

144i Determination of Shear on Cells Grown in Culture Dishes on a Shaker Table Using Computational Fluid Dynamics

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The effects of hemodynamic forces on cellular responses have been studied for more than thirty years, but the mechanisms linking cause and effect are still not well known. Wall shear stresses are widely accepted as the primary influence affecting characteristics of anchored cells subjected to fluid flow. Orbital shakers are ideal for in vitro cell culture experiments and are widely used throughout the cell culture industry because of their simplicity. More importantly, orbital shakers provide oscillatory flow, somewhat like that experienced by pulsing fluid movement in the human vasculature system. Despite the prevalence and simplicity of usage, few have attempted to employ the orbiting shaker apparatus as a means for correlating shear stresses to cellular responses due to the complexity involved in accurately calculating wall shear stresses exerted by the fluid.

The role of computerized flow modeling with computational fluid dynamics (CFD) in vasculature applications is rapidly increasing due to the advancement of high performance computing and commercially available software used for simulating, visualizing, and analyzing fluid flow. Computational models that solve the Navier-Stokes equations for pulsatile flow provide a means to predict fluid dynamic properties that are difficult to or cannot be determined in vivo. Despite advancements in CFD capabilities, the oscillatory fluid motion in one of the most common in vitro cell culture apparatuses, an orbiting shaker, has yet to be modeled.

This project employs CFD modeling to describe fluid behavior in in vitro cell cultures resulting from motion imparted by an orbital shaker apparatus. These computationally derived results are compared with prior, less sophisticated estimates presented in the literature and with the limited data available from other experimental methods. Simulation results for preliminary cases predict maximum wall shear stresses equal to three and four times less than what current estimation techniques predict.

To fully characterize the flow regimes, limits of non-dimensional variables, such as the Stokes Number, Froude Number, and slope ratio will be explored. Knowledge of the fluid dynamics inside an orbiting cylinder, covering a comprehensive set of operating conditions will significantly enhance the usefulness of simple shaker apparatuses in the study of hemodynamic effects on endothelial cell cultures.