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CONTRIBUTION OF COMPUTATIONAL SYSTEMS, MODELLING AND SIMULATION IN CARDIOVASCULAR DISEASES

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Abstract

Cardiovascular diseases (CVD) are disorders of the heart and blood vessels. They include coronary heart disease (CHD), peripheral arterial disease, and rheumatic heart disease, to name a few. The complexities of these diseases are rapidly exceeding. Thus, modern technology like computational systems, modeling and simulation are used to aid in the understanding of such diseases. This paper will analyze how these new ways contribute to the diagnosis and treatment of cardiovascular diseases (CVDs).

Keywords: *computational systems, modelling, simulation, cardiovascular disease*

INTRODUCTION

An estimated 17.9 million people died from CVDs in 2019, representing 32% of all global deaths. [1] Figuring out the age group which is most vulnerable to CVDs and making sure they get proper treatments is essential to avoid untimely death. Technologies like computational systems, modeling and simulation promise to pave the way to more personalized treatments for patients. Computational systems are systems that process information and display an output. Modeling involves making a representation of something, which helps in visualizing a hypothetical situation. Computational medicine aims to improve healthcare by making computational models of disease, personalizing these models using data from patients, and working on these models before to improve the diagnosis and treatment of the disease. [2] Simulation is an artificial model with a particular set of conditions in order to experience something that is possible in reality. This allows us to get a better grasp on hypothetical yet possible situations in the future. Aviation and aerospace industries have been using simulation as a teaching tool for many years. Simulators are now widely used in education and training in a variety of high risk professions and disciplines, including the military, commercial airlines, nuclear power plants, business and medicine. Recently, the inclusion of clinical skills training into the curricula of medical students has seen significant growth, through this experimental learning. [3]

Theory

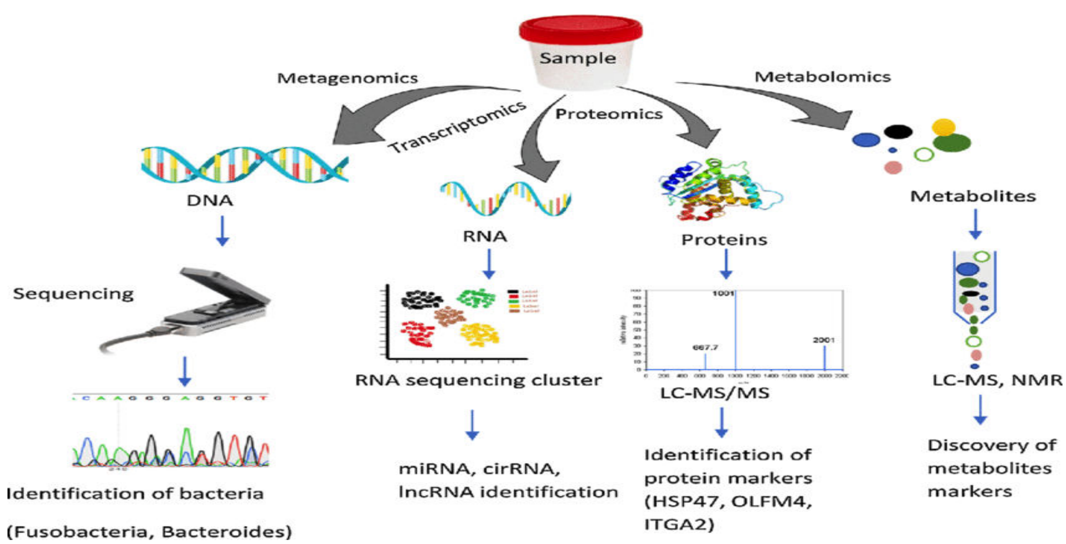
With precision medicine emerging as the future for cardiology, the diagnostic and therapeutic assessment of patients with cardiac disease increasingly relies on advanced imaging technology, genetic profiling, pharmaceuticals, medical devices and upcoming technology like computational models, the omics technique, and simulation. [4]

Computer simulations:

The use of computer simulations can be applied in a controlled and systematic manner to evaluate diverse interventions for reducing cardiovascular disease risks. Due to technological advancements, shortened training hours, and the increasing complexity of healthcare, simulation in Cardiology is rapidly expanding. In a risk-free environment, simulation enhances procedural competency and human factors training to improve patient safety. The use of simulation can be beneficial to novice trainees, experienced clinicians (e.g. for revalidation), and groups working together. We can test new procedures before implementing them, maintain seldom used skills, and assist underperforming doctors. A cardiovascular simulation provides doctors with critical information about the functioning of a patient's cardiovascular system as well as the most appropriate treatment strategy. Doctors can only get a limited amount of information about the fluid flow through a patient's heart or vessels from an MRI or CT scan. As a result, there is a lot of "guesswork" involved in treating patients with cardiovascular problems. With limited information, doctors will assess the situation and predict how the body will react to various treatment options. The problem with this approach is that it does not accurately capture the complexity of the human body and the diversity of the human population. By providing doctors with additional information specific to the patient, cardiovascular simulation addresses this issue and enables doctors to design more effective treatment plans.[5]

Omics techniques:

As cardiovascular diseases are complex states, influenced by both genetics and the environment, they require an investigation of many biological levels to understand. Omics techniques generate very large, complex and non-linear datasets, which mandate a systems biology approach, that is, the understanding of a biological process through examining the interactions between heterogeneous components. By using this technique, the doctor can reveal the complex characteristics of the disease, enabling them to make more informed decisions. [6]



This image shows the different types of omics that are extracted by a sample given by the patient, which are then sequenced. Different sorts of revelations can take place after the sequencing. Moreover, as this is at the genetic stage, more information will be revealed to the doctor about the disease , and how it is affecting the body.

Computational model:

A computational model uses computer programs to study complex systems using an algorithmic or mechanistic approach and is widely used in a diverse range of fields spanning from physics, chemistry and biology to economics, psychology, cognitive science and computer science. Among computational models of the various physiological systems, the heart is the most highly advanced example of a virtual organ, capable of integrating data at multiple scales, from genes to the whole organ. [7] The personalised interactive nature of such a virtual-patient simulation adds value to the existing clinical workflow by offering more quantitative and objective insight in the underlying disease cause of a patient. In addition, the model provides a platform for virtual evaluation and trial and improvement on the computational model for better therapy. [8]

CONCLUSION

The use of computer models in cardiology may become the new quantitative method for detecting and treating cardiac diseases thanks to their ability to provide rapid, low-risk, and low-cost diagnosis based on the physiology and pathology of patients without subjective assessment. New clinical developments and personalization of cardiac care will be driven by the discipline of computational cardiology in the future, as it grows and develops. By integrating "omic" strategies, we will be able to identify novel molecular mechanisms that contribute to CVD faster and more precisely. Eventually, this may lead to the identification of new pathways or drug targets. Although understanding the interactions between different omics data requires increasingly complex concepts and methods, we argue that hypothesis-driven investigations and independent validation must still accompany these novel systems biology approaches to realize their full potential. Simulation is rapidly becoming a mainstay of cardiovascular education, training, certification, and the safe adoption of new technology. If cardiovascular medicine is to continue to lead in the adoption and integration of simulation, then, it must take a proactive position in the development of metric-based simulation curriculum, adoption of proficiency benchmarking definitions, and then resolve to commit resources so as to continue to lead this revolution in physician training.

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