Computational Evaluation of Platelet Activation Induced by a Bioprosthetic Heart Valve

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It is known that bioprosthetic heart valves (BHVs) have better hemodynamics and lower thromboembolic events compared with their mechanical counterparts; however, patients implanted with BHVs still face the potential of such complications. The risk of a clinical thromboembolism is on average 0.7% per year in patients with tissue valves in sinus rhythm. In this study, we developed a computational fluid dynamic (CFD) model of a BHV implanted in an aortic root and investigated the BHV-induced platelet activation using a damage accumulation model previously applied to mechanical valves. The CFD model was validated against published experimental data, including the flow velocity profile across the valve and the transvalvular pressure drop, and close matches were obtained. Hemodynamic performance measures such as flow velocity, turbulent kinetic energy, and wall shear stress were explored. Lagrangian particle tracking was used to calculate the extent of platelet activation for central bulk flow and flow in the vicinity of the leaflets. A peak flow of 2.22 m/s was observed at 40 msec after peak systole in the vicinity of a fold at the base of the leaflets. With the platelet activation expressed as 0?100% of activation threshold levels, mean damage on one pass was $2.489 \times 10^{?7}$% and maximum damage on one pass was $8.778 \times 10^{?4}$%. Our results suggested that the potential for BHV-induced platelet activation was low and that the leaflet's fully open geometry might play a role in the extent of blood element damage.

Author Name:
Eric Sirois
Wei Sun
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