Shear Rates Derived From Ultrasound Images and Particle Image Velocimetry

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Shear stress is a primary determinant of endothelial function. Shear rates calculated from pulse wave Doppler (PWD) are of limited value as the large sample volume limits spatial resolution. Particle image velocimetry (PIV) applied to ultrasound derived images may be used to determine shear rates and corresponding shear stress.

Latex tubing (0.6 cm. diameter) was suspended in a plexiglass flow chamber with an acoustic window for ultrasound interrogation. Five dilutions of pentaspan and voluven, using normal saline, were driven by a commercial fluid pump at steady flow. Ultrasound images were acquired with a linear probe at 10 MHz and a frame rate of 78 frames per second. Echo-contrast was added to the solutions until images appropriate for analysis with PIV were obtained. Mid-tubing velocity was determined by pulse wave Doppler to provide a standard for comparison.

Echo PIV (ePIV) derived velocities corresponded closely to theoretical values derived using Poiseuille's Law. Closest fit was achieved for 100% normal saline with <4% difference between the ePIV and theoretical velocity profiles. A close fit was achieved between pentaspan ePIV and theoretical wall shear stress values at 25°C at all concentrations.

EPIV represents an improved means of quantifying fluid velocity profiles, and shear stress. Unlike Doppler and MRI, PIV is not dependent upon the angle of interrogation and does not require high cost scans to reconstruct the volume. ePIV can also be applied to study flow characteristics *in vivo* within implanted devices in the heart including heart valves and stents.