Artificial Cardiovascular and Hemodynamics Experiment (ACHE)

TEXAS A&M UNIVERSITY Engineering

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TEXAS A&M UNIVERSITY
ROBOTICS TEAM & LEADERSHIP EXPERIENCE

Intro & Problem Definition

Heart Failure affects over 25 million people worldwide and brings nearly a million new cases each year. [1] While assisting devices such as LVADs currently provide support, the massive prevalence of incurable heart failure often escalates to far too many biventricular failure cases. As transplant options are limited, Total Artificial Hearts (TAH) promise a scalable future treatment.

Usage in Industry

While TAH technology is still on the bleeding edge, various TAH designs have shown success worldwide. Only two models are currently approved for human trials in the United States:

BiVacor:

Pros:

- Single moving part and compact design
- Reduced hemolysis compared to prev designs

Cons:

- Continuous flow vs physiological pulsatility [2]
- Thrombogenic risk requires aggressive anticoagulation

SynCardia Total Artificial Heart:

Pros:

- Pulsatile flow maintains arterial compliance and organ perfusion
- Variable cardiac output responsive to patient

Cons:

- External pneumatic driver weighs 13.5 lbs
- Percutaneous drivelines increase infection risk

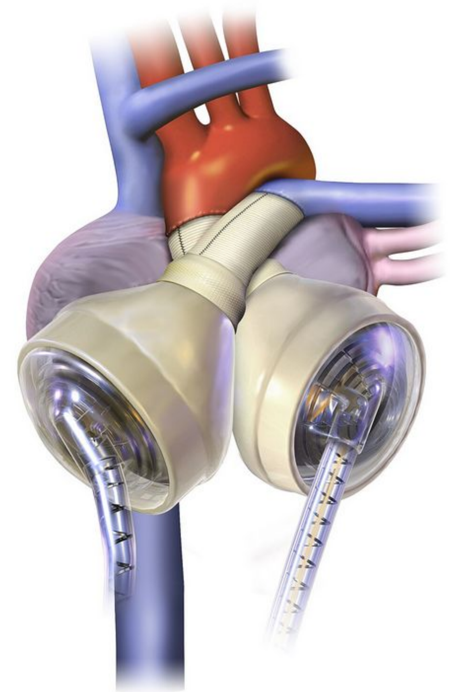


Figure 1. *SynCardia Total Artificial Heart*

Luciasyncardia, CC BY 4.0, via Wikimedia Commons

Mission Statement

Our mission is to engineer a total artificial heart (TAH) that replicates the human heart's pumping mechanism through controlled contraction and relaxation while minimizing the weight and size of external drivers. By integrating fluid simulation and a dual-ventricle prototype, we aim to explore key principles of cardiovascular biomechanics, validate our design against current TAH benchmarks, and enhance our understanding of biomedical device development.

Mechanical

This semester we designed a 3D printed mold of a single ventricle for silicone casting.

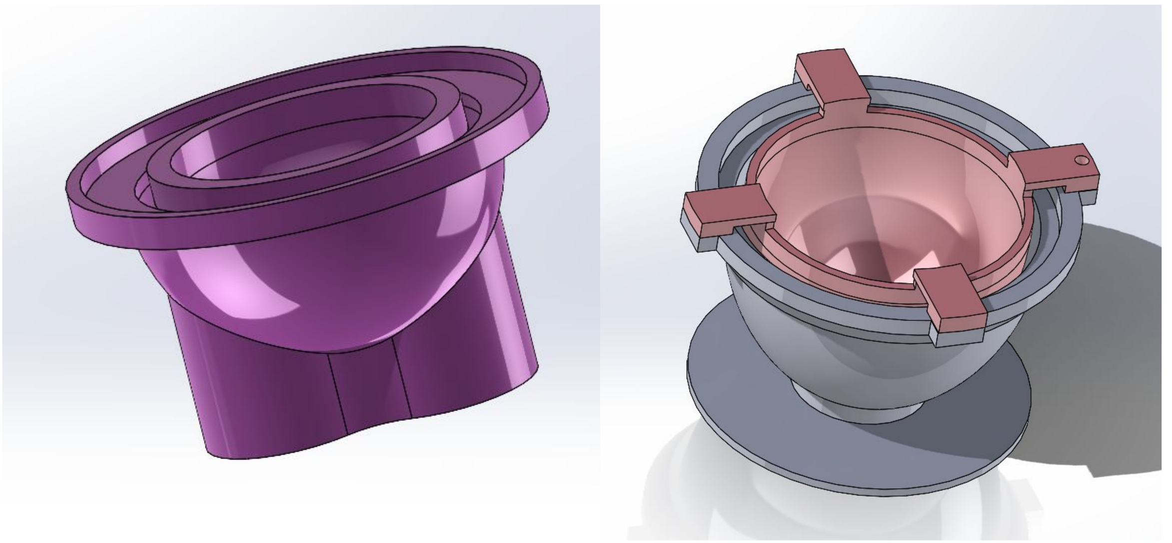


Figure 2. *First silicone mold 3D CAD*

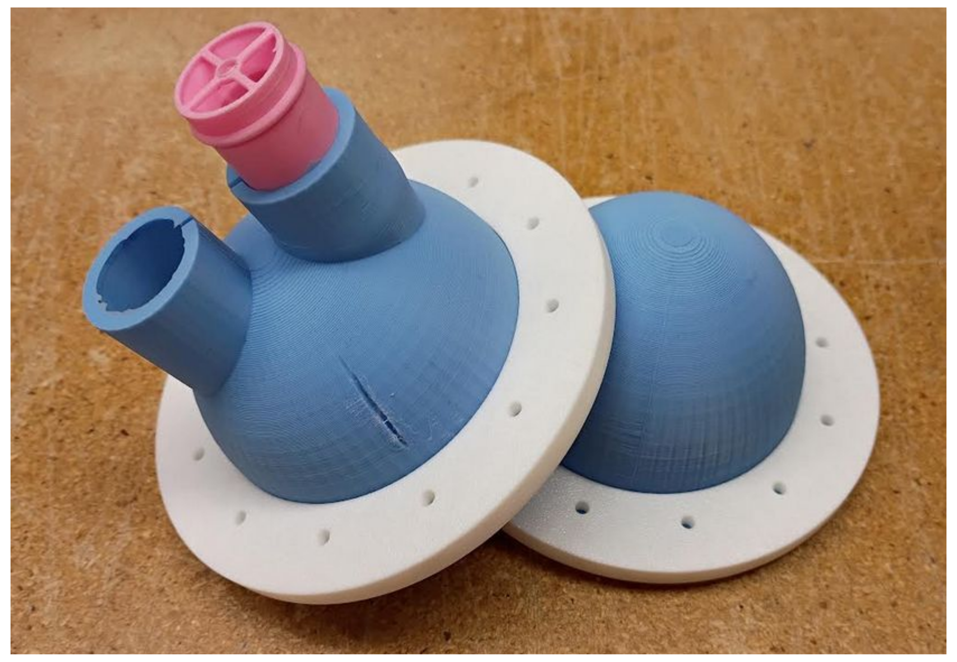
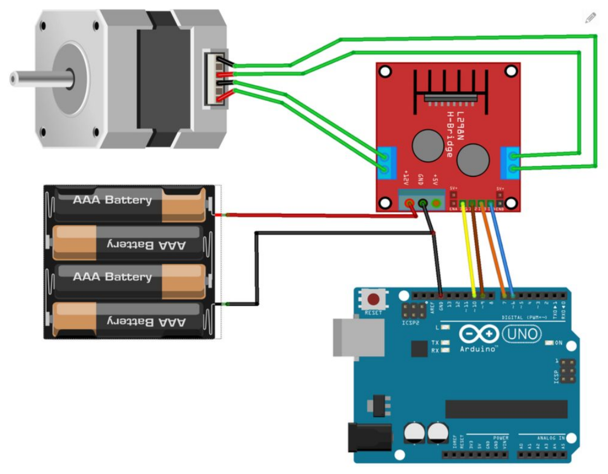


Figure 3. *Initial Silicone prototype with check valve and ring clamp*

Our first prototype used Shore 50A silicone and is actuated with helically wrapped cables, based on aspects of the design developed by Arfaee, et al. [3]

This allows us to begin gathering pressure and force measurements and explore core device principles.

Electrical



Testing will be done using components which we had access to previously.

Figure 4. *Wiring Diagram for Bipolar* **Nema 17** *Stepper Motor With L298N Motor Driver Module [2].*

Simulation

This semester, we began learning Ansys Fluent to use in simulating our TAH design for optimization.

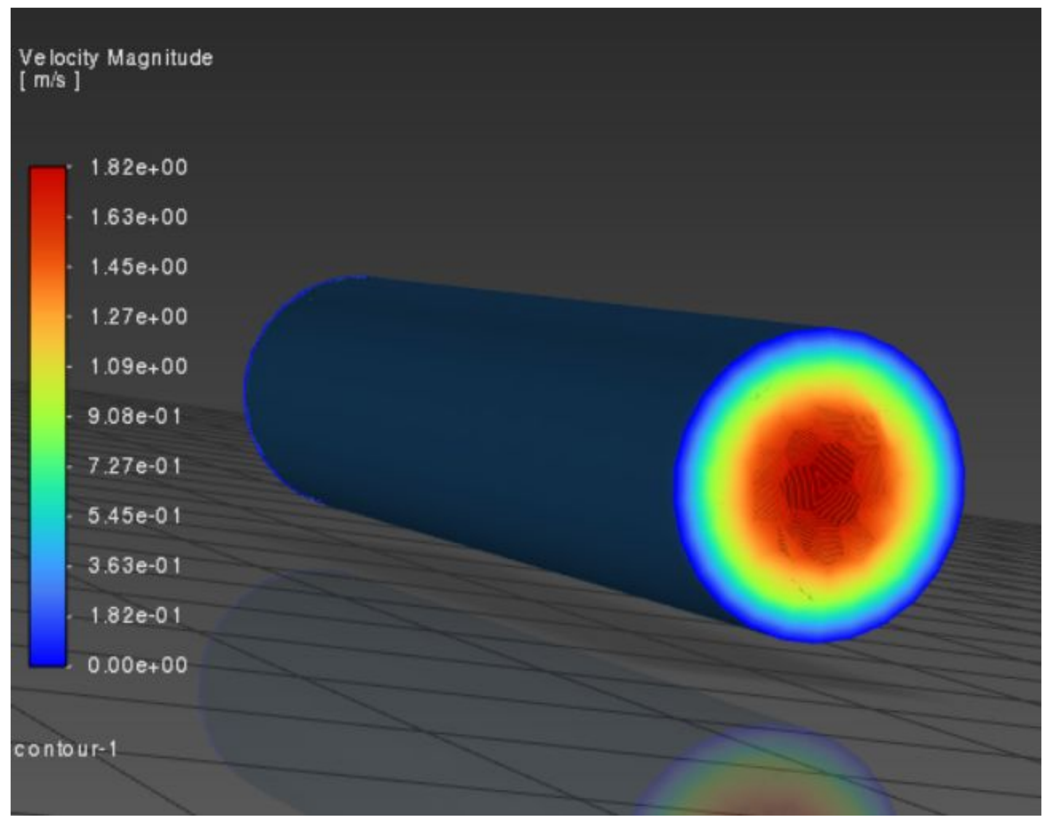


Figure 5. *Velocity measurements of water through pipe in Ansys Fluent*

The following interface was used to visualize data gathered from the model in this manner:

- A blood pressure was determined by measuring a "systolic" pressure reading when the model was contracted and a "diastolic" reading when the model finished contracting
- MAP was calculated using these readings, and a heart rate was calculated by determining how fast the model pumped
- Continuous pressure readings are plotted on a rolling basis compared to a continuous "EKG" reading that modeled the signals being sent to the model to contract

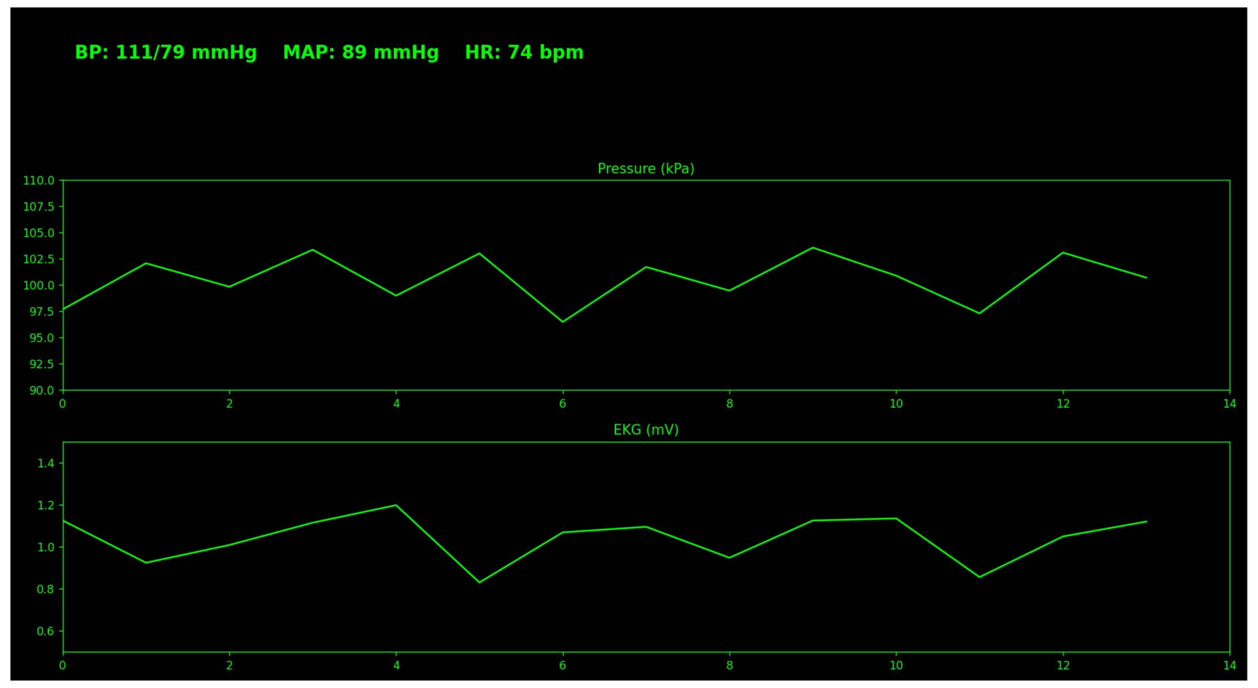


Figure 6. *Blood pressure measurements using simulated data.*

Next Steps

1. Fully develop a singular ventricle pump
2. Analyze different actuation methods to determine the smallest, most efficient system
3. Develop concrete testing plans
    - Ansys fluid simulations
    - Qualitative wear tests
    - Measured pressure and cardiac output
4. Decide between silicone and TPU soft shells
    - Elasticity and volumetric displacement
    - Long-term wear
5. Develop two functioning ventricles
6. Synchronize the ventricles with the body's control systems
7. Choose electrical components based on testing data
8. Redesign more compact and durable prosthetic

Sources

[1] Savarese G, Lund LH. Global Public Health Burden of Heart Failure. Card Fail Rev. 2017 Apr;3(1):7-11. doi: 10.15420/cfr.2016:25:2. PMID: 28785469; PMCID: PMC5494150.

[2] Nader Moazami, Walter P. Dembitsky, Robert Adamson, et al. Does pulsatility matter in the era of continuous-flow blood pumps?, The Journal of Heart and Lung Transplantation, https://doi.org/10.1016/j.healun.2014.09.012.

[3] Harsh291, "Bipolar Stepper Motor With L298N Motor Driver Module," in Fritzing, L. M. D. Module, Ed., ed. Instructables.

[4] Arfaee, M., Vis, A., Bartels, P.A.A. *et al.* A soft robotic total artificial hybrid heart. *Nat Commun* **16**, 5146 (2025). https://doi.org/10.1038/s41467-025-60372-6