ICCES, 2023, vol.27, no.3
DOI: 10.32604/icces.2023.09754

PROCEEDINGS

An Explicit and Non-Iterative Moving-Least-Squares Immersed-Boundary Method and Its Applications in the Aorta Hemodynamics with Type B Intramural Hematoma

Wenyuan Chen[1], Tao Zhang[2] and Yantao Yang[1,*]

[1] State Key Laboratory for Turbulence and Complex Systems, Department of Mechanics and Engineering Science, College of Engineering, Peking University, Beijing, 100871, China

[2] Vascular Surgery Department, Peking University People's Hospital, Beijing, 100044, China

[*]Corresponding Author: Yantao Yang. Email: yantao.yang@pku.edu.cn

ABSTRACT

Based on the moving-least-squares immersed boundary method, we proposed a new technique to improve the calculation of the volume force representing the body boundary. For boundary with simple geometry, we theoretically analyze the error between the desired volume force at boundary and the actual force applied by the original method. The ratio between the two forces is very close to a constant and exhibits a very narrow distribution. A spatially uniform coefficient is then introduced to correct the force and can be fixed by the least-square method over all boundary markers. Such method is explicit and non-iterative, and is easy to implement into the existing scheme. We apply the new method to analyze the aorta hemodynamics with type B intramural hematoma for a group of 20 patients (The Ethical Review Board of Peking University People's Hospital approved the study protocols, and informed consent about data collection and figure presentation in this paper was obtained from all patients). Based on the wall-shear-stress field, the mean oscillatory shear index (OSI) over the hematoma section are calculated. We also calculate the blood pressure difference P_d between the inlet and outlet and study the duration T_d of high pressure in one cardiac cycle for different patients, which we think is important for the periodic loading process. By combining two criteria, namely the duration $T_d > 0.05$s and the mean oscillatory shear index OSI > 0.125, we can distinguish the patients with tear from those without for a confidence pvalue of .023. We then propose a new parameter $|\nabla_\tau p|$ which is the magnitude of tangential gradient of pressure as an indicator for tear locations. Similar study with larger group of patients are needed to further validate the feasibility of the proposed parameters and criteria.

KEYWORDS

Immersed boundary method; moving least squares; aorta hemodynamics; type B intramural hematoma

Funding Statement: The author(s) received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.