



CHIRURGIE CARDIAQUE / CARDIAC SURGERY

USING TECHNOLOGY AND INNOVATION TO ADDRESS THE THREE DELAYS IN ACCESS TO CARDIAC SURGERY

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Introduction

Cardiovascular diseases (CVD) make up the leading cause of mortality in the world with 17.65 million deaths every year, of which more than 80% occurs in low- and middle-income countries (LMICs).⁽¹⁾ With the ongoing shift of the global burden of CVD towards low-resource settings, a mortality rate of 25 million deaths is projected in these regions by 2030.⁽²⁾ Nevertheless, it is estimated that 93% of the population in LMICs do not have access to safe cardiac surgical care, due to lack of nearby facilities, limited specialist and allied health workforce, and high risk of catastrophic expenditure. As such, there is a pressing need to address the barriers in receiving cardiac surgical care.

The Three Delays Framework can be used as a model to examine the barriers underlying access to cardiac care. The First Delay, the delay in recognizing the disease and seeking care, comprises health illiteracy, stigma of the condition, misperceptions of or lack of trust in modern medicine, and economic barriers. The Second Delay, the delay in reaching care,

includes the time and difficulty reaching the nearest facility providing cardiac surgical care, dependent on road infrastructure, climate conditions, availability of private vehicles, public transport, or ambulatory services, and the geographical distance to the facility. The Third Delay, the delay in receiving care, includes a four-fold delay: a delay in receiving appropriate care at the initial facility, delay in timely referral to another facility to receive definite care, delay in receiving appropriate definite care at a second facility, and a delay in post-operative care and long-term follow-up in the setting of cardiac diseases.

The availability of workforce, in particular surgical specialist workforce, is a constant and widespread issue in LMICs. Sub-Saharan Africa, for example, relies on only 1 cardiothoracic surgeon per 4 million people.⁽³⁾ In total, they possess only 1% of the world's total cardiothoracic surgical workforce. In addition, lack of surgical and medical infrastructure imposes an additional barrier for receiving care. For example, in LMICs, dedicated cardiac

intensive care units (CICUs) with specialized personnel is limited, but dramatically improves outcomes in patients following cardiac surgery.⁽⁴⁾ Telemedicine is a useful tool to overcome geographical barriers and lack of workforce in order to provide quality care and medical education from a distance. Clinicians are able to use mobile videoconference systems to remotely access a patient's room and monitor vital signs. This, in turn, can allow for better care and service for the patient, whilst saving time and reducing costs of clinicians, patients, and their families.⁽⁵⁾ For heart failure, telecare decreased hospitalization and mortality rates by 20% with corresponding reduction in medical expenses and increase in the quality of life.⁽⁶⁾ Similarly, the use in follow-up after cardiac surgery has proven effective in reducing readmission rates and preventing unnecessary visits (and related costs and anxiety), with high levels of satisfaction by both surgeons and patients.⁽⁷⁾ Moreover, the use of "electronic CICUs" (e-CICUs) serviced through telemedicine and adapted to local needs has proven logistically feasible and effective in reducing ICU and hospital length-of-stay for both adult and paediatric cardiac care compared to pretelemedicine periods.^(4,8) In a day and age of widespread cellular use and expanding internet connectivity, the use and development of mobile health (mHealth) innovations to scale up access to healthcare in low-resource settings becomes increasingly important. mHealth devices allow for reductions in costs, higher ease of use, and portability to help bridge existing gaps in cardiac care through decentralizing diagnostics and medical management to health professionals and CHWs in remote locations.⁽⁹⁾ In this study, we review existing and potential technological innovations to address the three delays limiting access to cardiac surgical care in low- and middle-income countries.

Methods

A focused literature review was done searching the medical database PubMed using the keywords "technology", "innovation", "low-income", "low-resource", "developing country", "rheumatic heart disease", "congenital heart defect", and "cardiac surgery" to identify literature on low-cost innovations and technology to bridge the gap to accessing cardiac surgical care.

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Results

The First Delay - Delay in Seeking Care

Any delay in recognizing existing disease or being aware of the availability of necessary treatment increases the likelihood of not receiving timely care and thus negatively influences outcomes and long-term prognosis. Although cost is traditionally mentioned as an important factor in deciding to seek care, other factors, such as recognizing the disease and the perception of the quality of the available care, influence this decision more.^(10,11) For the former, training community health workers (CHWs) to timely detect signs of cardiac surgical disease is an effective and low-cost way to reduce the delay in seeking care. The use of handheld echocardiography, rather than sole auscultation, is an effective and low-cost innovation to detect early cardiac disease, in particular RHD, by trained non-physicians.^(12,13) This can be strengthened through web-based evaluation of echocardiograms using a cloud-based server through specialists from a distance.⁽¹⁴⁾ More broadly, using mHealth kits able to monitor vital signs (e.g., mobile blood pressure, oxymetry, pocket echocardiography, iPhone electrocardiogram, and point-of-care BNP) allows for timely referral for cardiac interventions and lower probability of hospitalization or death.⁽¹⁵⁾

The Second Delay - Delay in Reaching Care

Identifying and reaching the nearest facility able to provide affordable and quality cardiac care relies upon the organization of the prehospital chain to access the clinical setting. Initiating effective pre-hospital care through training lay first responders has proven to improve survival by reducing the time to treatment in trauma care.⁽¹⁶⁾ Mobile surgical units for cardiovascular disease further reduce the time to treatment and can serve as a bridge between immediate life-saving care in the pre-hospital setting and more complex permanent interventions upon reaching the surgical facility.⁽¹⁷⁾

The Third Delay - Delay in Receiving Care

In order to avoid delays in care and prevent needless suffering, decentralizing diagnosis and management of cardiac with appropriate medical therapy and timely referral to surgical facilities is possible and necessary.⁽¹⁸⁾

Conferencing between remote hospitals and cardiac centers allows for the optimization of and reduction in (unnecessary) patient transfers.⁽¹⁹⁾ After receiving surgical care for cardiac diseases, immediate and long-term medical care and follow-up screening is essential to warrant optimal health outcomes. Cardiac rehabilitation, due to the costs and lack of widespread specialized centers, is traditionally hardly accessible for patients in LMICs. Through telemedicine using videoconferencing, patients are able to access rehabilitation at distant sites with similar results as conventional rehabilitation sites.⁽²⁰⁾ For example, the eRegister system by the World Heart Federation ensures real-time patient data collection and secondary prophylaxis, whilst keeping patients reminded of appointments through the use of SMS reminders and CHWs compliant with diagnostic guidelines through electronic forms.⁽²¹⁾

Discussion

Technological innovation has the ability to reduce all three delays in accessing cardiac surgical care, in addition to strengthening post-operative and long-term primary health systems to ensure optimal short-and long-term outcomes. The use of digital health kits including portable echocardiography and mHealth devices able to monitor oxymetry, blood pressure, ECG, and point-of-care BNP allows for efficient and cost-effective early diagnosis and follow-up of cardiac conditions ranging from RHD to heart failure. In addition, the widespread use of smartphones, cellular use, and internet connectivity allows for remote monitoring and conferencing of experienced specialists with less experienced specialists in rural hospitals or community health workers in community facilities. Moreover, patients are able to be reminded of medication use, rehabilitation instructions, or screening reminders through mobile texting. Altogether, mHealth can bridge the gap in accessing cardiac care. One barrier in receiving care for cardiac surgical disease is the availability of equipment, in particular to replace valves in patients with severe aortic stenosis or mitral stenosis, the latter commonly due to rheumatic heart disease (RHD). Every year, over 290,000 valve replacements are done around the world, the majority taking place in Europe and the United States, accounting for a US\$2 billion market.

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Due to the high costs, use in LMICs remains scarce in the light of the higher need due to RHD. The creation of low-cost biomolecularly enhanced polymeric heart valve with hyaluronan, as opposed to traditional use of tissue valves, allows for high biocompatibility and lifelong durability, able to be placed using trans-catheter aortic valve replacement (TAVR). In addition, the polymeric heart valve material does not require anticoagulation therapy, minimizing costs and need for close monitoring and follow-up of patients. In addition to potential widespread use of technology to improve patient care, the ability to improve the skills and opportunities for surgeons arises in a similar manner. Mobile applications have allowed students and health professionals around the world to practice their medical and surgical knowledge and skills outside the clinical setting. For example, Touch Surgery, a free mobile application with over 2 million users worldwide, lets users learn, prepare, and test for surgical procedures at any given location at any given time through a library of over 150 interactive, cognitive surgical simulations.⁽²²⁾ Virtual reality is slowly becoming used to give students, residents, and surgeons remote access to surgical procedures elsewhere in the world to learn from experts in a virtual real-time manner. Moreover, a digital health platform can connect cardiac specialists all over the world through a collaborative platform for training, education, research, and patient care, with the ability to expedite information sharing and service coordination to create a practical pathway for the delivery of cardiac care in LMICs. Lastly, such a platform would promote the establishment of a coalition of stakeholders, including, but not limited to cardiothoracic surgeons, cardiologists, industry, governments, and funders, to discuss and advance cardiac care around the world.

Conclusion

Access to cardiac surgery in developing countries remains scarce and delays in accessing treatment and follow-up care occur at all levels of the care pathway. Innovative mHealth and technological strategies to promote early diagnosis of surgical cardiac conditions, reduce readmission rates, and ensure proper

postdischarge management of patients are feasible and affordable in bridging the current gaps in LMICs. In addition, mobile connectivity allows for remote interaction between patients and medical specialists, as well as the creation of a web-based community of health professionals and stakeholders to improve cardiac care around the world.

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