COMMENTARY

Modeling of coronary circulation particles for the development of drug carriers

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ABSTRACT

Cardiovascular Diseases (CVD), the leading cause of death worldwide and its principal manifestations, are characterized by atherosclerotic plaques and thrombosis, chronic inflammatory consequences. Finding non- or minimally invasive treatment options for these effects on the coronary network is crucial and has turned into a cross-disciplinary issue. As a result, research is currently being done on smart drug delivery systems, which are specifically based on micro- and nanoparticles, as a viable way to provide non- or minimally invasive therapeutic processes. In contrast to traditional interventional cardiology procedures, computational models enable us to investigate, devise, and anticipate treatment plans based on smart drug delivery devices with less time and expense. Additionally, the improvement and development of computer techniques and models have produced a vast and useful understanding of patient-specific medication design and therapy approaches.

INTRODUCTION

Numerous cardiac disorders known as CVD are brought on by atherosclerosis in the arterial network surrounding the heart. Atherosclerosis is characterized by two elements: thickening of the artery walls and shrinkage of the cross-sectional area of the lumen. Forming a thrombus, which is essentially the outcome of breaking an atherosclerotic plaque, causes the change in circulatory hemodynamic behavior, to varying degrees. Significantly, the worsening of such a process may eventually result in ischemic strokes and Myocardial Infarctions (MI). The traditional methods of treating thrombosis and atherosclerotic plaques have been updated and improved throughout time. However, the invasive nature of such therapies and the high risk of restenosis need the creation of novel therapeutic strategies. A potential area of current nanomedicine is the delivery of treatments using micro- and nanoparticles. The development of atherosclerotic plaques and vascular disorders in the heart network of vessels is thought to have started with the inflammation. Accordingly, in this particular sector, extensive research has been done on the controlled release of drug carriers of various sizes and shapes as well as their near wall movement (margination). These studies target inflammatory or tumor-associated antigens on cell surfaces and advance our knowledge of how to optimize targeted medication delivery strategies. In that regard, the interaction of hydrodynamic forces, particle transport, and efficient contacts with the targeted cell surfaces are crucial elements of every intelligent vascular drug delivery system that makes use of micro and nano particles. Importantly, a number of factors, including the nanoscale size of the carriers, the complex vascular biochemical environment, the dynamics and nonlinearity of the delivery process, the metabolism and clearance of the drug, and extravasation among different barriers, make it difficult to analyze and measure targeted drug delivery system indices in vivo. However, by applying proven mathematical tools, non-intrusive, profitable, and fairly accurate ways to obtain this information may be within reach. The well-established computational particulate fluid dynamics that these mathematical tools translate to may simulate the transport of diluted species. Computer-based modeling actually helps us comprehend and investigate the scaled complexity of pathophysiological processes across multiple scales. Additionally, this strategy is crucial for advancing and improving patient-specific therapeutics, especially in

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nanomedicine. In order to analyze bioadhesion, transport, and interaction of micro- and nanoparticles with the targeted locations in coronary haemodynamics, it is crucial to use a multi-scale mathematical model. Here, computational fluid-particle dynamics is a nice example of an integrated continuum particle-based technique. Such models have been employed and have successfully served as a technique to study the pathophysiology of arterial networks at various flow sizes. The investigative domain is a crucial element in the development and application of computational methods. To examine the flow of blood, a variety of mathematical techniques can be used, depending on the size of the investigation region. To be more precise, the current high flow rate enables us to describe the fluid features and fate correctly by using continuum approaches in arteries with diameters greater than 500 m, such as the LAD in the coronary network. The nature of blood flow appears to be progressively non-Newtonian as artery diameters decrease below 500 m, however continuum assumptions can still be used to predict it. The design of drug carriers has proven difficult due to factors such as a high bioadhesion probability, the capacity to travel close to the vessel walls (marginate), and the ideal particle density at the drug-cell interaction locations. Beyond these variables, the success of drug delivery is directly influenced by the distribution of micro- and nanocarriers throughout the cross-section of the vessel, particularly at the location of the lumen plaque. The biological components of the human body and the particle's structure play a role in this factor. Clearly, physical aspects of the body, such as haematocrit and artery size, can have an impact on blood flow parameters. Additionally, the distribution of micro- and nanoparticles inside the artery and needle have a major impact on the structural characteristics of particles, such as the size and shape of drug carriers. It can be a useful and accurate assumption to think of the blood and drug-carrying particles floating in it as a scattered flow. This indicates that compared to the volume fraction of particles, which is less than 1%, the volume fraction of blood, the continuous phase, is far higher. In other words, the particles only take up a small amount of the blood's volume and do not move it around. This presumption is consistently upheld for various fibrinolytic medication dosages given in the coronary circulation. Worldwide, Cardiovascular Diseases (CVD) continue to be the number one cause of mortality and disability. The most prevalent kind of CVD and a major contributor to ischemic heart disease is atherosclerosis, an inflammatory disease of the arterial wall. A strong strategy for creating new regulations for the treatment of atherosclerotic plaques and thrombosis is the targeted delivery of medicines based on micro- and nanoparticles. Atherosclerotic plaques and thrombosis, which are the main symptoms of Cardiovascular Diseases (CVD), the leading cause of death worldwide, are their distinguishing features. It is imperative to find non- or minimally invasive treatments for these effects on the coronary network, and this has become a problem that cuts across disciplines.