Supplementary Material

# Description of viscous energy loss rate

Viscous energy loss rate (VELR) represents the rate of flow mechanical energy loss due to friction between two adjacent fluid layers moving at a different velocity (i.e., fluid shear).[1] Assuming blood as an incompressible and Newtonian fluid, VELR per unit volume can be calculated as,

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where indicates the dynamic viscosity and indicates the velocity component along direction where , and correspond to the Cartesian axes , and , respectively. A dynamic viscosity of 3.2 cP was assumed for blood in the aorta.[2]

# Description of vorticity

Vorticity represents the angular velocity vector of a fluid element under rotation present when flow becomes spatially nonuniform and increases as flow exhibits stronger turbulent or faster vortical flow motion. Vorticity ( is a vector quantity calculated by taking the curl to the velocity vectors,

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where first, second and third element corresponds to the vorticity components along , and axis, respectively.

1. P. K. Kundu and I. M. Cohen. Fluid Mechanics, fourth edition. Elsevier; 2008. p. 112-113.

2. N. Westerhof, N. Stergiopulos, M. I. Noble, et al. Snapshots of hemodynamics: an aid for clinical research and graduate education: Springer; 2018.