ENGINEERING

McMaster University

Project 2 – Independent Research Summary

Bi-Leaflet Mechanical Heart Valves

ENGINEER 1P13 – Integrated Cornerstone Design Projects

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Submitted: December 10, 2020

Executive Summary

For more than 100 million individuals worldwide, valvular heart disease is a significant health concern and has a strong rate of mortality. In the treatment of valve heart disease, the bileaflet is a mechanical heart valve with a long service life and reliable performance.[1] A replacement heart valve is a device meant to fulfill the function of any of the heart's natural valves. Bi-leaflet mechanical heart valves are comprised of two semi-lunar disks linked by narrow hinges to a rigid ring. The standard materials used to make these valves are graphite, nitinol, Polyethylene Terephthalate, Pyrolytic Carbon (LTI) paint, Polytetrafluoroethylene and Titanium alloys. [2]

References

[1] W. Li, Z. Gao, Z. Jin, and J. Qian, "Transient Study of Flow and Cavitation Inside a Bileaflet Mechanical Heart Valve," *Appl. Sci.*, vol. 10, no. 7, p. 2548, 2020.

[2] Ansys Granta EduPack software, Granta Design Limited, Cambridge, UK, 2020

Annotated Bibliography

[3] P. Rajashekar and others, "Development of mechanical heart valves-an inspiring tale," *J. Pract. Cardiovasc. Sci.*, vol. 1, no. 3, p. 289, 2015.

In this study, the author identifies that the Prosthetic heart valves have been designed to look for biocompatible materials and hemodynamically tolerant designs. The quest for preventing thromboembolic complications and the related side effects of mechanical prothesis valves and durability of anticoagulation lead to bioprosthesic tissue valves. They thought more about the time it took to suture or mount the valve to the heart, so that the

valve would remove the need to suture the prosthetic valve. Mechanical fixation took just a few minutes to execute. The basic characteristic of this fixation was the application of many curved pins in the aortic annulus to hold the valve.

[4] M. Grigioni, C. Daniele, G. D'Avenio, and V. Barbaro, "The influence of the leaflets' curvature on the flow field in two bileaflet prosthetic heart valves," *J. Biomech.*, vol. 34, no. 5, pp. 613–621, 2001.

In this research the authors investigate about the structure and geometry of the bileaflets. The geometry of the two leaflets, which can be very significant in deciding the flow area, is a key feature of bileaflet valves. A thorough analysis of the speed and turbulence shear stress peak (TSSmax) values was performed at four distances from the valve plane with Laser doppler anemometry (LDA). TSSmax is the important parameter for determining the risk of the implantation of a prosthetic system with hemolysis and platlet activation, communicating continuously with blood.

[5] M. J. King, J. Corden, T. David, and J. Fisher, "A three-dimensional, time-dependent analysis of flow through a bileaflet mechanical heart valve: comparison of experimental and numerical results," *J. Biomech.*, vol. 29, no. 5, pp. 609–618, 1996.

The authors describe in this research that during the first study, the flow through a bileaflet mechanical heart valve during the first half of systole was predicted using computational fluid dynamics. A three-dimensional ventricle, valve, and ventricle model There was also the development of a three-dimensional ventricle,valve ,ventricle model sinus and aorta geometry. The flow through the valve was assumed to be Newtonian and Laminar. The

model was considered to provide a fair predictor of prevailing patterns of downstream flow.

Additional References

[6] L. Goubergrits, U. Kertzscher, and M. Lommel, "Past and future of blood damage modelling in a view of translational research," *Int. J. Artif. Organs*, vol. 42, no. 3, pp. 125– 132, 2019.

[7] S. Guhathakurta and S. Galla, "Progress in cardiovascular biomaterials," *Asian Cardiovasc. Thorac. Ann.*, vol. 27, no. 9, pp. 744–750, 2019.

[8] E. Sandrine, "In the Wake of the 'Implant Files': Unheard Ideas to Make Device-Based Therapies safer and always more Innovative."