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Numerical Assessment of Blood Trauma in BiVentricular Assist Device (BVAD)

Dong Choon Sin[a], Andy CC Tan[a], Hyo Jung Kim[b], Won Cheol Kim[b]

[a] *Institute of Health and Biomedical Innovation, Queensland University of Technology, Australia*
[b] *School of Mechanical and Aerospace Engineering, Gyeongsang National University, Korea*

Abstract and objective

A CFD assessment of shear induced hemolysis in the early design phase of artificial prosthetics may decrease time and costs of development. Among the cardiac assist devices available, the BVAD has attracted worldwide interest because patients who received a left ventricular assist device (LVAD) have extended lives. However, some of them develop right heart failure syndrome, and these patients required a right ventricular assist device (RVAD). In this paper, a numerical analysis was performed to predict the share stresses which may allow possible blood trauma analysis in BVAD.

Keywords:

CFD, BVAD, blood trauma, Hemolysis

Introduction

Ventricular assist devices (VADs) have become widely used in bridging to heart transplantation, bridging to recovery, or destination therapy. However there is still insufficient understanding of fluid mechanics related issues in the clearance gap of the BVAD. The design nature of the pump requires sufficient washout in the clearance between the impeller and the stationary pump housing inner surface. In this paper, a numerical analysis was performed to predict the share stresses in the clearance regions of the BVAD.

Methods

The BVAD (Fig 1) is under development at the Queensland University of Technology in Brisbane, Australia.

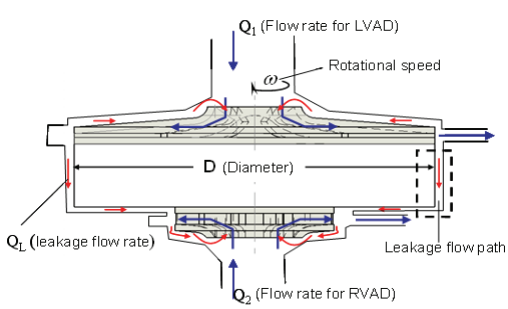

Figure 1 - The schematic drawing of the BVAD

The shear stress in blood is comprised of molecule viscosity stress and Reynolds stress components. A scalar stress value can be obtained according to Bludszuweit's stress formula[1]:

$$\sigma = \left[\frac{1}{6} \sum (\sigma_{ii} - \sigma_{jj})^2 + \sum \sigma_{ij}^2 \right]^{\frac{1}{2}} \quad (1)$$

where σ is the scalar stress (pa) and σ_{ij} is the stress tensor. In order to predict the blood damage, it is necessary to define a threshold shear stress value leading to blood cell damage.

Results

Figure 2 shows the results of 2,200 rpm on the stress distribution. The maximum scalar stress value reached in the back region is 245 N/m2. The threshold levels of 500 Pa have been reported as the design condition in the development of centrifugal blood pump for exposure times of 0.1 s. [2]. Therefore, exposing the blood cells to such levels of fluid stress will not likely result in blood trauma based on these computational results.

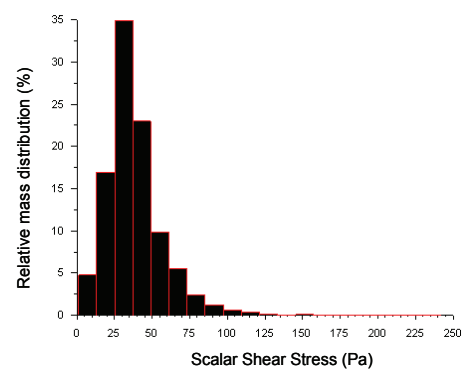

Figure 2 - Mass weighted distribution of scalar shear stress in clearance gap

In future studies, the CFD predictions will be compared quantitatively to data that are being obtained using PIV measurements.

References

[1] Apel, J., et al., Assessment of Hemolysis Related Quantities in a microaxial Blood Pump by Computational Fluid Dynamics. Artificial Organs 2000:25 pp. 341-347
[2] Paul, R., et al., Shear stress related blood damage in laminar coquette flow. Artificial Organs 2003:27 pp. 517-529