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

The team completed the preliminary design presentation and report. They have received material samples and gotten feedback from the client on the material choice. The team is now working on segmenting the CTA scan and developing the model for 3D printing.

Summary of Weekly Team Member Design Accomplishments

- Team:
    - Finished preliminary design presentation and report
    - Started segmenting CTA scan for development of model

- Hunter Belting:
    - Finished my section of the preliminary report and reviewed the whole report for submission.
    - Met with the client to discuss both the elastic 50A and the flexible 80A materials that will be used for the model.
    - Worked with the team to be segmenting the CTA scan.

- Anna Balstad:
    - Finished preliminary design presentation and report
    - Met with client to discuss material choices
    - Worked with team to begin segmenting CTA scan

- Rebecca Poor:
    - Completed individual portion of preliminary report and revised report with team
    - Provided feedback on feedback fruits for individual and team review
    - Began segmenting CTA scan

- Daisy Lang:
    - Finished section of the preliminary report
    - Completed all references for preliminary report
    - Began looking at camera systems for use in our device

Weekly / Ongoing Difficulties

N/A

Upcoming Team and Individual Goals

- Team:
    - Continue work on segmenting the CTA scan to allow for manipulation in SolidWorks. This could include getting help from a professor or professional to accurately segment the heart.
    - Begin working on getting materials ordered and working with the client and our budget to ensure that the materials will arrive in a timely manner.
    - Continue focusing on how the different components of the model will be attached together.

- Hunter Belting:
  - Working with the client to understand how to gain access to the budget, whether she will order the materials or how she wants to have purchasing done. The vendor should be Formlabs.
  - Continue working with the team to segment the CTA scan and start manipulations of the model within SolidWorks.

- Anna Balstad:
  - Continue segmenting CTA scan
  - Begin editing STL files to determine how to connect heart componentss

- Rebecca Poor:
  - Continue segmenting CTA scan to create model
  - Communicate with vendors for 3D printing materials

- Daisy Lang:
  - Continue looking at camera systems for use in device
  - Begin brainstorming ways to test annulus and create expandable section

Project Timeline

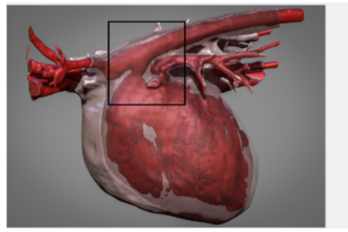
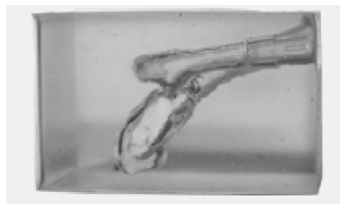
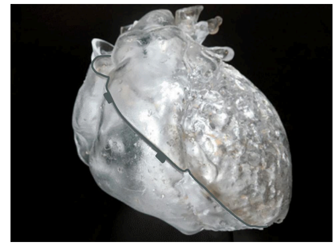
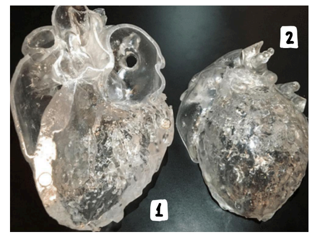
Project Goal	Deadline	Team Assigned	Progress	Completed
PDS	9/20	All	100%	x
Design Matrix	9/27	All	100%	x
Preliminary Presentations	10/4	All	100%	X
Preliminary Deliverables	10/9	All	100%	X
Show and Tell	11/1	All		
Poster Presentations	12/6	All		

Final Deliverables	12/11	All		

Expenses

Item	Description	Manufacturer	Part Number	Date	QTY	Cost Each	Total	Link
Component 1								
Component 2								
Component 3								
TOTAL:								**$0.00**

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**	