Flow Pattern Analysis in the Moving Actuator Type Total Artificial Heart

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Introduction

Thromboembolitic complication in the artificial hearts is one of the major factors which disturb their long term implantation. These thromboembolitic events are strongly influenced by surface characteristics of materials and fluid dynamics inside of blood pump. Several researchers have investigated the fluid dynamics in the artificial ventricles with various techniques [1,2,3]. They tried to find velocity and shear stress distributions quantitatively in the artificial ventricles. But their relationship to thrombo-embolitic complication is not well-known until now.

In this paper, we studied flow patterns in the moving actuator type total artificial heart(TAH) qualitatively by flow visualization technique. Potential areas of thromboembolitic complication are investigated through flow patter analysis.

Materials and Methods

In order to obtain flow patterns in the artificial ventricle, we made a transparent pump system(TPS) with a ventricle and a simple circulatory system as shown in figure 1. Polystylene particles(IRA 904, Amberite ion exchange resin, Rohm & Hass Co., Philadelphia, PA), less than 100um,were suspended in the testing fluid as scatterers and planar He-Ne laser light source illuminated the artificial ventricle located in the center of TPS through a cylindrical lens. Pictures of flow patterns during various parts of cardiac cycles were captured by use of a still photo camera(Sam Sung Minolta, alpha 9000) at shutter speed of 1/30, 1/60, and 1/125 and Kodak 35mm ASA 400 Tri-X film. The testing fluid was a blood analogue consisting of 36.7% glycerine (by volume) and distilled water. In order to select photographing time, a digital time displayer which

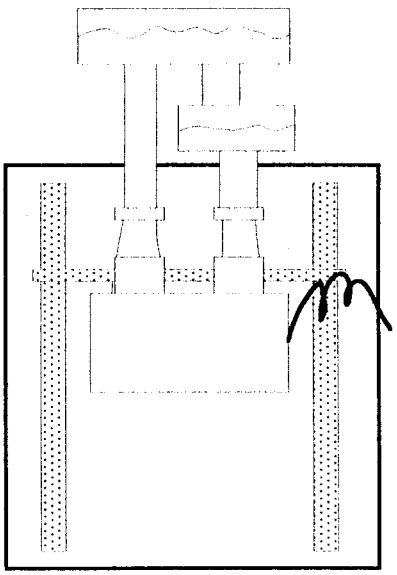

Figure 1 Schematic diagram of Transparent Pump System

indicate systolic and diastolic phase at the interval of 1/30 and 1/60 sec was made. Displayed time was taken together with flow pattern by the still camera.

Results and Discussion

Analysis of flow patterns in series will show the procedure of flow pattern formation according to the moving actuator motion. In diastolic phase, two large vortex are occurred and several flow separation points were observed as shown in figure 2. These points as well as valvular areas are potential for thromboembolitic complication.

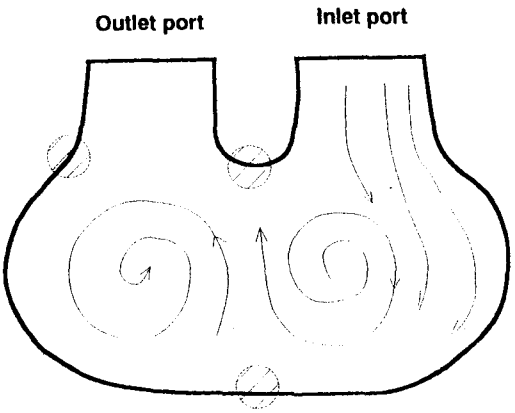

Figure 2 Shcematic diagram of flow pattern in the artificial ventricle during diastolic phase
: flow separation point

Reference

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[3] C. Clark, W. Jin, A. Glaser, "The fluid mechanics of a sac-type ventricular assist device", The Inter. J. of Artif. Org., Vol. 13, No. 12, pp814-822, 1991