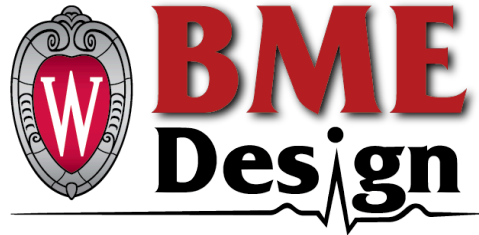


Progress Report: April 5th - April 11th, 2024



**Computed Tomography (CT) Circulation
Phantom to Assess Hyperdynamic Contrast
Flow Rates**

Client: Dr. Giuseppe Toia gtoia@uwhealth.org

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Team:

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Problem statement

A CT phantom is a device used to calibrate Computed Tomography machines by acting as a “stand in” for human tissues [1]. Most phantoms currently in use are static; they do not allow for dynamic flow. Some patients obtaining a CT scan may need a circulatory support device, such as a VA-ECMO (veno-arterial extracorporeal membrane oxygenation) [2] device. There is a clinical need for a CT phantom with dynamic flow capabilities to study the correct ways to conduct CT vascular imaging for patients on ECMO devices. This phantom should model the inflow and outflow of an ECMO patient and have capabilities to simulate the addition of contrast media into the vascular system. Ultimately, this device will help medical personnel to better understand the flow of CT contrast through a patient on an ECMO machine, as the circulation flow rate of an ECMO patient differs from a patient not on ECMO.

Brief status update

The team is still working on finding the right pump for the system and was provided a few options by the BME teaching lab. Currently, the centrifugal pump is the choice to be tested and the team is working on finding an air compressor to work it. The team is also in the prototyping phase. An overall circuit design was roughly decided on, including a 6L fluid reservoir to mimic the total blood in the body. Connectors for the tubing and pump will be purchased and 3D modeling of an initial draft is being worked on to be printed next week. The team also met with CT technicians at UW hospital to better understand the procedures we are working to mimic. The team will take these scans and compare the MROI plots to those of our system.

Difficulties / advice requests

Previous design

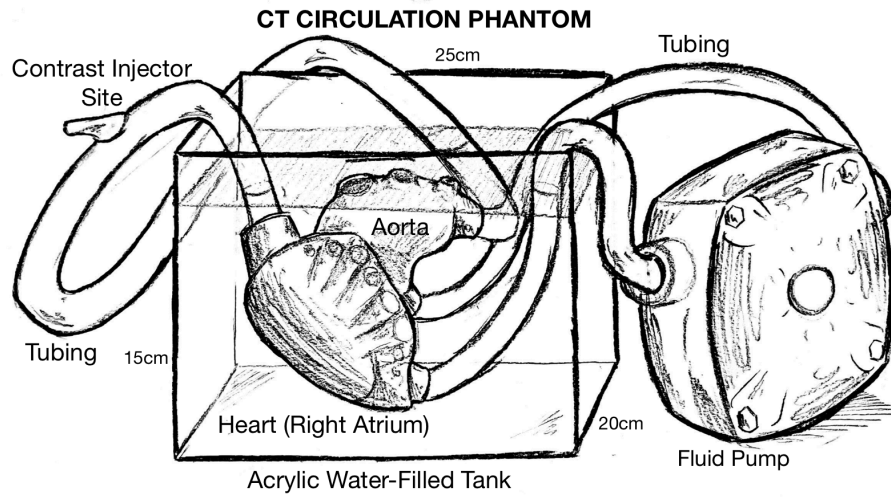


Figure 1: Final design sketch.

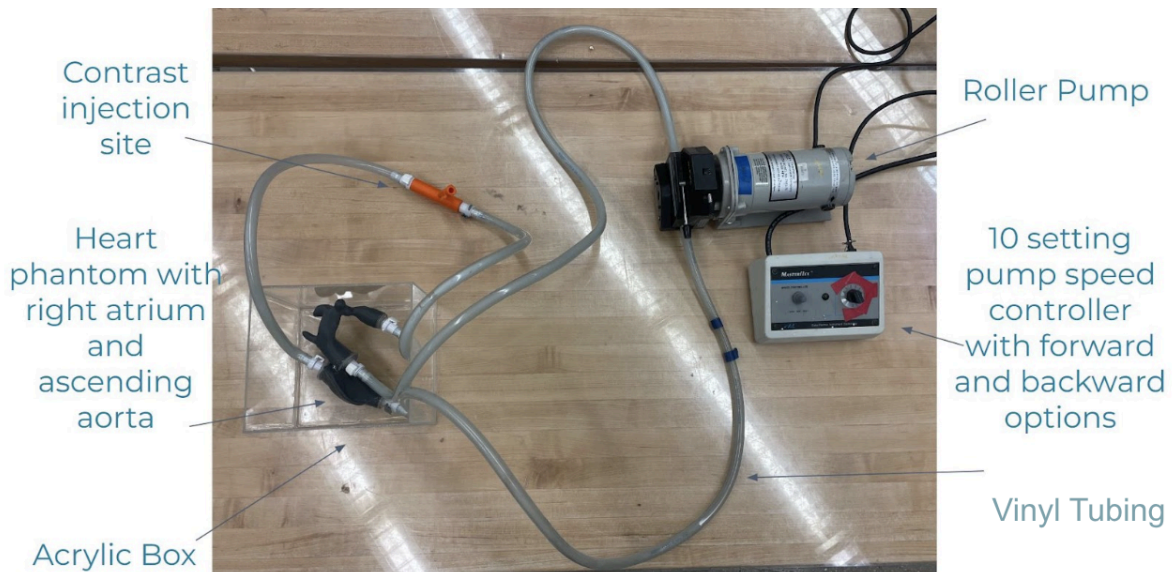


Figure 2: Final fabricated circulation phantom prototype with acrylic box, heart phantom, injection site, roller pump, speed controller, tubing, and connectors

Current Design

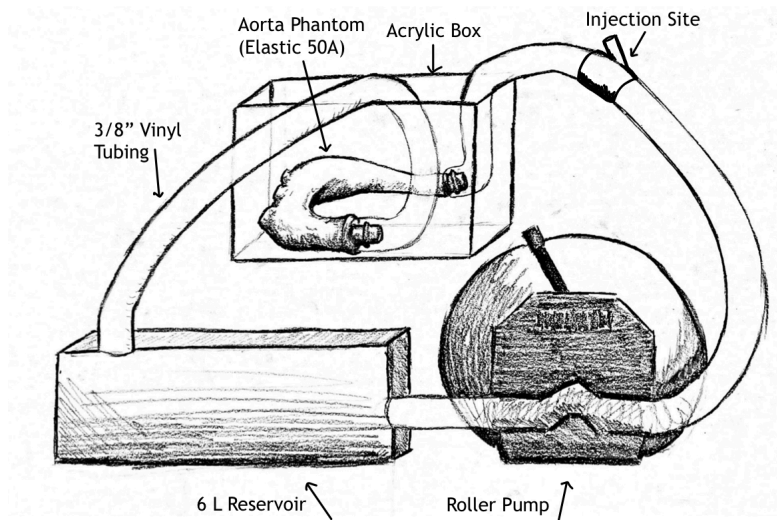


Figure 3: Current circulation phantom design including large reservoir, roller pump with flow capabilities up to 8 L/min, injection site, and aortic arch phantom

Materials and expenses

| Item | Description | Manufacturer | Mft Pt# | Vendor | Vendor Cat# | Date | # | Cost Each | Total | Link |
|------------------------------|---|--------------|---------------------------|---------------|-------------|-----------|---|-----------|---------|------------------------------|
| Category 1- Materials | | | | | | | | | | |
| Elastic 50A Resin | Elastic used for printing connector 3D print 5.41 mL | FormLabs | RS-F 2-EL CL-0 2 | UW Makerspace | Elastic | 2/28/2024 | 1 | 1.63 | \$1.63 | Makerspace |
| Elastic 50A Resin | Elastic used for printing the aorta and connectors 44 mL | FormLabs | RS-F 2-EL CL-0 2 | UW Makerspace | Elastic | 3/20/2024 | 1 | 12.84 | \$12.84 | Makerspace |
| Elastic 50A Resin | Elastic used for reprinting the aorta (larger size) 161.44 mL | FormLabs | RS-F 2-EL CL-0 2 | UW Makerspace | Elastic | 4/9/2024 | 1 | 46.82 | \$46.82 | Makerspace |
| Category 2 | | | | | | | | | | |
| Tubing adapter | Connector to join together 3/8 inch | Green Leaf | CBA 3812 | ACE Hardware | 48762 | 3/13/2024 | 2 | 2.79 | \$5.58 | ACE Hardware |

| | | | | | | | | | | |
|------------------|--|-------------|----------------|--------------|---------|----------|---|--------------|----------------|------------------------------|
| | tubing to ½ inch tubing into the pump | | BG1 | re | | | | | | |
| Tubing adapter | Connector to join tubing with flipped dimensions (¾ in x ½ in) | Green Leaf | CBA 1238 BG1 | ACE Hardware | 48764 | 4/6/2024 | 2 | 2.79 | \$5.89 | ACE Hardware |
| PVC Vinyl Tubing | Tubing used to connect the printed aorta and pump | ACE Proline | CP01 2038 010H | ACE Hardware | 4315552 | 4/3/24 | 1 | 9.48 | \$9.48 | ACE Hardware |
| | | | | | | | | TOTAL | \$82.24 | |

Major team goals for the next week

1. Begin assembling the circuit
2. Continue testing

Next week's individual goals

- Lucy O'Cull
 - Connect the phantom, tubing, and pump
- Emma Flemmer
 - Connect the circuit, phantom, and pump
 - Obtain reservoirs
 - Contact CT techs to schedule a scan time
- Sophie Speece
 - Connect the aorta phantom together. This may include modeling pipe fitters based on the outer diameter of the printed aorta
- Lizzie Maly
 - Clean up aorta reprint and attempt to connect into piping
 - Explore options to begin testing for both flow rate and ct.
- Shriya Kaushik
 - Help with fabricating the aorta
 - Go to the store and purchase piping and exchange connectors

Timeline

| Task | Jan | Feb | | | | March | | | | | April | | | | May | |
|------|-----|-----|---|----|----|-------|---|----|----|----|-------|----|----|----|-----|----|
| | 26 | 2 | 9 | 16 | 23 | 1 | 8 | 15 | 22 | 29 | 5 | 12 | 19 | 26 | 3 | 10 |

| | | | | | | | | | | | | | | | | |
|------------------------|---|---|---|---|---|---|---|---|---|---|---|--|--|--|--|--|
| Project R&D | | | | | | | | | | | | | | | | |
| Empathize | | | | | | | | | | | | | | | | |
| Background... | X | X | | | | | | | | | | | | | | |
| Prototyping | | | | | | X | X | X | X | | X | | | | | |
| Testings | | | | | | | | | | | | | | | | |
| Deliverables | | | | | | | | | | | | | | | | |
| Progress Reports | X | X | X | X | X | X | X | X | X | X | X | | | | | |
| Prelim presentation | | | | | X | | | | | | | | | | | |
| Final Poster | | | | | | | | | | | | | | | | |
| Meetings | | | | | | | | | | | | | | | | |
| Client | | | X | | | | | | | | | | | | | |
| Advisor | X | X | X | X | X | X | X | X | X | | X | | | | | |
| Website | | | | | | | | | | | | | | | | |
| Update | X | X | X | X | X | X | X | | | | | | | | | |

Filled boxes = projected timeline
X = task was worked on or completed

Previous week's goals and accomplishments

- Lucy O’Cull
 - Picked up materials at ACE
 - Completed initial tests on the pump with the new adapters and pumps to determine good fit
 - Assisted in flow rate testing
 - Worked on executive summary
 - Helped remove supports on the model
- Emma Flemmer
 - Team meeting and flow rate testing
 - Brainstormed design ideas to limit air bubbles in the pump
 - Worked on the executive summary
- Sophie Speece
 - Remodeled the aorta phantom to be twice as large
 - Printed the updated phantom and began removing supports
- Lizzie Maly
 - Assisted in flow rate testing
 - Worked on expanding size of aorta to be life size
- Shriya Kaushik
 - Team meeting to test the pump
 - Worked on executive summary

Activities

| Name | Date | Activity | Time (h) | Week Total (h) | Sem. Total (h) |
|----------------|-------------|--|-----------------|-----------------------|-----------------------|
| Lizzie Maly | 01/31/2024 | Literature Research | 2 | 2 | 2 |
| Shriya Kaushik | 01/31/2024 | Background and literature research | 2 | 2 | 2 |
| Sophie Speece | 01/31/2024 | Literature research | 2 | 2 | 2 |
| Lucy O’Cull | 01/31/2024 | Literature research | 2 | 2 | 2 |
| Emma Flemmer | 02/01/2024 | Literature research | 2 | 2 | 2 |
| Sophie Speece | 02/02/2024 | Literature research on VA-ECMO background information | 2 | 2 | 2 |
| Lucy O’Cull | 02/05/2024 | Group meeting planning and review PDS for delegation | 0.5 | 0.5 | 2.5 |
| Lucy O’Cull | 02/08/2024 | Contribution to PDS | 1 | 1.5 | 4 |
| Emma Flemmer | 02/05/2024 | Communication with client and advisor | 0.5 | 0.5 | 2.5 |
| Emma Flemmer | 02/08/2024 | Research and writing for the PDS | 1.5 | 2 | 4 |
| Sophie Speece | 02/08/2024 | Literature research focused on existing designs | 2 | 2 | 4 |
| Lizzie Maly | 02/08/2024 | Literature Research | 1.5 | 2 | 4 |
| Lizzie Maly | 02/08/2024 | Contribution to PDS | .5 | 2 | 4 |
| Shriya Kaushik | 02/08/2024 | PDS sections | 0.5 | 0.5 | 2.5 |
| Shriya Kaushik | 02/08/2024 | Researching and reading old reports | 1.5 | 1.5 | 4 |
| Lucy O’Cull | 02/12/2024 | Worked on abstract | 0.5 | 0.5 | 4.5 |
| Lucy O’Cull | 02/13/2024 | Group design matrix discussion | 1 | 1.5 | 6 |
| Lucy O’Cull | 02/15/2024 | Literature research | 1 | 2.5 | 7 |
| Emma Flemmer | 02/13/2024 | Contributed to abstract | 0.5 | 0.5 | 4.5 |
| Emma Flemmer | 02/14/2024 | Team meeting to discuss designs | 1 | 1.5 | 5.5 |
| Emma Flemmer | 02/15/2024 | Materials research | 1.5 | 3 | 7 |
| Sophie Speece | 02/14/2024 | Met with team and researched potential 3D printing materials | 2.5 | 2.5 | 6.5 |

| Name | Date | Activity | Time (h) | Week Total (h) | Sem. Total (h) |
|----------------|-----------|---|----------|----------------|----------------|
| Lizzie Maly | 2/14/2024 | Team Meeting to Discuss | 1 | 2 | 5 |
| Lizzie Maly | 2/14/2024 | Pump Research and Material Research | 1 | 2 | 6 |
| Shriya Kaushik | 2/14/2024 | team meeting | 1 | 1 | 5 |
| Shriya Kaushik | 2/14/2024 | Researched pumps and materials | 2 | 2 | 7 |
| Lucy O'Cull | 2/22/2023 | Researched mathematical modeling | 2 | 2 | 9 |
| Emma Flemmer | 2/21/2024 | Worked on preliminary presentation | 1 | 1 | 8 |
| Emma Flemmer | 2/20/2024 | Communicated with client resources to arrange meeting times | 0.5 | 1.5 | 8.5 |
| Sophie Speece | 2/22/24 | Acquired heart and aorta 3D files online and began to augment them in Meshlab, Meshmixer and Blender to fit project needs | 1 | 1 | 7.5 |
| Shriya Kaushik | 2/22/24 | Worked on prelim presentation, continued research | 1 | 1 | 8 |
| Lizzie Maly | 2/21/24 | Worked on prelim presentation | 1 | 1 | 7 |
| Lizzie Maly | 2/22/24 | Research material options for design matrix | 1 | 2 | 8 |
| Sophie Speece | 2/23/24 | 3D modeled two different connection designs so that the aorta can more seamlessly connect to the tubing and prevent leaks | 1 | 1 | 8.5 |
| Sophie Speece | 2/24/24 | Smoothed aortic arch and root model, then began attaching aforementioned connections | 2 | 3 | 10.5 |
| Sophie Speece | 2/27/24 | Sketched out Final Design | 0.5 | 3.5 | 11 |
| Sophie Speece | 2/28/24 | Worked on writing and editing slides of the preliminary presentation | 1 | 4.5 | 12 |
| Emma Flemmer | 2/28/2024 | Work on the preliminary presentation | 1 | 1 | 9.5 |
| Shriya Kaushik | 2/28/2024 | Work on the preliminary presentation | 1 | 1 | 9 |
| Lizzie Maly | 2/28/2024 | Worked on preliminary presentation | 1 | 1 | 9 |
| Lucy O'Cull | 2/28/2024 | Worked on preliminary presentation | 0.5 | 0.5 | 9.5 |
| Emma Flemmer | 3/5/2024 | Pump meeting | 0.5 | 0.5 | 10 |
| Emma Flemmer | 3/6/2024 | Worked on preliminary report | 1 | 1.5 | 11 |
| Lucy O'Cull | 3/5/2024 | Pump meeting | 0.5 | 0.5 | 10 |

| Name | Date | Activity | Time (h) | Week Total (h) | Sem. Total (h) |
|----------------|-----------|--|----------|----------------|----------------|
| Lizzie Maly | 3/6/2024 | Worked on preliminary report | 1 | 1 | 10 |
| Lizzie Maly | 3/6/2024 | Met to evaluate pumps | .5 | 1.5 | 10.5 |
| Sophie Speece | 3/7/2024 | Worked on preliminary report | 0.5 | 0.5 | 12.5 |
| Shriya Kaushik | 3/6/2024 | Worked on preliminary report | 1 | 1 | 10 |
| Lucy O'Cull | 3/7/2024 | Worked on preliminary report | 1 | 1.5 | 11 |
| Emma Flemmer | 3/12/2024 | Meeting with CT techs at WIMR | 1 | 1 | 12 |
| Lucy O'Cull | 3/12/2024 | Meeting with CT techs at WIMR | 1 | 1 | 12 |
| Sophie Speece | 3/12/2024 | Zoom meeting with CT techs | 1 | 1 | 13.5 |
| Lizzie Maly | 3/13/2024 | Discussed fabrication and circuit with team | .5 | .5 | 11 |
| Lucy O'Cull | 3/13/2024 | Discussed fabrication and circuit with team | 0.5 | 0.5 | 12.5 |
| Emma Flemmer | 3/13/2024 | Picked up materials from ACE Hardware and WIMR | 1 | 2 | 13 |
| Emma Flemmer | 3/13/2024 | Discussed fabrication and circuit with team | 0.5 | 2.5 | 13.5 |
| Sophie Speece | 3/13/2024 | Discussed fabrication and circuit with team | 0.5 | 0.5 | 14 |
| Shriya Kaushik | 3/13/2024 | Discussed circuit schematics with team | 0.5 | 0.5 | 11 |
| Emma Flemmer | 3/19/2024 | Brainstormed circuit design | 0.5 | 0.5 | 13.5 |
| Shriya Kaushik | 3/18/2024 | Met with team and advisor to assemble circuit | 0.5 | 0.5 | 11.5 |
| Sophie Speece | 3/19/2024 | Aorta and connectors 3D modeling, wrote portions of aorta fabrication protocol | 4 | 4 | 18 |
| Lizzie Maly | 3/12/2024 | Met with CT Techs at WIMR | 1 | 1 | 11.5 |
| Lizzie Maly | 3/18/2024 | Met with team and advisor to assemble circuit | .5 | 1.5 | 12 |
| Lizzie Maly | 3/19/2024 | Worked on connector SolidWorks to add to 3D model | 1 | 2.5 | 13 |
| Emma Flemmer | 4/3/2024 | Team meeting and print cleanup | 1.5 | 1.5 | 15 |
| Lucy O'Cull | 4/3/2024 | Team meeting and print cleanup | 1.5 | 1.5 | 14 |
| Lucy O'Cull | 4/3/2024 | Call to action write up | 0.5 | 2 | 14.5 |
| Lizzie Maly | 4/3/2024 | Team Meeting and print cleanup | 1.5 | 1.5 | 14.5 |

| Name | Date | Activity | Time (h) | Week Total (h) | Sem. Total (h) |
|----------------|-----------|---|----------|----------------|----------------|
| Shriya Kaushik | 4/3/2024 | Print cleanup and team meeting | 1.5 | 1.5 | 13 |
| Lucy O'Cull | 4/6/2024 | ACE tubing and adapter procurement, initial fit testing | 1 | 1 | 15.5 |
| Sophie Speece | 4/9/2024 | Aorta remodeling | 1.0 | 1.0 | 19 |
| Emma Flemmer | 4/10/2024 | Team meeting and pump testing | 1 | 1 | 16 |
| Lizzie Maly | 4/10/2024 | Team meeting and pump testing | 1 | 1 | 15.5 |
| Sophie Speece | 4/10/2024 | Team meeting and pump testing | 1.0 | 2.0 | 20 |
| Emma Flemmer | 4/11/2023 | Executive summary work | 0.5 | 1.5 | 16.5 |
| Shriya Kaushik | 4/10/2023 | Executive summary | 0.5 | 0.5 | 13.5 |
| Shriya Kaushik | 4/10/2023 | Team meeting and pump testing | 1 | 1.5 | 14.5 |
| Lucy O'Cull | 4/10/2023 | Team meeting and pump testing | 0.5 | 1.5 | 16 |
| Lucy O'Cull | 4/11/2024 | Executive summary work & print post-processing | 0.5 | 2 | 16.5 |