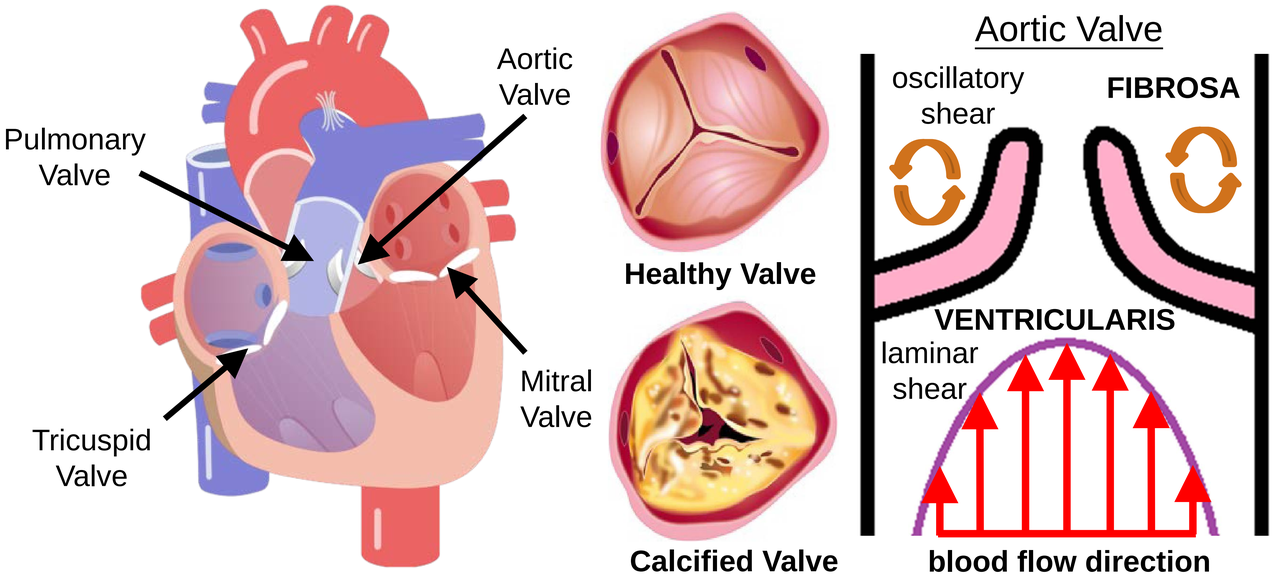
Assembly of a Pulsatile Flow Bioreactor System to Facilitate Oscillatory-flow Conditions to Optimize *In Vitro* Engineered Valve Tissue Growth

Denise Hsu[1], Manuel Perez[1], Elnaz Pour Issa[1], Maria Montesinos[1], Brittany Gonzales[1], Alejandro Pinero[1], and Sharan Ramaswamy[1]

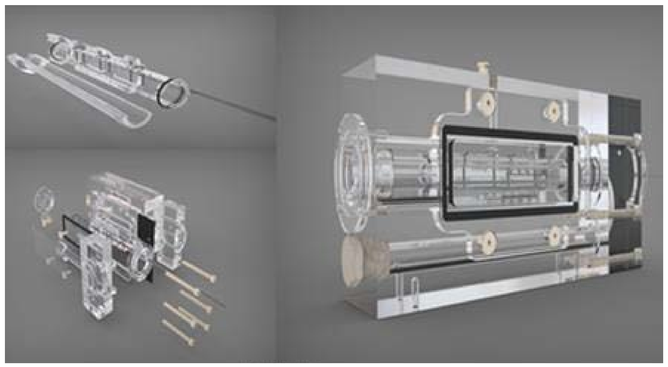
[1] Department of Biomedical Engineering, Florida International University, Miami, FL

Introduction



- Applications of tissue engineering and regenerative medicine show promise in cardiovascular diseases, which are the world's leading causes of death.
- Fluid shear stresses have been shown to influence growth of engineered tissues.
- The human cardiovascular system is subjected to pulsatile flow and pressure from heart pulsation, and this pulsatile flow subjects heart valves to oscillatory shear stresses.
- To study the effects of pulsatile flow and oscillatory shear stresses on cardiovascular tissue development, we developed a bioreactor that mimics the human hemodynamic environment.

Methods

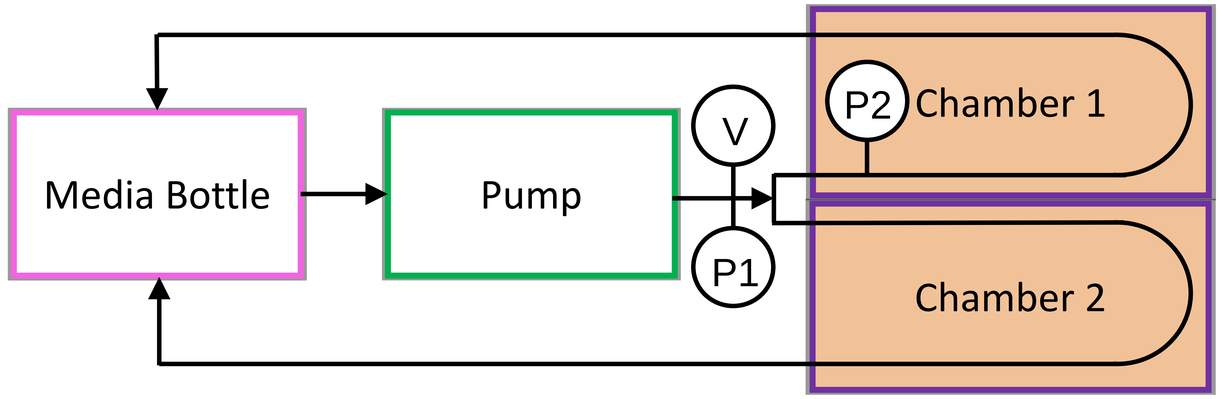


Bioreactor Conditioning Chamber Assembly

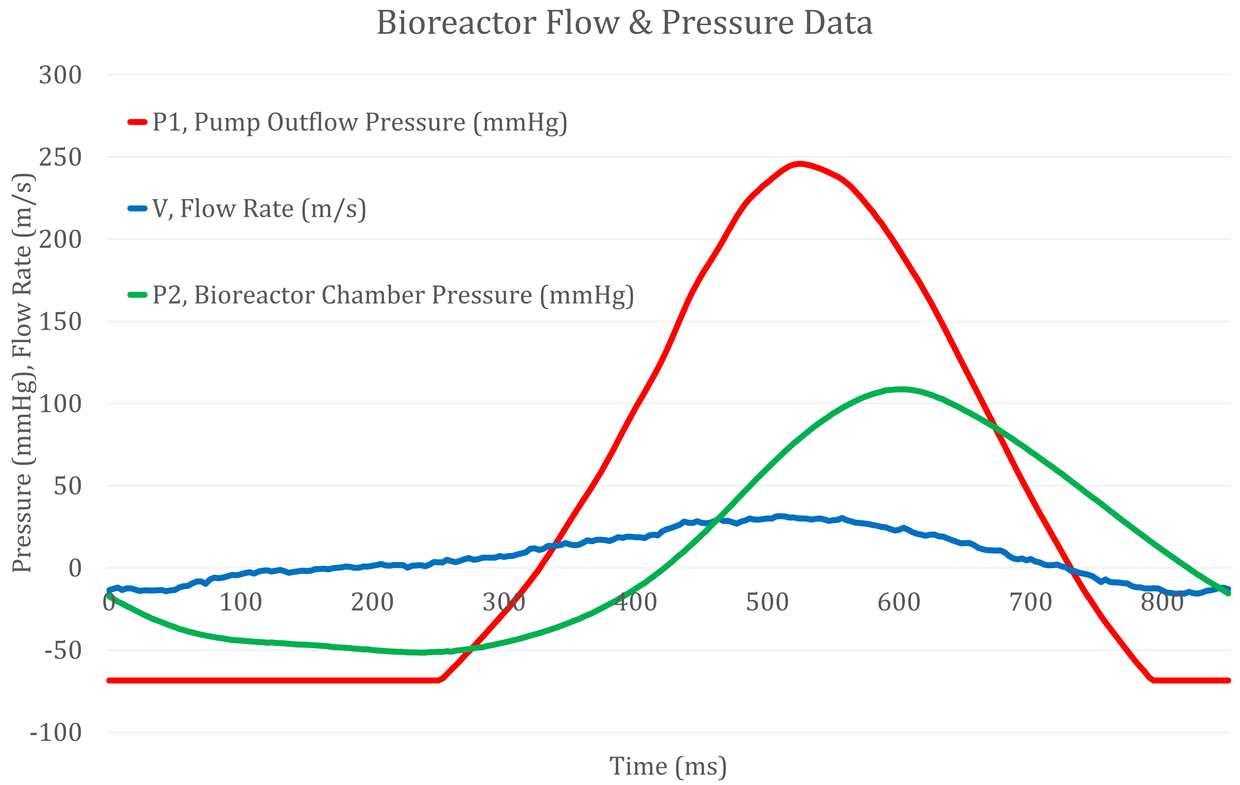
Vivitro Pulse Duplicator

- Bioreactor flow loop schematic and chamber assembly consists of a previously designed U-shaped tubular system (Ramaswamy JBME, 2014), connected to pulse duplicator pump system (Vivitro Systems, BC, Canada).
- Pressures and velocities were recorded at pump outflow and inside the bioreactor chambers, using pressure transducers and flow probes from Vivitro Pulse Duplicator (Vivitro Systems, BC, Canada).
- Flow and pressure sensors were embedded in the flow loop.
- Vivitest software was used to obtain relevant hydrodynamic data.
- With known diameters and the Bernoulli's equation, flow inside the bioreactor chamber can be determined.

$$\frac{\rho V_2}{2} + P_2 + \rho g z_2 = \frac{\rho V_1}{2} + P_1 + \rho g z_1$$



Results



- The downstream flow profile for a full cardiac cycle was determined based on sensor data.
- From the pressure values, a phase lag exists between pump output and inside the bioreactor chambers, however, distinct pulsate profile was apparent inside the chamber and within the physiological range, indicating that the system is capable of reproducing desired oscillatory flow conditions.

Conclusions

- We integrated an *in vitro* bioreactor system that imparts physiologically relevant pulsatile flow-based, oscillatory shear conditioning to 3D tissue constructs.
- Re-creating fluid-induced stresses will further facilitate mechanobiological investigations in heart valve development.