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Technology for Diagnosis, Treatment, and Prevention of Cardiometabolic Disease in India

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ABSTRACT

Cardiometabolic diseases (CMD) are a major cause of mortality, morbidity and disability worldwide. Among Indians, CMD onset is at a much younger age and is prevalent in all sections of the society. Prevention, control and management of CMD and its risk factors is a major public health challenge, and alternative approaches need to be explored and integrated into public health programs. Advancements in the fields of computers, electronics, telecommunication and medicine have resulted in the rapid development of health-related technology. In this paper we provide an overview of the major technological advances in diagnosis, treatment and prevention within the field of CMD in the last few decades. This non-exhaustive review focuses on the most promising technologies that the authors feel might be of relevance in the Indian context. Some of the techniques detailed include advances in imaging and mobile phone technology, surgical techniques, electronic health records, Nano medicine, telemedicine and decision support systems.

Cardiometabolic diseases (CMD) (i.e. diabetes mellitus/DM, cardiovascular disease/CVD, and kidney disease) were responsible for approximately 33% (17.6 million) of deaths in the years 2010.[1] This enormous burden of CMD morbidity and mortality has increased in parallel to the prevalence of the major risk factors (i.e. high body mass index, high blood pressure/BP, high blood glucose, tobacco use and physical inactivity).[2] In order to slow down the progression of this epidemic, it is important to detect and manage CMDs at a nascent stage, wherein technology can play a significant role. Modern technology has played a significant part in transforming health care (HC) across the globe. Some of these technologies have played an important role in prevention, surveillance, diagnosis and treatment to reduce CMD burden in the last few years.[3]

Technology can act as an interface between physicians and patients, physicians among themselves, and physicians of varying levels of expertise. It can also be seen as a tool for collating and analysing data and helps in chalking out appropriate management plans. Substantial evidence exists on the diverse role technology can play in several aspects of delivering HC, saving cost and improving quality of care. This amalgamation of HC and technology continues to improve saving lives across the globe. In this paper we provide an overview of the major technological advances in diagnosis, treatment and prevention in the field of CMD in the last few decades (Fig 1). This non-exhaustive review focuses on the most promising technologies that the authors feel might be relevant in the Indian context.

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Abbreviations and Acronyms

AMNET = Americas' Network for Chronic Disease Surveillance

BM-DCEP = Bone Marrow–derived Circulating Endothelial Progenitors

BP = Blood Pressure

BRFSS = Behavioural Risk Factors Surveillance System

CARRS = Cardiometabolic Risk Reduction in South Asia

CAS = Carotid Artery Stenting

CHW = Community health workers

CDC = Centre for Disease Control

CMD = Cardiometabolic diseases

CTA = Computed Tomography Angiography

CV = Cardiovascular

CVD = Cardiovascular Diseases

DM = Diabetes mellitus

DSS = Decision Support Systems

ECG = Electro cardio graph

EHR = Electronic Health Records

GIS = Geographical Information Systems

GWAS = Genome-wide Association Studies

HC = Health Care

HRIDAY = Health Related Information Dissemination Amongst Youth

IIP = Implantable Insulin Pump

ISRO = Indian Space Research Organization

IT = Imaging Technologies

LAVD = Left Ventricular Assist Device

LMICs = Low and Middle Income Countries

MBPN = Multilayer Back Propagation Network

MDM = Medical Decision-Making

MDS = Million Deaths Study

Role of technology in CMD diagnosis

Advances in medical imaging techniques, nanomedicine, computerized decision support systems (DSS), and electronic health records (EHR) are some of the most promising developments in the field of medicine as a whole. The development of genomic and proteomic multiplex technologies have tremendously improved biomarker discovery and application to diagnostic and therapeutic decisions in clinical practice. Technical advances from basic diagnostic tools to high resolution imaging have led to a better understanding of physiology and anatomy of the cardiovascular (CV) system, thereby, helping gain more detailed insights.

Advances in imaging technologies (IT)

In India, several improvements in diagnostic methods and a number of new techniques have been developed and tested to aid in the decision making process. The "medical decision-making (MDM) system" has been used for an automated diagnosis and classification of ultrasound carotid artery images. This system provides a computer-based output for HC professionals and radiologists to aid diagnosis in patients. Two types of contour extraction techniques and multilayer back propagation network (MBPN) systems have been developed. This helps the physician to extensively study the characteristics of carotid arteries in a more reliable manner.[4]

Kumar A. et al. discuss the role of three-dimensional computed tomography angiography (3D-CTA) in the management of aneurism. They specifically describe how using 3D-CTA with 64 slice multi detector CT has improved the pre-operative assessment of both ruptured and un-ruptured aneurysms.[5] Maheshwary S. et al. introduced a novel approach for detection of discontinuities in the QRS complexes.[6] A less complex 'haar' wavelet was used for low-power consumption which can be used in battery-operated devices (mobile phone, personal digital assistant/pda devices, tablets etc). For ECG-specific applications, they have formulated the postulates for detection of notches and extremes with proposed criteria for identification of various morphologies.[6]

Advances in nanomedicine

Nanomedicine is an emerging field that utilizes nanotechnology concepts for advanced therapy and diagnostics. This convergent discipline merges research areas such as chemistry, biology, physics, mathematics and engineering. It bridges the gap between molecular and cellular interactions, and has the potential to revolutionize medicine. Nano medicine has tremendous potential for biomedical applications, such as radiological imaging, vascular implants, gene therapy, myocardial infarction and targeted delivery systems.[7] Some specific areas where nanotechnological approaches for CVD diagnosis and therapy have been advocated include nanoparticles for multimodal image contrast and improved treatment of CVD.[8]

Veiseh O et al. discuss the nanotechnology based approach for management of DM. Nanotechnology can be used in continuous glucose monitoring and insulin delivery systems. Glucose nanosensors are being incorporated into implantable devices, providing more accurate tracking of blood glucose levels while also providing the basis for glucose-responsive nanoparticles that better mimic the body's physiological needs for insulin.[9] Godin and colleagues consider the recent development in nanotechnology for improving diagnosis and therapy of CVD. A variety of "nanoparticle drug delivery systems" have been and are still being developed for treatment of CVD and other conditions. This allows local, directed and prolonged delivery of drug into the target cells.[8]

A major application of nanotechnology in CMD diagnosis involves creating images of atherosclerosis, restenosis and other cardiovascular conditions. Identification of biomarkers provides a powerful approach for screening, diagnosis, prognosis and therapeutic monitoring. Prognosis for patients suffering from CVD can be improved by obtaining more sensitive, specific, and faster assessments of diagnostic markers. Nanotechnology helps in improving detection of existing biomarkers and discovery of new biomarkers. A "lab-on-a-chip approach" has been developed in combination with nanotechnology to improve the sensitivity and accuracy of biomarker detection.[10] New generation biosensors have revolutionized CVD diagnosis and prognosis enabling it to be used as rapid screening tools to detect disease biomarkers at the earliest stage. Advances in