Computational Modeling of Atherosclerotic Arteries

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Atherosclerosis, one of the major risks of cardiovascular diseases, is associated with various coronary artery diseases (CAD) such as angina, myocardial infarction and heart attack. Even though hemodynamic properties have been proposed as a predominant factor in the process of CAD so far, the blood flow of lesion expected is practically difficult to measure in in vivo system. One of the best ways which evaluate hemodynamics is to use computational fluid dynamics (CFD) analysis by 3-dimensional (3D) atherosclerotic coronary arteries.
In the present study, we segmented coronary CT images DICOM formatted using both Mimics v.18.0 and 3-matics v.10.0 software. By the 3D reconstructed coronary arteries, we applied a pulsatile blood pressure waveform to the ascending aorta for providing a biomimetic environment using COMSOL Multiphysics v.5.2 and ANSYS v.17.0 software.
The CFD simulation which combined with CT Angiography imaging allowed the certainly detailed characterization of complex flow velocity, pressure, and wall shear stress indirectly measured. This approach made us to assess the stress depending on the alterations of its hemodynamic as well as coronary arteries structure in atherosclerotic lesion. There was significant difference in shear stress between the control and atherosclerotic arteries. Furthermore, our 3D artery model showed that low shear stress not only increases the occurrence of plaque, but is also varied depending on lumen and plaque shapes.
CFD modeling in cardiovascular system provides a better understanding the pathophysiology of cardiovascular disease and may help early medical planning along with surgical interventions in the future.

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