1. Introduction

The circulatory and reproductive systems can be considered as tubular transport systems of blood cells and gametes, respectively. Both systems involve complex flows and fluid-structure interactions of large displacements and large deformations. In addition, multiple scales and multiple processes need to be considered. Because of their importance in health and fundamentals, great effort has been put in developing numerical methods for these systems and in understanding the underlying flow physics. In spite of the many achievements, it is still a challenge to model these systems accurately using numerical methods. Moreover, there still remains much concerted development towards grasping the complicated flow physics within such systems by using advanced numerical methods and mathematical models. Therefore, the goal of this special issue was to collect together recent contributions on the development of numerical methods for complex flows and fluid-structure interaction in circulatory and reproductive systems and/or on addressing the complicated flow physics and heat and mass transfer in these systems for fundamental understanding as well as engineering applications. The papers can be divided into three groups as detailed below.

2. Patient-Specific Geometry Simulations

The work by J. S. Byun, S.-Y. Choi, and T. Seo attempts to investigate the hemodynamic phenomena in the cerebral arteries before and after surgery of the aneurysm with patient-specific pre- and postsurgery cerebral arterial geometries by using three-dimensional computational fluid dynamics models. In the models, the flow is approximated by an incompressible and Newtonian fluid in laminar flow regime, and the vascular wall is assumed to be rigid. The flow patterns, the inflow jet streams, and the wall average shear stress have been considered by using different patient-specific geometries. Several interesting findings are reported, among which the average shear stress distribution associated with aneurysm rupture is attractive and could provide useful insight in predicting the risk of aneurysm rupture.

X. Liu et al. present a numerical study of flow characteristics in the patient-specific upper airway obstructed by the pharyngeal collapse. In this study, the patient-specific geometries are used, the flow dynamics is solved by using computational fluid dynamics, and the turbulence is modeled by the large eddy simulation. The numerical simulations are validated with their measurement by a laser Doppler anemometry. Simulations are conducted by varying flux rate under
both continuous inspiration and expiration with focus on
discussing the velocity fields and static pressure fields and their
correlation with the upper airway statuses (e.g., narrowing
of pharynx). Such information could provide guidance for
the treatment of obstructed respiratory disease. In addition,
the numerical procedures reported can be directly applied
to study flows in narrowed artery, arteriovenous graft, and
arteriovenous fistula.

3. Cell/Capsule Dynamics

J.-T. Ma, Y.-Q. Xu, and X.-Y. Tang report a size-dependent cell
sorting scheme based on a controllable asymmetric pinched
flow by using an immersed boundary-lattice Boltzmann
method. The scheme employs a device which consists of 2
upstream branches, 1 transitional channel, and 4 downstream
branches. To study the cell sorting efficiency, systematic
simulations are conducted by varying the inlet flow ratio, the
cell size, and the outlet flow ratio. The device is approved to be
effective by the finding that cells of different diameters can be
successfully sorted into different downstream branches. This
work provides a reference for the design of microfluidics for
cell/particle sorting.

The work by F.-B. Tian presents an immersed boundary-
lattice Boltzmann method for capsule fluid-structure interac-
tion involving non-Newtonian fluid (e.g., power-law fluid).
In this method, the capsule dynamics and the fluid dynamics
are coupled by using the immersed boundary method; the
incompressible viscous power-law fluid dynamics is obtained
by solving the lattice Boltzmann equation where a shear
rate-dependant relaxation time is used to achieve the non-
Newtonian rheology. The non-Newtonian flow solver is vali-
dated by considering a power-law flow in a channel and then
applied to study the deformation of a capsule in a power-law
shear flow by varying the Reynolds number, dimensionless
shear rate, and power-law index. Several interesting results
that are distinctive in the power-law flow are reported. This
work provides an alternative for fluid-structure interactions
involving non-Newtonian fluid. Further effort can be made to
explore applications of non-Newtonian effects in cell/particle
sorting.

4. Molecular Dynamics Simulation

Y. Ge et al. present a study on the effects of solution concen-
tration on ion distribution in a nanopore-based device inspired
from red blood cells by using a molecular dynamics method.
It is found that the density peaks for both the counterion and
cion near the charged wall increase at different speeds with
the increase of the solution concentration if the screening
effects appeared, and consequently the potential near the
charged wall of the nanopore switches from a negative value
to a positive one during the simulation. This work provides
insights in controlling the ion permeability and improving
the cell transfection as well as the design of nanofluidic
devices. In addition, it inspires future work on multiscale

methods including the method in this work and those
methods in the studies by F.-B. Tian and J.-T. Ma, Y.-Q. Xu,
and X.-Y. Tang to tackle multiscale cell dynamics.

The wide biomedical and mechanical engineering science
community will be interested in this special issue. Both
researchers and practitioners will find results presented in
this issue helpful in many applications.

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