World Academy of Science, Engineering and Technology
International Journal of Biomedical and Biological Engineering
Vol:10, No:04, 2016

Oxygen Transport in Blood Flows Pasts Staggered Fiber Arrays: A Computational Fluid Dynamics Study of an Oxygenator in Artificial Lung

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Abstract : The artificial lung called extracorporeal membrane oxygenation (ECMO) is an important medical machine that supports persons whose heart and lungs dysfunction. Previously, investigation of steady deoxygenated blood flows passing through hollow fibers for oxygen transport was carried out experimentally and computationally. The present study computationally analyzes the effect of biological pulsatile flow on the oxygen transport in blood. A 2-D model with a pulsatile flow condition is employed. The power law model is used to describe the non-Newtonian flow and the Hill equation is utilized to simulate the oxygen saturation of hemoglobin. The dimensionless parameters for the physical model include Reynolds numbers (Re), Womersley parameters (α), pulsation amplitudes (A), Sherwood number (Sh) and Schmidt number (Sc). The present model with steady-state flow conditions is well validated against previous experiment and simulations. It is observed that pulsating flow amplitudes significantly influence the velocity profile, pressure of oxygen (PO2), saturation of oxygen (SO2) and the oxygen mass transfer rates (m˙_O2). In comparison between steady-state and pulsating flows, our findings suggest that the consideration of pulsating flow in the computational model is needed when Re is raised from 2 to 10 in a typical range for flow in artificial lung.

Keywords : artificial lung, oxygen transport, non-Newtonian flows, pulsating flows
Conference Title : ICBM 2016 : International Conference on Biomedical and Microbial Engineering
Conference Location : Los Angeles, United States
Conference Dates : April 05-06, 2016