PIV Measurements with high temporal Resolution behind Artificial Heart Valves

R. Kaminsky[1,3], M. Rossi[2], L. Scalise[2], S. Kallweit[3], P. Verdonck[1]
[1] Institute Biomedical Technology, Ghent University, Belgium
[2] Universita Politecnica delle Marche, Ancona, Italy
[3] ILA GmbH, Jülich, Germany

There are approximately 225,000 heart valve surgical procedures performed worldwide each year. The performance of different heart valve types is, beside others, mostly given by the quality of the blood flow in all regions within and behind the valve itself. PIV measurements with high temporal resolution is an accepted experimental tool to compare the quality of the blood flow across heart valves. The flow behind an two fiffernt types of artificial aortic heart valve was investigated in a mock-up in a collaboration between University Politecnica delle Marche (Ancona,Italy) and ILA GmbH (Jülich, Germany). The time-resolved 2D PIV measurements show the time evolution of the flow behind a bileaflet Carbomedics valve and a monoleaflet Bjork-Shiley Monostrut heart valve. The combination of a Nd:YLF high-repetition-rate double-cavity laser with a high frame rate CMOS camera allows the detailed acquisition of the time-dependent, unsteady flow dynamics behind the two different valves. The flow behind the tilting disc valve is characterized by a strong unsteady and asymmetric flow pattern, high degree of turbulence, peak velocities up to 1m/s in contrast with the features observed for the flow behind the bileaflet valve. homogeneous and symmetric flow pattern leading to a lower degree of turbulence.
A comparison of the shear strain distributon at maximum average flow velocity is an estimate of the valve's potential for blood damage. The shear strain distribution for the bileaflet valve is higher near the arterial wall and the two wakes of the valve flaps are visible close to the outlet. The shear strain distribution for the monoleaflet valve is strongly inhomogenous. The wake of the valve flap is clearly visible and turbulent structures due to the unsteady behaviour of the flow are dominating the shear strain distribution. As a result the tested monoleaflet has more potential for blood damage compared to the tested bileaflet valve.

Correspondence to: Rado Kaminsky, ILA GmbH, Karl-Heinz-Beckurststr. 13, Julich, Germany, Email: rado@ila.de