Time-resolved PIV of the pulsatile flow from an ex vivo heart perfusion model

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HIGHLIGHTS

• Time-resolved PIV was applied to a high Womersley number flow regime generated by a peristaltic pump in a mechanical flow loop analogous to the left flow loop of an ex vivo heart perfusion (EVHP) system.
• Data was collected downstream from a compliant section representative of the in vivo human aorta.
• Results using a Newtonian fluid and a non-Newtonian fluid were compared based on non-dimensionalized velocity profiles taken at five time steps during one pump cycle.

ABSTRACT

In North America, only 36-39% of available donor hearts are successfully transplanted. This is often attributed to the narrow six hour time window currently available for transplantation and the fact that many donated organs are rendered unusable. A method called ex vivo heart perfusion (EVHP) enables the use of damaged donor hearts by preserving the heart’s beating function outside the body from the time of donation until transplantation. To date, research efforts have been directed towards understanding the metabolic environment required to sustain cardiac performance in the EVHP system, but now there is interest in understanding the effect of fluid dynamics on system performance. The region of most interest is the left flow loop which mimics an in vivo flow region characterized by the presence of the highly compliant aorta and significant unsteady effects. This work has undertaken the development of a mechanical flow loop analogous to the left side of the EVHP system with the ultimate intent of studying the effect of tubing compliance on both Newtonian and non-Newtonian fluids in a large Womersley number pulsatile flow regime. The focus of this investigation was to use time-resolved particle imaging velocimetry (PIV) to compare the flow fields obtained from Newtonian and non-Newtonian fluids using the well-understood symmetric pulsatile flow from a peristaltic pump. Results were compared based non-dimensionalized velocity profiles obtained at five time steps during one pump cycle. The resulting profiles (Fig. 1) indicate that fluid viscosity has a significant effect on the generated flow fields in high-frequency pulsatile flow regimes.

![Fig. 1 Non-dimensionalized velocity profiles obtained for Newtonian (water) and non-Newtonian (0.2 wt.% aqueous solution of polyacrylamide) fluid at five times during pump cycle: (a) t/τ = 0.2, (b) t/τ = 0.4, (c) t/τ = 0.6, (d) t/τ = 0.8, (e) t/τ = 1.0]