IMPELLER POSITION IN THE HEARTMATE 3 AND ITS IMPACT ON NUMERICAL HEMOCOMPATIBILITY ASSESSMENT

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Introduction

In magnetically levitated rotodynamic blood pumps (RPBs), such as the HeartMate 3, the impeller position depends on a balance of magnetic and fluid-dynamic forces. Thus, the impeller position is affected by different operating conditions with altered gap clearances around the impeller. These secondary flow channels between the impeller and housing are a major determinant of hemocompatibility [1]. The aim of this study was to measure the impeller position within the Heartmate 3 (HM3) over a wide range of operating conditions and to assess its impact on computational fluid dynamic (CFD) predictions of hemocompatibility.

Methods

Axial impeller position was measured with a laser sensor (Welotec GmbH, AWL7/4) through an acrylic glas replica of the lower volute casing of the HM3. Radial impeller position was determined by the HM3 system and confirmed by high-speed camera recordings. Experiments were conducted for five different speeds (3000 rpm, 4000 rpm, 5000 rpm, 6000 rpm, 7000 rpm) over the entire flow range and with three different water/glycerol mixtures (2.5 mPas, 3.5 mPas, 4.5 mPas).

To assess the impact of impeller position on hemocompatibility the HM3 pump with a centered and a displaced impeller was simulated in CFD at a clinically relevant operating point at 6000 rpm, 3.5 mPas and 5 l/min [2]. Washout time and normalized index of hemolysis (NIH) were calculated using a passive scalar approach [3]. To further investigate hemocompatibility of the pump several parameters including blood volume exposed to shear stresses above thresholds associated with different kinds of blood damage [4] as well as the gap flows were compared.

Results

Figure 1 shows the radial and axial displacement for 3.5 mPa s. The radial impeller displacement is maximum at 0 l/min and decreases with increasing flow rates. Higher viscosities lead to higher radial displacements. The axial displacement is minimal at around 0 l/min and increases with flow rate. For all conditions the tilting angle of the impeller axis is less than 1°. Corresponding to experimental data, for CFD analysis the impeller was displaced by 144 µm in axial and 60 µm in radial direction.

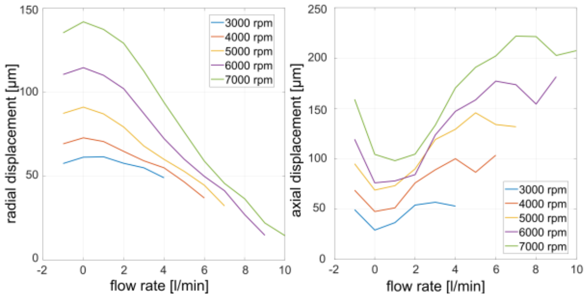

Figure 1: Radial (left) and axial (right) displacement for 3.5 mPa s and speeds form 3000 rpm to 7000 rpm.

CFD analysis revealed comparable values for global pump parameters (pressure head and flow rate) in both simulations (deviations of < 1 %). Numerical assessment of washout and NIH were not influenced substantially by the displaced impeller (< 2%). Most local parameters differed less than 4 %.

Discussion

In this study, the effect of operating conditions on radial and axial displacement of the HM3 impeller are reported to facilitate more accurate numerical predictions of hemocompatibility. Accompanying CFD simulations suggest that in the investigated operating point a displaced impeller has no considerable impact on global pump parameters including washout and NIH. Further assessment and analysis of different operating conditions and the effect of impeller position on local flow phenomena are ongoing. Of note, the impeller was displaced only stationary; hence, dynamic effects were not considered in this study.

References

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