

Modular Shear Stress Platform

Audrey Jebasingam and Dr. Patrick Journey
Biomedical Engineering Department, College of Engineering

Abstract

The goal of this project is to develop and characterize an automated flow loop to apply physiologic shear stresses to endothelial cells and platelets. Different steady, oscillatory, or pulsatile flow patterns can induce atheroprotective or atheroprone EC phenotypes. These phenotypes promote EC structure remodeling, cell transdifferentiation, actin gene expression, and activation of the NF-kappaB transcriptional pathway. Changes in different flow waveforms have shown to suppress anti-inflammatory, anti-oxidative, and anti-thrombotic mediators, like KLF2 and KLF4. The modular flow loop will allow for integration of novel microfluidic chip designs to study the effects of vessel geometry on endothelial cell function and platelet activation.

Project Activities or Findings

- Build a flow loop and flow chamber unit to produce steady, oscillatory and pulsatile shear stresses.
- 3-D print a flow chamber unit out of non-cytotoxic and biocompatible materials.
- Characterize the pressure and flow rates produced.

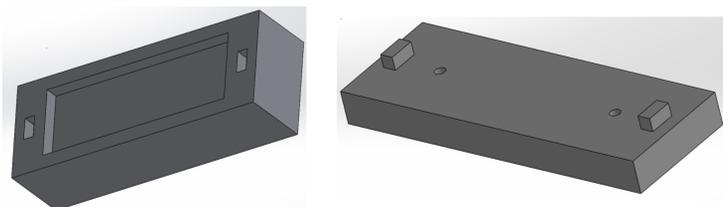


Figure 1: 3-D model of top and bottom part of flow chamber unit by using Solidworks to create design.



Figure 2: 3-D print of top and bottom part of flow chamber unit, printed in polylactic acid.

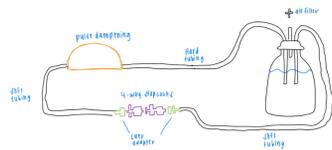


Figure 3: Sketch of the entire flow set up. The flow chamber unit will be inserted between the 4 way stopcocks.

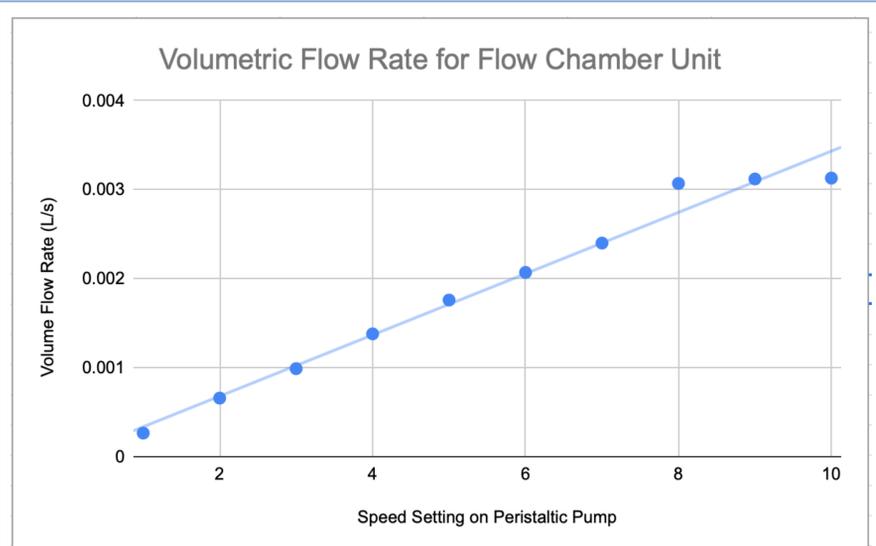


Figure 4: The volumetric flow rate from each speed setting on the peristaltic pump. The flow rate will need to match a similar flow rate inside blood vessels, in order to mimic in-flow into the flow chamber unit.

Research Questions

- *What is the impact of blood flow on endothelial cells under different inflow and shear stress conditions?*

Citations

Baeyens, N., Bandyopadhyay, C., Coon, B. G., Yun, S., & Schwartz, M. A. (2016). Endothelial fluid shear stress sensing in vascular health and disease. *Journal of Clinical Investigation*, 126(3), 821–828. doi: 10.1172/jci83083

Lee, J., Estlack, Z., Somaweera, H., Wang, X., Lacerda, C. M. R., & Kim, J. (2018). A microfluidic cardiac flow profile generator for studying the effect of shear stress on valvular endothelial cells. *Lab on a Chip*, 18(19), 2946–2954. doi: 10.1039/c8lc00545a