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On the Image-Based Non-Invasive Diagnosis of Cardiovascular Diseases

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Abstract: Cardiovascular diseases are the leading cause of human deaths worldwide. Traditional diagnostic tools of cardiovascular diseases are either based on 2D static medical images, or invasive, bringing troubles to both patients and doctors. Our team is committed to the development of image-based non-invasive diagnostic system for cardiovascular diseases. We have made progress mainly in the following areas: 1) 4D flow technology for heart and large blood vessels. According to MRI 4D Flow data, three-dimensional velocity fields within blood vessels were constructed. Divergence-fee smoothing (DFS) was proposed to eliminate the high frequency noise in the hemodynamic flow field, and make the smoothed velocity field to satisfy the divergence-free condition. The vascular wall shear stress, pressure and other physiological indicators were obtained, their accuracy can meet the need of clinical applications. 2) Accurate noninvasive diagnostic techniques for coronary arterial disease. According to coronary CTA imaging data, 3D reconstruction of coronary arteries was achieved coronary stenosis and plaque lesion were identified and analyzed. Coronary microcirculation was modeled using a 0d model; the coronary artery FFR was computed through the Fast FFR technique, which was based on the reduced-order computational fluid dynamics (CFD). The Fast FFR technique can compute the FFR within 5 minutes. Similar techniques have been used in the preoperative evaluation of intraluminal artery bypass. 3) *In vitro* evaluation of artificial heart valves and blood-contacting artificial organs. High-fidelity CFD and PIV technique were developed to study the flow field in the artificial heart valve and blood pumps. In vitro platform for experimentally and numerically evaluate the blood damage were also developed.

Keywords: Cardiovascular diseases, coronary artery, 4D flow, FFR, CFD, PIV.

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