [21].

In particular, scheduled visits were conducted, with patients and clinicians being at home. This permitted the uninterrupted care of established patients and the restriction of travel and exposure cost. Telecardiology helped clinicians to optimize the clinical management of heart failure patients at home, and to improve their quality of life, reducing emergency department access and also promoting self-management. Community paramedicine or mobile integrated health care programs allowed patients to be treated in their homes, with higher-level medical support provided virtually [22]. For severely-ill patients at home, such programs could facilitate evaluation before hospital transfer, potentially allowing them to bypass the emergency departments and be placed directly in a hospital bed, reducing exposure for health care workers and

other patients. We should also note that online training modules and remote training sessions are available for clinicians or patients requiring just-in-time training or assistance during their first call [23].

However, the wider integration of telecardiology in clinical practice requires solid action to overcome psychosocial and regulatory barriers. Remote care can make the patients feel they are being treated less thoroughly due to the lack of physical interaction with the doctor. Data protection for patients and physicians enrolled in telecardiology applications is also pertinent. International and national authorities have recently emphasized data protection at a regulatory level. Manufacturers need to adapt their devices to the changing regulatory frameworks worldwide while maintaining the full functionality of their applications. Given that frequent changes in the legal accreditation of the devices can greatly affect patients, it is important to create channels of delegation between stakeholders and healthcare workers, manufacturers, and patient representatives. Simultaneously, physicians and patients need to receive adequate information about confidentiality. Clear boundaries of self-monitoring ought to be set to prevent patients from skipping consultations, self-diagnosing, self-treating, or even sharing their health records with third parties. Finally, medical education curricula worldwide need to be accordingly amended for the consolidation of practicing and future physicians' skills.

CONCLUSION

Telemedicine has made a significant contribution to addressing several concerns emerging through the COVID-19 pandemic, one of the most difficult challenges of contemporary medicine. Telecardiology can drive the evolution of modern cardiology, facilitating remote communication and consultation between doctors and patients. Despite its weaknesses in terms of instant interventional procedures and data protection, telecardiology applications increase the likelihood for accurate and timely diagnosis of cardiovascular diseases for the mean cardiac patient. Continuing education and recruitment of specialists in telecardiology can increase the quality of the provided healthcare services.

The ancient Greek myth of Hercules and the Lernaen Hydra resembles the new challenges appearing through the COVID-19 pandemic in the field of cardiology. In the myth, a new head of the monster would emerge as soon as Hercules would cut another one. Hercules managed to turn the tide only when his comrade, Iolaus, burnt away the heads of the Hydra. In the 21st century, the COVID-19 pandemic, in combination with problems stemming from the lack of data protection, digital and health illiteracy, poses the management of cardiovascular diseases at peril. Although physicians remain responsible for addressing such challenges, telecardiology can be as helpful as Iolaus decreasing the burden of logistics and bypassing spatial and hygienic restrictions. Certainly, incorporating this interface in the current paradigm of practice can be challenging for both physicians and patients. Telecardiology may be doubted, yet as long as the doubts are perceived as challenges, there will be many milestone achievements.

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AUTHORS' CONTRIBUTION

CT and LM conceptualized the article, wrote the first draft, and designed the figure(s). ASP, DVM and AL revised the first draft and wrote the second draft, AA and MAK supervised the project and made critical revision. All authors have agreed to publish the present article.

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