Multidimensional imaging-based models for cardiovascular procedural skills training (BVP model)

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Problem Statement

Interventional cardiology is a rapidly expanding field in veterinary medicine. Pulmonary valve stenosis occurs when a dog is born with a malformed pulmonary valve, which restricts blood flow from the right heart to the lungs. Balloon valvuloplasty is a palliative procedure in which a balloon-tipped catheter is inserted into the jugular vein to the valve and is then inflated to help reduce the severity of the stenosis. Recently, the UW-Madison School of Veterinary Medicine has experienced a decrease in caseloads of canines with pulmonary valve stenosis, preventing the cardiology residents from being able to practice repairing this disorder. There is a need for a heart model to mimic pulmonary valve stenosis for residents to learn and practice repairing these valves.

This device, a model-based simulation program will be implemented to maintain the cardiologists' surgical skill set and to aid in cardiology resident training. Simulator training using multidimensional imaging-based models will augment the training already provided in the interventional lab and help protect against the ebb and flow of procedural caseload eroding skills. It also provides a more consistent experience for our residents and provides an objective method of assessing individual progress amongst our trainees.

The goal is to develop a silicone 3D model of canine pulmonary valve stenosis which can be used to learn/practice essential skills like handling of guidewires/catheters, balloon positioning and inflation, and communication between veterinary interventionists. Computed tomography angiography (CTA) of dogs with pulmonary valve stenosis will be used to create the 3D models, which will be secured in place. Lastly, a document camera will project an image of what the user is doing with their hands onto a screen. This provides a more realistic recreation of the interventional surgery, where the surgeon watches a fluoroscopy screen to monitor the movement of the interventional equipment inside the patient.

Summary of Weekly Team Member Design Accomplishments

- Team:
    - Completed individual portions of research paper
    - Designed the pump electrical and make progress on heart design
- Hunter Belting:
    - Completed the MTS testing/analysis of the mechanical traits for Elastic 50A
    - Worked and completed the individual portion of the research paper
    - Began looking into the tank in relation with the base of the heart model
- Anna Balstad:
    - Wrote sections of the research paper
    - Updated the PDS to include the specifications for the pump and fluid flow system
    - Continued editing the heart STL
- Rebecca Poor:
    - Researched electrical design for pump power
    - Created electrical schematic and ordered parts to power pump
    - Assisted in viewing heart STL updates
    - Completed individual portion of research paper
- Daisy Lang:
    - Purchased 12V, 1.5A power converter for electrical circuit
    - Created new circuit design and received approval from Makerspace
    - Began IRB protocol document
    - Restructured preliminary report

Weekly / Ongoing Difficulties

N/A

Upcoming Team and Individual Goals

- Team:
    - Submit IRB request
    - Create full model usage test questionnaire
    - Print jugular vein and new heart model
    - Submit preliminary report

- Hunter Belting:
    - Peer review the preliminary research paper
    - 3-D print the jugular model in Elastic 50A and the updated heart chambers in Flexible 80A as a first look at the modifications
    - Understand constraints, etc. of the tank which will hold the water and model so that one can be ordered.

- Anna Balstad:
    - Edit the preliminary research paper

    - Finalize edits to the heart model and print a prototype

- Rebecca Poor:
    - Complete and review preliminary research paper
    - Assemble pump electrical components
    - Initial feasibility testing on pump volume flow

- Daisy Lang:
    - Submit IRB for approval
    - Assemble and preliminary test pump assembly
    - Complete and submit Preliminary Report

Project Timeline

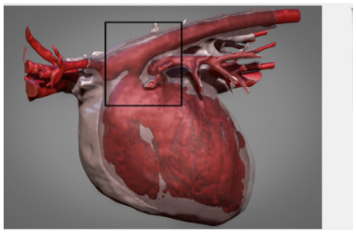
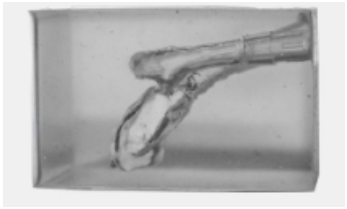
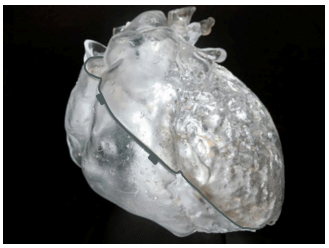
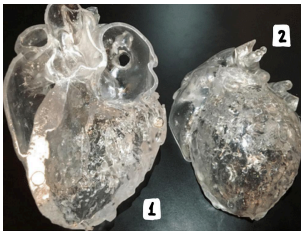
Project Goal	**Deadline**	**Team Assigned**	**Progress**	**Completed**
Preliminary Presentation	2/7	All	100%	X
Preliminary Report	2/26	All	75%	
Executive Summary	4/18	All		
Final Poster Presentation	4/25	All		
Final Deliverables	4/30	All		

Expenses

Link to spreadsheet: https://docs.google.com/spreadsheets/d/1zrmdodVMy9Tak7XrOqHdQ6oMQDw5lYqqROYaAgWNKoQ/edit?usp=sharing

Item	Description	Manufacturer	Manufacture Part Number	Vendor	Date	QTY	Cost Each	Total	Link
3D Printed Materials									
Elastic 50A	Heart and Jugular Material	Formlabs	RS-CFG-ELCL-02	Formlabs	10/14/2024	1	$208.57	$208.57	https://formlabs.com/store/materials/elastic-50a-resin-v2/
Flexible 80A	Orignial Material for Heart	Formlabs	RS-CFG-FL80-01	Formlabs	10/14/2024	1	$208.57	$208.57	https://formlabs.com/store/materials/flexible-80a-resin
Model Stand Materials									
Super Glue	Secure Jugular to Heart and Stand to Base Plate: 0.07 oz Tube	The Original Super Glue Corporation	SGH2J	Makerspace	11/19/2024	2	$2.42	$4.84	https://supergluecorp.com/product/super-glue-tube/
3D Printed Stand	PLA Prints of stand to hold the Jugular and Heart	N/A	N/A	Makerspace	11/19/2024	2	$8.00	$8.00	N/A
Acrylic Base Plate	Secure the Model	N.A	N/A	Makerspace	11/19/2024	1	$0.00	$0.00	N/A
Phone Stand	Phone Tripod Stand, 85" Tall Cellphone Tripod with Gooseneck Remote, Flexible Tripod Stand for iphone, Portable Phone Stan Tripod for Recording, Compatible with iPhone 14 13 12 pro Android Cell phone	Vivtiv	p18-353	Amazon	2/13/2025	1	$21.99	$21.99	https://www.amazon.com/Cellphone-Gooseneck-Flexible-Record
Pump Materials									
Perisaltic Pump	900ml/min high Flow peristaltic Pump 12V dc Brush Motor Liquid dosing Pump with BPT Tube	Kamoer	KPHM900-HB-B24	Amazon	2/7/2025	1	$58.88	$58.88	https://www.amazon.com/dp/B0BB75XPRX/ref=sspa_dk_detail
Tubing	10 Feet - 1/4" ID x 3/8" OD Clear Vinyl Tubing, Translucent Plastic PVC Tubing Hose Pipe for Water Air Pump	Kesoto	601279606865	Amazon	2/13/2025	1	$6.99	$6.99	https://www.amazon.com/Kesoto-Clear-Translucent-Plastic-Tubi
Hose Clamps	3/8" Heavy Duty Double Snap Grip Nylon Hose Clamps Several Ratcheting Adjustable Clamp	Quickun	767065462036	Amazon	2/13/2025	1	$11.59	$11.59	https://www.amazon.com/Quickun-Double-Several-Rat
							TOTAL:	**$529.43**	

Overall Design Matrix

Design Criteria	3D Printed One Piece 		Molded One Piece  		3D Printed Four Piece  	
Anatomical Accuracy (25)	3/5	15	2/5	10	**4/5**	**20**
Ease of Fabrication (20)	**4/5**	**16**	1/5	4	3/5	12
Durability (15)	3/5	9	2/5	6	**4/5**	**12**
Modularity (15)	1/5	3	1/5	3	**5/5**	**15**
Ease of Use (10)	**4/5**	**8**	3/5	6	2/5	4
Cost (10)	3/5	3	**4/5**	**8**	2/5	4
Safety (5)	4/5	4	**5/5**	**5**	4/5	4
Total (100)	58/100		42/100		**71/100**	

Design Matrix - Jugular Vein and Annulus

Design Criteria	Elastic 50A Resin - Formlabs 		Flexible 80A - Formlabs 		NinjaFlex TPU - NinjaTek 	
Compliance (25)	**5/5**	**25**	2/5	10	1/5	5
Surface Finish (20)	2/5	8	3/5	12	**4/5**	**16**
Transparency (20)	**5/5**	**15**	4/5	12	1/5	3
Ease of Fabrication (15)	2/5	12	**4/5**	**12**	1/5	3
Cost (10)	3/5	6	3/5	6	**4/5**	**8**
Durability (5)	2/5	4	3/5	6	**4/5**	**8**
Resolution (5)	**4/5**	**4**	**4/5**	**4**	2/5	2
Total (100)	**68/100**		**62/100**		**45/100**	

Design Matrix - Heart Chambers

Design Criteria	Clear Resin V5 - Formlabs 		Flexible 80A - Formlabs 		PolyJet Photopolymer - Stratasys 	
Compliance (25)	1/5	5	4/5	20	**5/5**	**25**
Surface Finish (25)	2/5	10	**4/5**	**20**	1/5	5
Transparency (20)	**5/5**	**20**	4/5	16	2/5	8
Ease of Fabrication (15)	**5/5**	**20**	4/5	16	1/5	4
Resolution (10)	4/5	**8**	4/5	8	**5/5**	**10**
Cost (5)	**5/5**	**5**	4/5	4	1/5	1
Total (100)	**68/100**		**84/100**		**53/100**	