THE UNIVERSITY of WISCONSIN MADISON

CT Circulation Phantom

Client: Dr Giuseppe Toia
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Team Members: Lucy O'Cull, Emma Flemmer, Sophie Speece, Shriya Kaushik, Lizzie Maly

Motivation

- Client Dr. Giuseppe Toia
  - Abdominal Radiologist
  - CT workflow and optimization

- Rise of VA-ECMO implementation
- Lack of standards

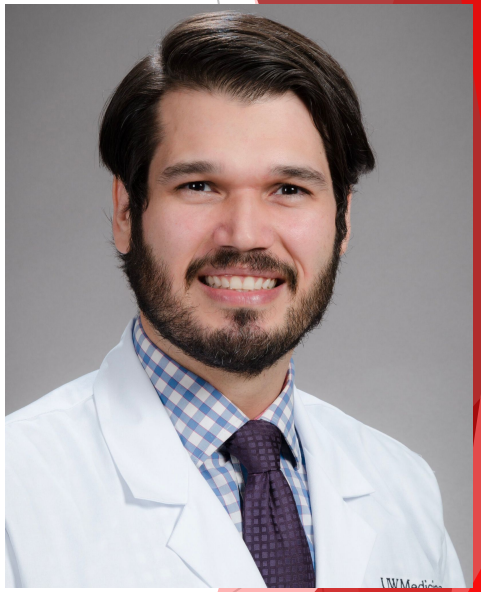


Figure 1: Dr. Giuseppe Toia

Background: VA-ECMO

- Veno-Arterial Extracorporeal Membrane Oxygenation
  - Form of life support that replaces function of heart and lungs
- Employed during cardiac surgery or during ICU treatment [1]
- Most commonly cannulated via the femoral artery and vein return (peripheral placement) [2]

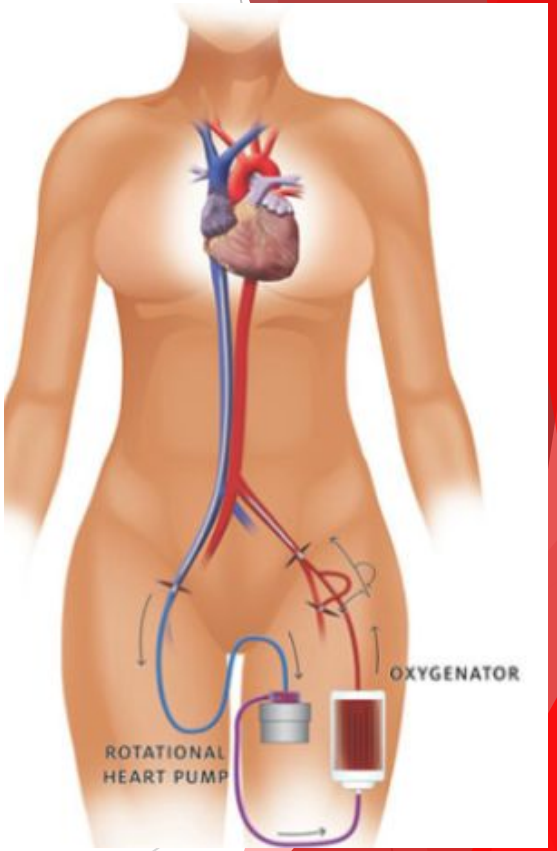


Figure 2: Schematic for peripheral placement of VA-ECMO device. [2]

Background: CT Imaging

- CT circulation imaging requires injection of iodinated contrast into the bloodstream
- VA-ECMO causes complex flow mixing
- Challenging to determine correct contrast volume and scan timing [3]

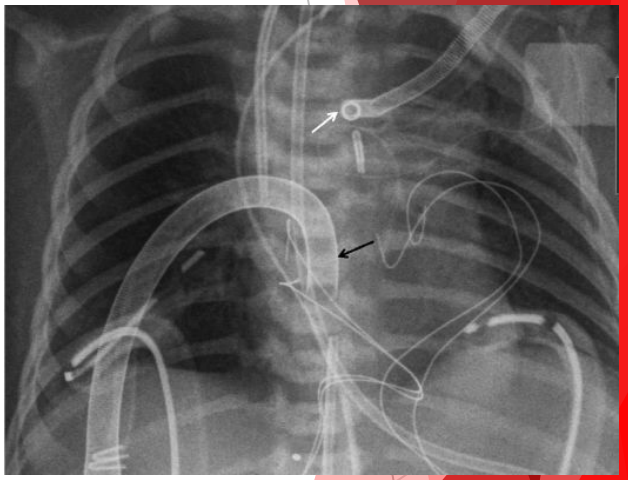


Figure 3: Pediatric VA-ECMO (central cannulation) chest radiograph [3].

Current Design

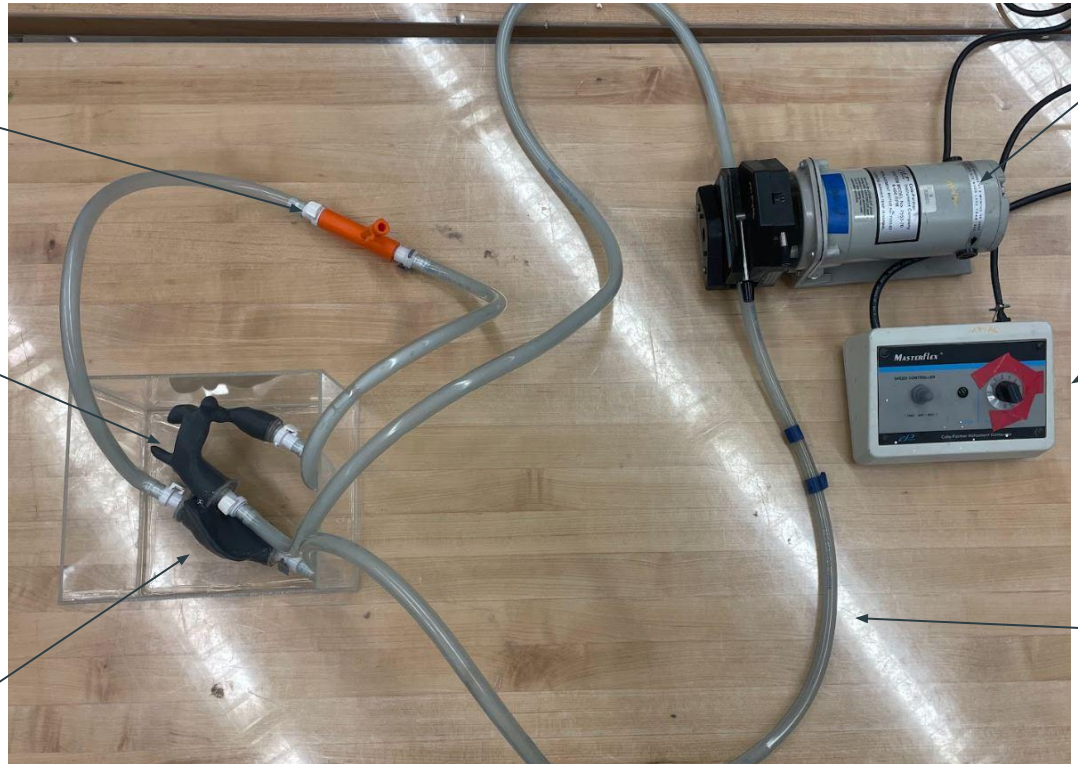
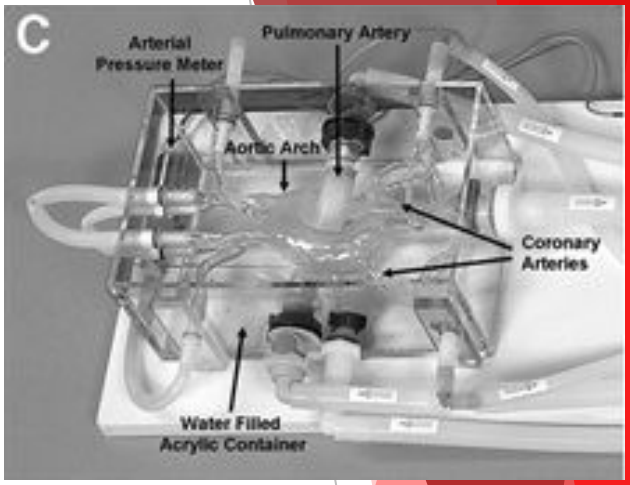
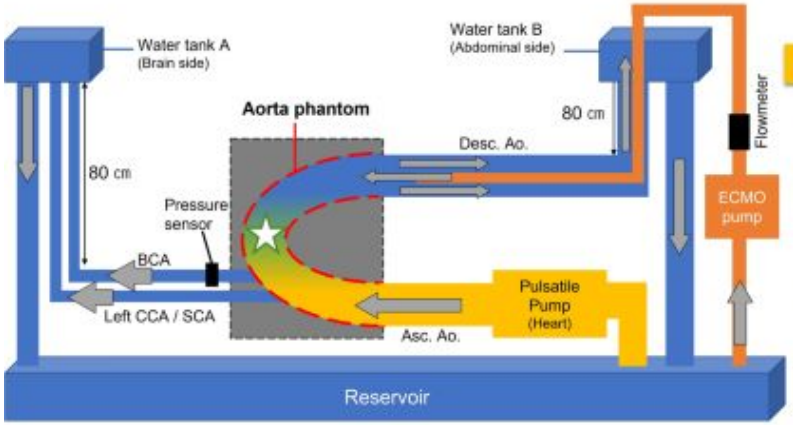


Figure 4: Previous Semester Final Design

Competing Designs

- No competing designs on the market
  - BUT several dynamic heart phantoms used in research





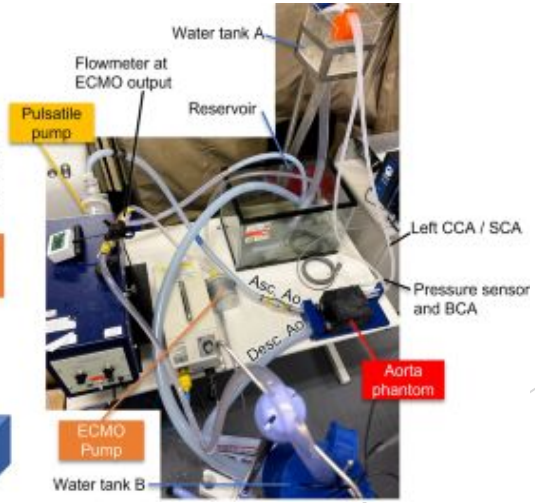


Figure 5 (above): Phantom to devise standard contrast injection [4]

Figure 6 (left): Phantom to assess “mixing zone” of cardiac output and VA-ECMO retrograde flow [5]

Problem Statement

- Often, patients on VA-ECMO require diagnostic CT imaging
  - This number is increasing (458% from 1990-2019!) [6]
- No current medical standard for imaging these patients [6]
- Will help determine how VA-ECMO effects contrast and imaging
- Improve patient care and outcomes

Product Design Specifications

- CT Phantom with flow capability
  - Ascending Aorta and Aortic Root
  - Why? Hemodynamic “mixing zone” [5]
- ECMO flow circuit
  - Adjustable flow rates (4-6L/min) [7]
- Iodinated Contrast Injector access
  - Measure HU from CT scan
- Cleanable
- Low cost

Pump Designs

Figure 7: Peristaltic Pump [8]

Roller Pump

- Used in the previous semester
- This model has max flow rate of 8L/min [8]

Figure 8: IVEK Megaspense Piston Pump [9]

Piston Pump

- Max flow rate of 5L/min [9]
- Often used in industrial settings [9]

Figure 9: Centrifugal Pump [10]

Centrifugal Pump

- Used in VA-ECMO devices [7]
- Max flow rate 8L/min [10]

Pump Design Matrix

Pump		MasterFlex I/P Peristaltic Pump		IVEK Megaspense Piston Pump		Capiox iCP Centrifugal Pump	
Pictures							
Criteria	**Weight**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**
Compatibility	35	5	35	2	14	3	21
Flow Rate	35	5	35	2	14	3	21
Cost	15	3	9	1	3	5	15
Ease of Operation	10	2	4	5	10	5	10
Energy Efficiency	5	4	4	2	2	4	4
Sum	**100**	**Sum**	87	**Sum**	43	**Sum**	71

Figure 10: Pump Design Matrix

Phantom Material Designs

Figure 11: Stratasys ABS M30 Resin [11]

Stratasys ABS M30 Resin

- Used in the previous semester
- Hard and lightweight

Figure 12: Elastic 50A Resin [12]

Formlabs Elastic 50A Resin

- Ideal for soft tissue applications [12]
- Silicone-like material

Figure 13: Stratasys TangoPlus [13]

Stratasys TangoPlus

- Flexible, soft, and rubber-like [13]
- Not available in the Makerspace

Phantom Material Design Matrix

Phantom Material		Stratasys ABS M30 Resin		Elastic 50A Resin		Stratasys TangoPlus	
Pictures							
Criteria	**Weight**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**	**Score (max 5)**	**Weighted Score**
Compatibility	30	2	12	4	24	5	30
Low Permeability	30	3	18	5	30	4	24
Anatomical Accuracy	20	1	4	5	20	5	20
Accessibility	15	5	15	5	15	2	6
Sustainability	5	3	3	1	1	3	3
Sum	**100**	**Sum**	52	**Sum**	90	**Sum**	83

Figure 14: Phantom Material Design Matrix

Final Design

- Pump: Peristaltic Pump
- Material: Elastic 50A Resin

Figure 15 (left): Peristaltic Pump

Figure 16 (right): Elastic 50A Resin

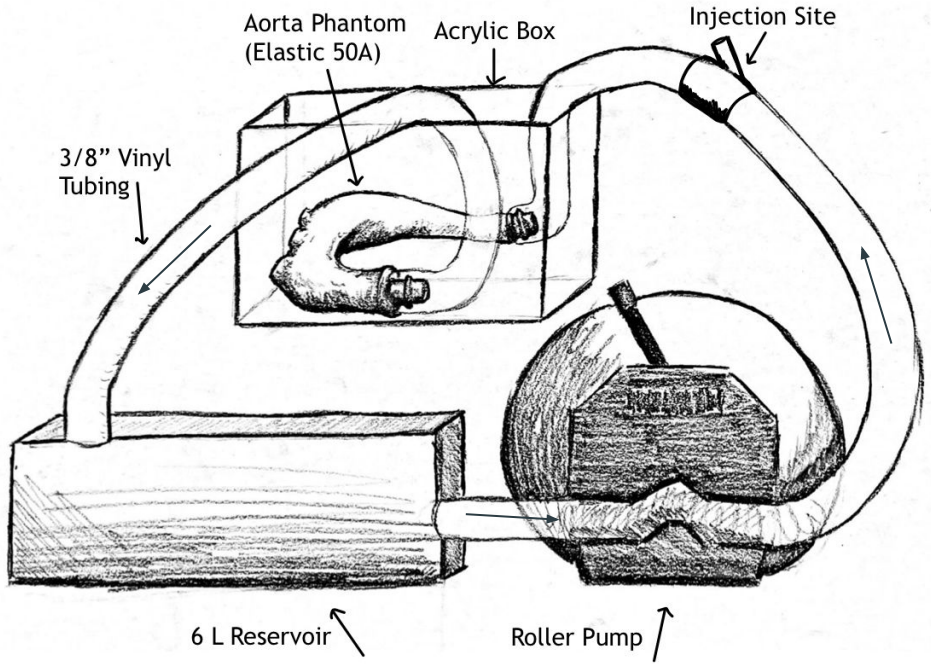


Figure 17: Final design drawing Note: pump and reservoir not to scale

Future Work

- Obtain pump and assemble components
- Design and print a 3D phantom model
- Begin preliminary testing

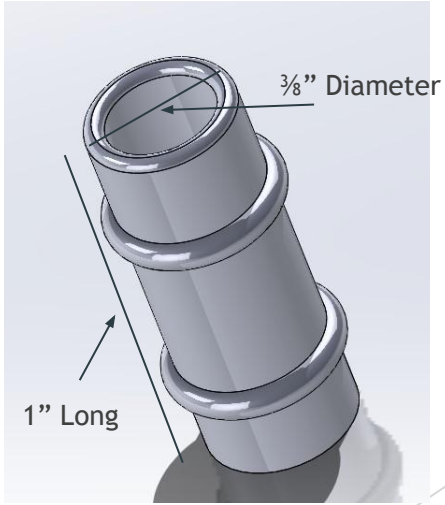


Figure 18: 3D connector model to be integrated

Figure 19: 3D Model of the aortic arch and root

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Questions?