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A NUMERICAL ANALYSIS OF THE BLOOD FLOW AROUND THE BILEAFLET MECHANICAL HEART VALVES WITH DIFFERENT ROTATIONAL IMPLANTATION ANGLES*

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Abstract: The effects of implantation angles of Bileaflet Mechanical Heart Valves (BMHVs) on the blood flow and the leaflet motion are investigated in this paper. The physiological blood flow interacting with the moving leaflets of a BMHV is simulated with a strongly coupled implicit Fluid-Structure Interaction (FSI) method based on the Arbitrary-Lagrangian-Eulerian (ALE) approach and the dynamic mesh method (remeshing) in Fluent. BMHVs are widely used to be implanted to replace the diseased heart valves, but the patients would suffer from some complications such as hemolysis, platelet activation, tissue overgrowth and device failure. These complications are closely related to both the flow characteristics near the valves and the leaflet dynamics. The current numerical model is validated against a previous experimental study. The numerical results show that as the rotation angle of BMHV is increased the degree of asymmetry of the blood flow and the leaflet motion is increased, which may lead to an unbalanced force acting on the BMHVs. This study shows the applicability of the FSI model for the interaction between the blood flow and the leaflet motion in BMHVs.

Key words: mechanical heart valve, rotational implantation, blood flow, leaflet motion, fluid-structure interaction

Introduction

The heart valves maintain a unidirectional blood flow by opening and closing depending on the difference of the pressures in the upstream and downstream sides of the valves. The two semilunar valves (aortic valve and pulmonary valve) are present in the arteries and they prevent the blood from flowing back from the arteries into ventricles.

If the heart valve is seriously deformed or diseased, the native heart valve may be replaced with a new heart valve，which can be either Biological Heart Valve or Mechanical Heart Valve (BHV or MHV). Mechanical heart valves are made totally of mechanical parts, well tolerated by the body. Due to the artificial materials involved, the patients with mechanical heart valves will have to rely on a lifelong blood-thinner (anticoagulant) medication. Among various mechanical heart valves, the Bileaflet Mechanical Heart Valves (BMHVs) are mostly used.

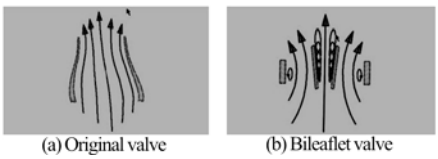

Fig.1 Typical flow patterns in different heart valves

Despite the widespread clinical use of mechanical valve replacements, the functions of these devices are far from perfect. The primary complications that remain as the major obstacles toward the ideal mechanical heart valve include (1) hemolysis, which is the destruction of red blood cells, (2) platelet des-

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