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.

Brief Status Update

Summary of Weekly Team Member Design Accomplishments

- Team:
  - Completed the final Design.
  - Met with the client to discuss the design and test the procedure with it.
  - Began working on the final deliverables for this semester.
- Hunter Belting:
  - Completed the modifications on the two heart chamber halves
  - Printed out the final design components and confirmed assembly worked
  - Met with client to test the final design functionality and understand what future work needs to be done
  - Began draft of individual portion of the final report
- Anna Balstad:
  - Wrote testing protocols
  - Analyzed testing results
  - Modeled part of heart stand
  - Helped with filling holes in heart model
  - Wrote draft for parts final report
- Rebecca Poor:
  - Completed heart stand design
  - Printed heart stand and evaluated usability with heart model
  - Drafted testing protocol for model usability testing
  - Drafted individual portion of final report
- Daisy Lang:
  - Wrote testing protocol for MTS Testing
  - Completed MTS Testing for Elastic 50A and Flexible 80A samples
  - Analyzed data from MTS Testing
  - Drafted individual report and poster sections

Weekly / Ongoing Difficulties

N/A

Upcoming Team and Individual Goals

- Team:
  - Continue working on the final deliverables
  - Draft the outreach proposal
  - Determine next steps/goals for the next semester

- Hunter Belting:
  - Work on the individual components for the final deliverables and work as a team to review final edits.

- Make preliminary edits to the model, such as printing out of elastic 50 for the heart chambers.
- Work with team on outreach.

- Anna Balstad:
  - Continue writing final report and working on final presentation
  - Prepare for final presentation
  - Work on outreach planning

- Rebecca Poor:
  - Revise and review final report
  - Begin working on final poster
  - Execute model usability testing
  - Analyze model usability testing results and summarize in final report

- Daisy Lang:
  - Revise the final report and poster
  - Finalize changes to preliminary report and add to final report

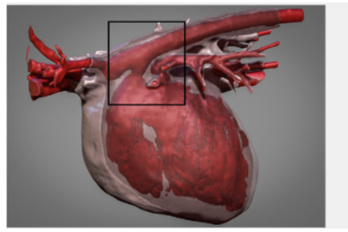
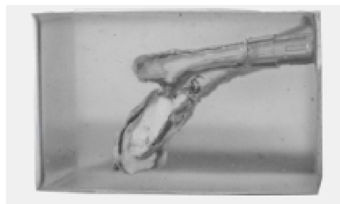
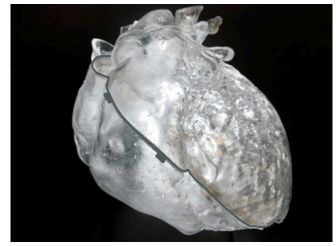
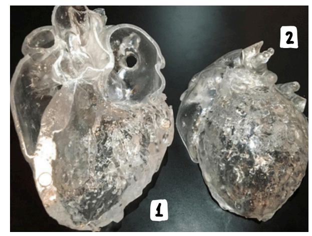
Project Timeline

Project Goal	**Deadline**	**Team Assigned**	**Progress**	**Completed**
PDS	9/20	All	100%	x
Design Matrix	9/27	All	100%	x
Preliminary Presentations	10/4	All	100%	x
Preliminary Deliverables	10/9	All	100%	x
Show and Tell	11/1	All	100%	x
Poster Presentations	12/6	All	5%	
Final Deliverables	12/11	All	5%	

Expenses

Item	Description	Manufacturer	Date	QTY	Cost Each	Total	Link
Category 1 3D Printed Material							
Elastic 50A Resin	Material for Jugular Vein and Annulus	Formlabs	10/14/24	1L	$208.57	$208.57	https://formlabs.com/store/materials/elastic-50a-resin-v2
Flexible 80A Resin	MAterial for Heart Chambers	Formlabs	10/14/24	1L	$208.57	$208.57	https://formlabs.com/store/materials/flexible-80a-resin
Category 2 Fabrication Materials							
Super Glue	Secure Jugular Veain to Heart	The Original Super Glue Coorporation	11/19/24	2 x 0.07 oz	$1.21	$2.42	https://supergluecorp.com/
Stand Print	Model Holder Stand	MakerSpace	11/20/24	2	$8.00	$16.00	N/A
					TOTAL:	**$435.56**	

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**	