

THE EFFECT of VARIOUS ASSIST LEVELS of LEFT VENTRICULAR ASSIST DEVICE on RISK of STROKE

Kaiyun Gu, Yage Zhang, Bin Gao, Yu Chang*, Yi Zeng

The college of Life Science and Bio-engineering
Beijing University of Technology
Beijing, 100124, P. R. China
changyu@bjut.edu.cn

Key Words: *LVAD, stroke, discrete phase, thrombi distribution.*

Objective: The rate of thrombosis has increased among patients who received the left ventricular assist device (LVAD)[1], leading to the increase of stroke. However, the hemodynamic effect of various assist levels of LVAD on the thrombi distribution is still sparks bitter controversy. In this paper, we used the numerical simulation of discrete phase to study this problem.

Methods: In this study, the blood assist index (BAI)[2], which was defined as the ratio of the blood pump energy and the total energy of the cardiovascular system integration in a cardiac cycle time average, was proposed to evaluate the assist levels of LVAD (BAI: 0%, 25%, 50%, 75% and 80%). We use particle trajectory to evaluate the movement of thrombus. Aorta bifurcation vessels and the left and right common carotid artery and subclavian artery mainly for brain blood flow. Figure 1 shows the reconstructed model which geometric structure comes from a patient. The model is extracted from CT data of the patient and reconstructed by using commercial software MIMICS. The conditions were set up, such as blood was effectively an incompressible fluid, the density of blood taken to be $1050 \text{ kg} \cdot \text{m}^{-3}$, a dynamic viscosity of $0.0035 \text{ Pa} \cdot \text{s}$, the density of thrombi taken to be $1117 \text{ kg} \cdot \text{m}^{-3}$, and the buoyancy force was neglected. 476 particles with 2mm diameter were randomly released at the inlet plane of the ascending aorta. For the inlet and outlets, the data are calculated from lumped parameter model, as shown in Figure 1.

Results: The particles distribute in different export, which shown that discrete phase can calculation the thrombi distribution. We statistics the ratio of thrombi distribution by 10 cardiac cycles in Table 1, which are the proportion of the number of outlets particles and the total grain counts. In the BAI of 0%, the particles flowing the cerebral embolism rates is 33.98%. In the BAI of 80%, the maximum is 38.95% flowing to the cerebral embolism. The maximum error of this method is about 14.6%.

Conclusion: LVAD under various Assist levels had no obvious difference on the risk of stroke.

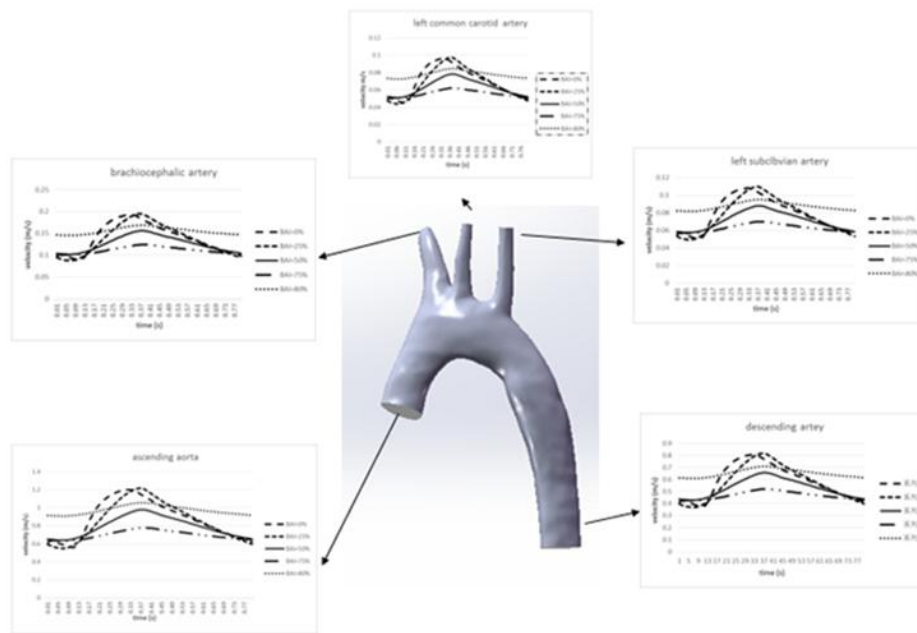


Figure 1 the reconstructed model and boundary conditions

Table 1 the ratio of thrombi distribution

BAI	Brachiocephalic artery	Left common carotid artery	Left subclavian artery	Descending aorta	Cerebral embolism rates
0%	20.09%	6.19%	7.69%	66.02%	33.98%
25%	19.97%	6.07%	8.24%	65.72%	34.28%
55%	18.64%	6.79%	8.11%	66.46%	33.54%
75%	20.14%	6.71%	9.49%	63.66%	36.34%
80%	20.05%	8.53%	10.37%	61.05%	38.95%
maximum relative error	7.2%	37.8%	34.8%	7.5%	14.6%

Acknowledgments: This work partly sponsored by the National Natural Science Foundation of China (Grant No. 11272022, 11372014, 11072007, 1122001). This work was also sponsored by Excellent Talents of Beijing (2013D008018000003), the BJUT Foundation Fund (015000514312002) and BJUT Talent Found and BJUT RIXIN Back-up Found (015000543114518).

REFERENCES

[1] Starling, R. C., Moazami, N., Silvestry, S. C., Ewald, G., Rogers, J. G., Milano, C. A., et al (2014). Unexpected abrupt increase in left ventricular assist device thrombosis. *New England Journal of Medicine*, 370(1), 33-40.

[2] Gao B, Gu KY, Zeng Y, Liu YJ, Chang Y, A Blood Assist Index Control by Intra aorta Pump : A Control Strategy for Ventricular Recovery[J]. *ASAIO JOURNAL*, 2011, 57(5) : 358-362.

[3] Gu KY, Chang Y, Gao B, Liu YJ, Zhang Z, Wang F. Lumped Parameter Model for Heart Failure with Novel Regulating Mechanisms of Peripheral Resistance and Vascular Compliance[J]. *ASAIO JOURNAL*, 2012, 58(3) : 223-231.