Hemodynamic design optimization of a ventricular cannula applying Computational Fluid Dynamics (CFD)

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Abstract

Nowadays, a Ventricular Assist Device (VAD) is a hope of clinic solution to patients with heart failure. This study presents the design of the "trumpet mouth" ventricular cannula (TMVC) connected to a pediatric VAD, optimized to reduce the conditions that generate blood damage. The flow through the TMVC is analysed using Computational Fluid Dynamics (CFD) techniques. The optimization of the TMVC considered the turbulent and byphasic nature of the flow at the systolic and diastolic phases of the cardiac cycle. To assess the hemodynamic performance of the cannula, three geometric parameters were chosen as input or independent variables in the optimization: the cannula tip curvature angle (è) and the inner and outer curvature radii (R1 and R2). The output parameters or objective functions were the Modified Index of Hemolysis (MIH), the Modified Index of Platelet Lysis (MILpl) and the fluid pressure drop (ÄP). The mathematical optimization passed through an enhanced sampling process of combined scenarios of input parameters and thereafter, the response surface was generated using the Kriging algorithm. The selection of the geometric parameters that minimized MIH, MILpl and δP were obtained after the application of a Multi-Objective Genetic Algorithm (Moga) and the generation of Pareto fronts to obtain the points that met the established conditions of reduction of blood damage. The optimal geometric parameters for the ventricular cannula obtained through the optimization process are: è (27.29 degrees), R_1 (0.83 mm) and R_2 (0.20 mm). The final results showed a reduction in MIH for both cardiac phase configurations in the zone of the cannula tip and an overall reduction of 25% and 60% in the MIH and MILpl, respectively, compared to the damage for the cannula with nominal input parameters.

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