<table>
<thead>
<tr>
<th><strong>Title</strong></th>
<th>Measurement of cardiovascular device flow at scales approaching cell size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Author(s)</strong></td>
<td>Bellofiore, Alessandro; Quinlan, Nathan J.</td>
</tr>
<tr>
<td><strong>Publication Date</strong></td>
<td>2009-09-24</td>
</tr>
<tr>
<td><strong>Item record</strong></td>
<td><a href="http://hdl.handle.net/10379/689">http://hdl.handle.net/10379/689</a></td>
</tr>
</tbody>
</table>

Some rights reserved. For more information, please see the item record link above.
Measurement of Cardiovascular Device Flow at Scales Approaching Cell Size

Alessandro Bellofiore, Nathan J. Quinlan
National Centre for Biomedical Engineering Science and Dept. of Mechanical and Biomedical Engineering, National University of Ireland, Galway, Ireland
alessandro.bellofiore@nuigalway.ie

Mechanical heart valves (MHVs) are still used in about half of all heart valve replacements because of their unrivalled durability. Even so, the models currently implanted induce haemolysis and thrombosis, attributed to abnormal flow patterns. Although the short duration of forward flow prevents the development of a full turbulent spectrum, complex unsteady flow features develop across a range of length and time scales [1]. The objective of this research is to determine the microscale flow structures experienced by cells.

To capture the small scales of the turbulent flow, we have developed a 5.8:1 scaled-up aortic MHV model, enabling particle image velocimetry (PIV) measurements at spatial resolution of 50 µm and temporal resolution of 570 µs in equivalent physiological scale. This resolution is unprecedented; recent state-of-the-art PIV measurements are at resolution of 135 µm / 67000 µs [1], 1200 µm / 333 µs [2] and 120 µm / 570 µs [3]. Complete similarity with the physiological-scale valve is ensured by preserving relevant dimensionless parameters. Measurements are taken in a realistic aortic flow waveform, with a peak Reynolds number of 6000 and leaflets fixed in the open position.

The figure shows a typical instantaneous velocity map collected 18 mm downstream of the leaflet tip at peak systole, directly revealing the smallest structures in the local field. (All dimensions and velocities are expressed in equivalent physiological scale.) Intensity and duration of instantaneous shear stress are measured in the range of detectable length scales throughout the heart cycle to evaluate their potential for blood damage.

Acknowledgement
This research is supported by Science Foundation Ireland under grant RFP-07-ENMF450.

References