THE UNIVERSITY of WISCONSIN MADISON

CT Circulation Phantom

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Overview

- Background
- Competing Designs
- Problem Statement
- Product Design Specifications
- Design Alternatives
- Design Matrix
- Future Work
- Acknowledgments

Background

- Computed Tomography (CT) Phantom
  - Mimics body for a CT Scanner
  - Realistically can be made from anything
  - Purpose is to calibrate scanner or to simulate a biological process [2]

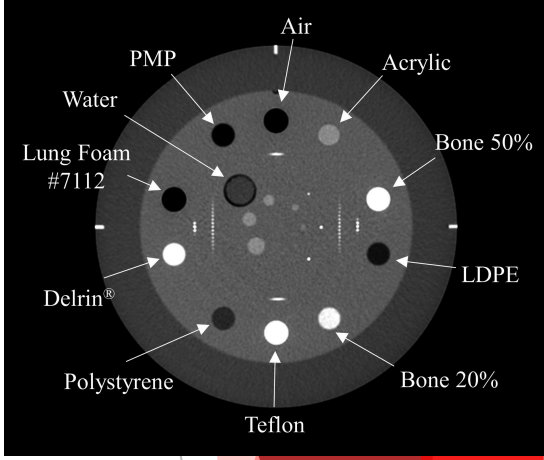


Figure 1. Example of a calibration phantom [1]

Background

- For use with VA-ECMO Patients
  - Venoarterial extracorporeal membrane oxygenation [3]
  - Lifesaving device
  - Patients with heart failure
  - Often need CT Scans

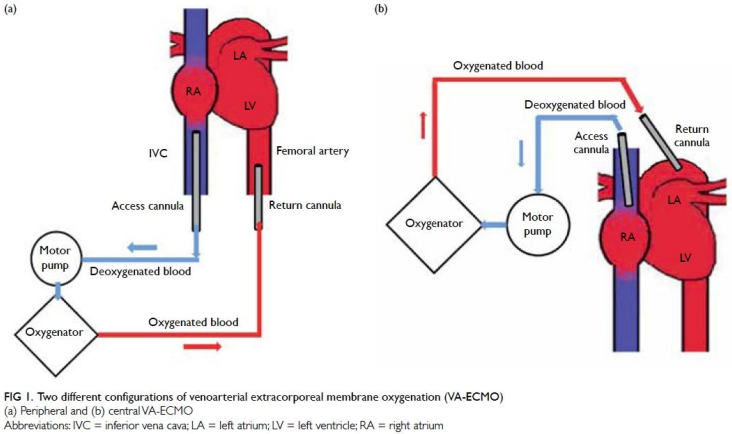


FIG 1. Two different configurations of venoarterial extracorporeal membrane oxygenation (VA-ECMO)
(a) Peripheral and (b) central VA-ECMO
Abbreviations: IVC = inferior vena cava; LA = left atrium; LV = left ventricle; RA = right atrium

Figure 2. Basic VA-ECMO model. For our design we are looking only at model (a)

Background

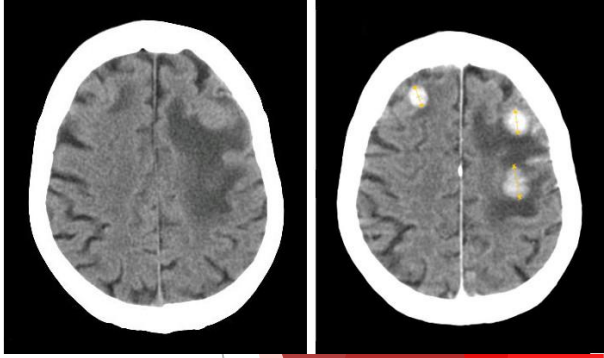


Figure 3. Comparing CT Scans with and without Iodinated Contrast.

- CT scans require Iodinated Contrast
  - Iodinated Contrast helps make blood visible
  - Needs to be injected directly into the bloodstream
  - Injects in opposite direction to blood flow

Competing Designs

- No direct competing designs
- Many static phantom designs
  - They don’t simulate blood flow
- A few flow phantoms
  - Simulate blood flow
  - None tackle our problem

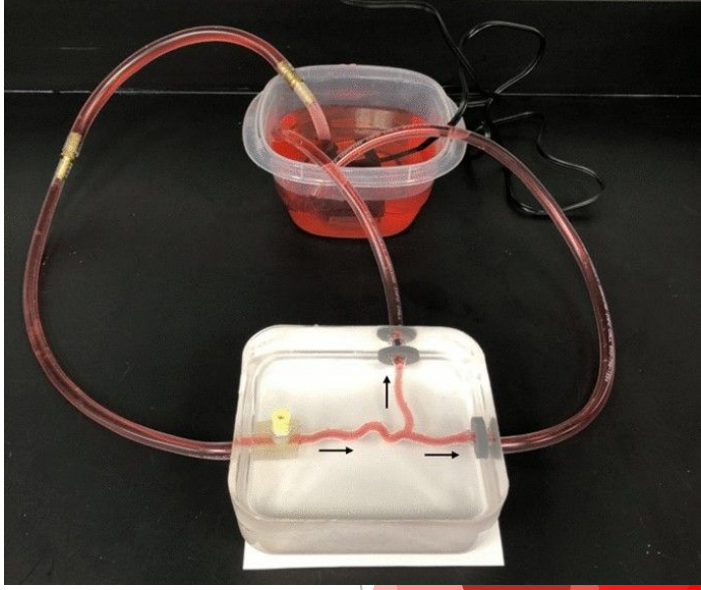


Figure 4. Example of a blood flow phantom [4]

Problem Statement

- Often, patients on VA-ECMO require diagnostic CT imaging
  - This number is increasing [5]
- No current medical standard for imaging these patients
- Will help determine how VA-ECMO effects contrast and imaging
- Improve patient care and outcomes

Product Design Specifications

- CT Phantom with flow capability
  - Right Atrium, Aorta
- ECMO flow circuit
  - Adjustable flow rates (4-6L/min)
- Iodine Injector access
  - Measure HU from CT scan
- Cleanable
- Low cost

ECMO Circuit Designs

Figure 5. ECMO Machine [6]

ECMO Machine

- Entire completed ECMO circuit
- ECMO pumping

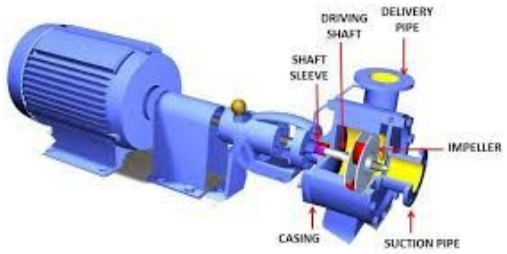


Figure 6. Centrifugal Pump [[7]

Centrifugal Pump

- Often used in ECMO circuits
- Constant flow

Figure 7. Pulsatile Pump [8]

Pulsatile Pump

- Mimics a human pulse
- Simple Machine

ECMO Circuit Design Matrix

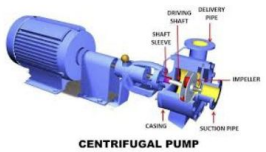
VA - ECMO Circuit		ECMO Machine		Centrifugal Pump		Pulsatile Pump	
Pictures						
Criteria	**Weight**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**
Adjustable Flow Rates	25	5	25	4	20	3	15
Compatibility	20	3	12	4	16	4	16
Usability	20	2	8	5	20	5	20
Maintenance	15	2	10	4	12	4	12
Safety	10	5	10	3	6	3	6
Cost	10	1	2	3	6	5	10
Sum	**100**	**Sum**	67	**Sum**	80	**Sum**	79

Figure 8. ECMO Circuit Design Matrix

Phantom Designs

Closed vs Open Systems

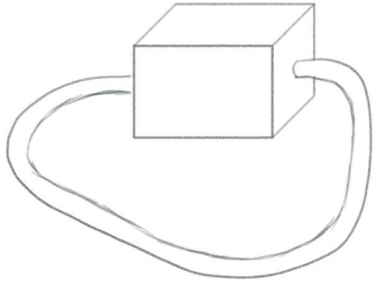


Figure #. Closed tubing system

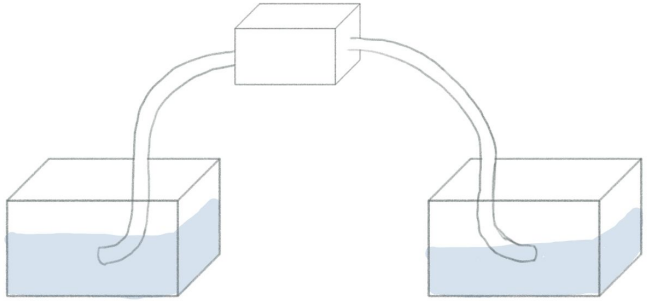


Figure #. Open tubing system

Heart Model Designs

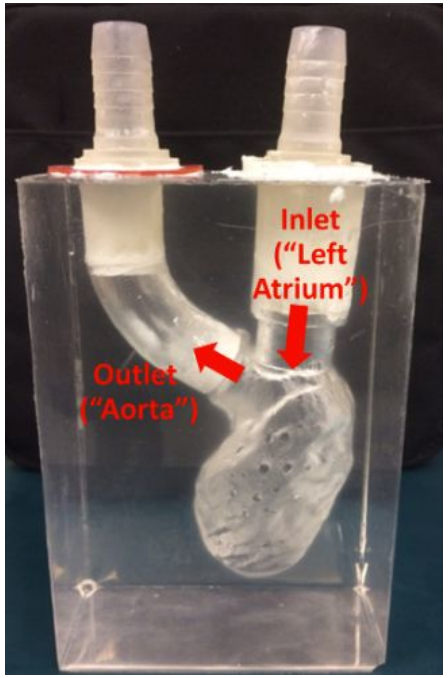


Figure 9. Negative space phantom [9]

Figure 10. Thin wall phantom

Phantom Design Matrix

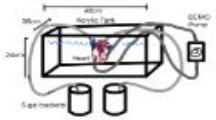
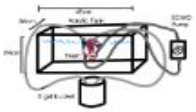
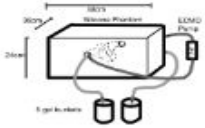
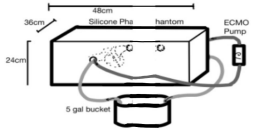
Phantom		Acrylic Box with 3D Printed Heart with an Open Circuit		Acrylic Box with 3D Printed Heart with a Closed Circuit		Negative Space Phantom with an Open Circuit		Negative Space Phantom with a Closed Circuit	
Pictures									
Criteria	Weight	Score (max 5)	Weighted Score	Score (max 5)	Weighted Score	Score (max 5)	Weighted Score	Score (max 5)	Weighted Score
Anatomical Accuracy	30	3	18	4	24	2	12	3	18
Ease of Fabrication	25	5	25	5	25	2	10	2	10
Maintenance	20	5	20	4	16	4	16	3	12
Duration of single use	15	3	9	5	15	3	9	5	15
Cost	10	4	8	4	8	2	4	2	4
Sum	**100**		80		88		51		59

Figure 11. Phantom Design Matrix

Final Design

- Acrylic Water-filled Tank
- Fluid Pump
- Top-half of Heart
- Injector Site

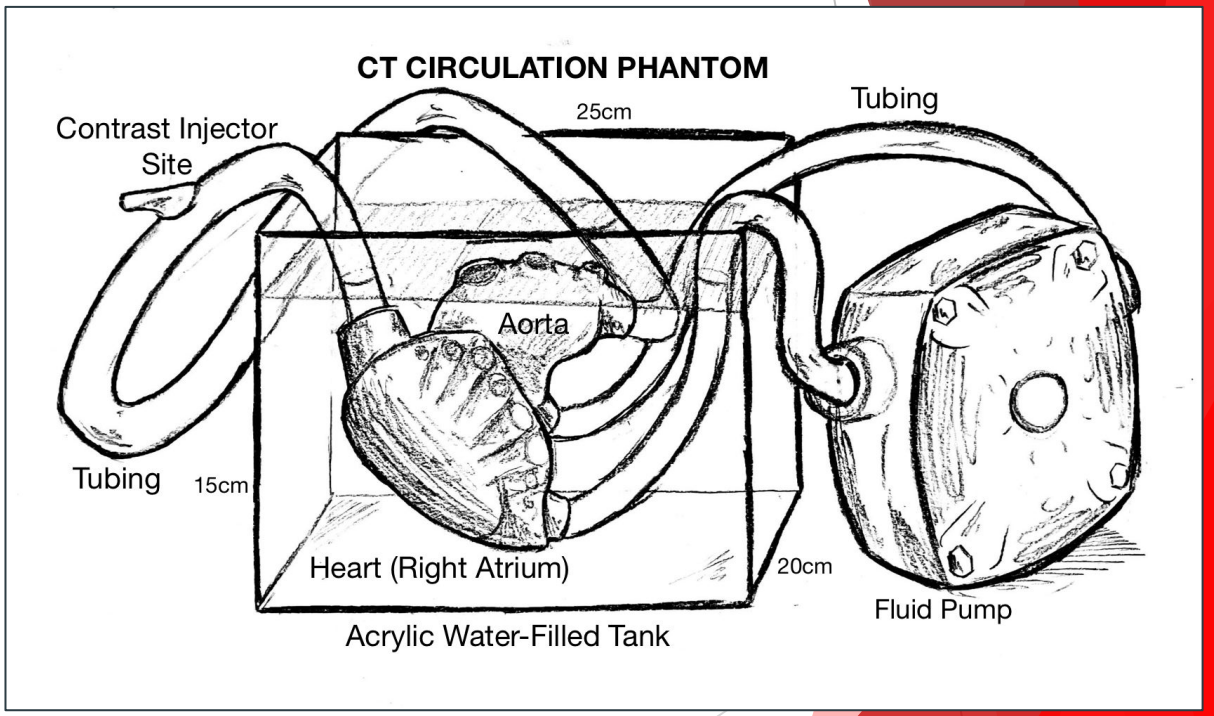


Figure 12. Final design drawing

Future Work

- Procure pump device and assemble components
- Create a 3D phantom model
- Begin preliminary testing

Acknowledgements

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Questions?