Numerical Investigation of Antegrade Flow Effects on Flow Pulsation in Fontan Operation Using a Multiscale Model

Mojdeh Monjezi [a], Mostafa Ghoreyshi [a], Mohammad Said Saidi [a], Bahar Firoozabadi [a], Ali Navabi [b]

[a] *Department of Mechanical Engineering, Sharif University of Technology, Iran;*
[b] *Department of Pediatric Cardiac Surgery, Imam Hospital, Iran*

This study considers blood flow in total cavopulmonary connection (TCPC) morphology, created in Fontan surgical procedure in patients with a single ventricle heart disease. Ordinary process of TCPC operation reduces pulmonary blood flow pulsatility; since the right ventricle being bypassed. This reduction may limit the long term outcome of Fontan circulation. There is an idea of increasing pulmonary flow pulsations by keeping main pulmonary artery (MPA) partially open while it was closed in ordinary TCPC operation. The purpose of the present study is to verify the effects of antegrade flow (AF) coming through stenosed MPA on pulmonary flow pulsations, by means of computational fluid dynamics (CFD). The 3-D geometry is reconstructed from CT angiography scan of a patient who has undergone an ordinary TCPC procedure. The stenosed MPA or pulmonary stenosis (PS) is virtually added to the original geometry. Inlet velocity profiles are obtained from echocardiography data of the same patient. AF profile in a cardiac cycle is obtained from a general pressure cycle of left ventricle, assuming a linear relationship between pressure gradient and flow rate in PS. We applied a 3D-1D coupled method to simulate blood flow in this situation more precisely. The results show that adding AF increases pulsatility index (PI) in both left and right pulmonary artery (LPA and RPA respectively). Moreover, adding AF leads to an increase in energy loss. It also increases the pulmonary-to-systemic flow ratio leading to increase in total cardiac flow rate and hence heart power.