CURRENT NUMERICAL TECHNIQUES FOR PREDICTION OF BLOOD HEMOLYSIS

R. Supiyev, L. Rojas-Solorzano

School of Engineering, Nazarbayev University (Astana, Kazakhstan)
rakhim.supiyev@nu. edu. kz

Key words: Blood Stream, Computational Fluid Dynamics, Hemolysis, Granular Kinetic Theory.

Introduction: Cardiovascular Diseases, the common name for various Heart Diseases, are responsible for nearly 17.3 million deaths annually and remain the leading global cause of death in the world. It is estimated that this number will grow to more than 23.6 million by 2030, with almost 80% of all cases taking place in low and middle income countries. Surgical treatment of these diseases involves the use of blood-wetted devices. However, blood can be damaged when flowing through these devices due to the lack of biocompatibility of surrounding walls, and most prominently, the excessive exposure of blood cells to shear stress for prolonged periods of time. This extended exposure may lead to a rupture of membrane of red blood cells, resulting in a release of hemoglobin into the blood plasma (hemolysis). Therefore, regions of high shear stress and residence time of blood cells must be considered thoroughly during the design of blood-contacting devices.

Method: In-vitro experiments have proven to be costly, time-intensive and ethically controversial. On the other hand, simulating blood behavior using Computational Fluid Dynamics (CFD) is considered to be an inexpensive and promising tool to predict blood damage in complex flows. Nevertheless, current state-of-the-art CFD models of blood flow to help predicting hemolysis are still far from being fully reliable for design purposes. Previous work have demonstrated that prediction of hemolysis can be improved when using a multiphase model of the blood instead of assuming the blood as a homogeneous mixture.

Results: The attempt of this study is to develop and validate a numerical model based on Granular Kinetic Theory (GKT) for solid phases that provides an improved prediction of blood cells segregation within the flow in a microtube. Simulations were based on finite volume method using Eulerian-Eulerian modeling for treatment of three-phase (liquid-red blood cells and platelets) flow including the GKT to deal with viscous properties of the solid phases.

Conclusion: Preliminary results show that the improved segregated model leads to a better prediction of spatial distribution of blood cells. Simulations were performed using ANSYS FLUENT platform.