Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

Journal of Health Disparities Research and Practice

Volume 9
Issue 5 *Special Issue - NIDDK STEP UP*

Article 71

2016

Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

Zulikayida Maimaiti
Max J. Lerman, BS , *Univeristy of Maryland College Park*
John P. Fisher, PhD , *University of Maryland College Park*

See next page for additional authors

Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

Abstract

Three-dimensional perfusion bioreactors have been shown to enhance cell viability and function through improved nutrient exchange. However, the ideal bioreactor scaffold geometry is still unknown. The focus of this study is to use computational fluid flow studies to inform bioreactor design. Specifically, we will model the effect of bioreactor design on fluid shear stress and then correlate these values with stem cell viability in the bioreactor. Previous studies have shown that the maximum shear stress level for the viability of human mesenchymal stem cells (hMSCs) is 0.3 dynes/cm^2. Two distinct Computer Aided Design models were created consisting of parallel planes of pillars (0.5 mm diameter, 2 mm height) in a linear array with 1 mm center to center spacing. One design consists of seven horizontal layers inserted into a 3D printed housing while the other consists of five layers encapsulated by a cylinder matching the inner diameter of silicon tubing (0.5 in). For *in vitro* testing, both scaffold designs were created by 3D printing and were coated with collagen to facilitate hMSC adhesion. To quantify results, hMSCs were harvested from the scaffolds for analyses by picogreen DNA quantification for total DNA and cell viability, and immunohistochemical markers for stem cell population maintenance. In the effort to establish a predictive model, we will compare the flow simulation results to the degree of cell proliferation in the bioreactor experiment. The significance of cell proliferation will indicate further improvements on the bioreactor design.

Keywords

Computation Flow Modeling; Bioreactor; 3D Printing

Authors

Zulikayida Maimaiti; Max J. Lerman, BS; John P. Fisher, PhD; and Jesse K. Placone, PhD

Journal of Health Disparities Research and Practice
Volume 9, Special Edition 1, Summer 2016, pp. 105

School of Community Health Sciences
University of Nevada, Las Vegas

Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

Zulikayida Maimaiti
Max J. Lerman, University of Maryland College Park
John P. Fisher, PhD, Fischell Department of Bioengineering and Department of Materials Science and Engineering, University of Maryland College Park
Jesse K. Placone, PhD**,** University of Maryland College Park
Coordinating Center: Stanford University

ABSTRACT

Three-dimensional perfusion bioreactors have been shown to enhance cell viability and function through improved nutrient exchange. However, the ideal bioreactor scaffold geometry is still unknown. The focus of this study is to use computational fluid flow studies to inform bioreactor design. Specifically, we will model the effect of bioreactor design on fluid shear stress and then correlate these values with stem cell viability in the bioreactor. Previous studies have shown that the maximum shear stress level for the viability of human mesenchymal stem cells (hMSCs) is 0.3 dynes/cm^2. Two distinct Computer Aided Design models were created consisting of parallel planes of pillars (0.5 mm diameter, 2 mm height) in a linear array with 1 mm center to center spacing. One design consists of seven horizontal layers inserted into a 3D printed housing while the other consists of five layers encapsulated by a cylinder matching the inner diameter of silicon tubing (0.5 in). For *in vitro* testing, both scaffold designs were created by 3D printing and were coated with collagen to facilitate hMSC adhesion. To quantify results, hMSCs were harvested from the scaffolds for analyses by picogreen DNA quantification for total DNA and cell viability, and immunohistochemical markers for stem cell population maintenance. In the effort to establish a predictive model, we will compare the flow simulation results to the degree of cell proliferation in the bioreactor experiment. The significance of cell proliferation will indicate further improvements on the bioreactor design.

Keywords: Computation Flow Modeling, Bioreactor, 3D Printing

ACKNOWLEDGEMENTS

The STEP-UP HS program is supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health, Grant number: R25DK078382.