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:
    - Continue development of the cardiac model with CT segmentation to isolate the annulus as well as Onshape to modify the segmented portions and add connection points.
    - Continue research into the jugular vein of the model, including how the material interacts with inserting the catheter multiple times through.
    - Develop questions for the client meeting to continue to gain further insight and knowledge about how the design should move forward.
- Hunter Belting:
    - Designed a CAD model to test how a silicone mold would work for inserting the
    - Brainstormed questions to ask the client during the meeting on Thursday, mostly involving the jugular vein and how she wants the model to be used.
- Anna Balstad:
    - Tested making a silicone jugular vein
    - Continued working on segmenting the heart
    - Met with graduate students to learn more about heart segmentation

- Rebecca Poor:
    - Continued working to segment the CT scans and try to segment just the valve
    - Researched jugular vein and connection into the heart
    - Edit the heart STL in onshape to add connection points

- Daisy Lang:
    - Researched possible tape options for jugular vein cover
    - Resized jugular vein CAD model to fit dimensions from a client meeting
    - Met with client to ask about tape samples and made plan to order three options

Weekly / Ongoing Difficulties
Segmenting the CT scans accurately and segmenting out the valve from the heart

Upcoming Team and Individual Goals

- Team:
    - Prepare for the show and tell by printing a model out of stock material.
    - Isolate and translate the annulus/heart valve to an stl file that can be modified and implemented into the heart chambers.
    - Begin development of the jugular vein as well as the connections it will have with heart halves.

- Hunter Belting:
    - 3-D print different components of the heart to test as well as printing parts that will be shown in the show and tell.
    - Work on getting a STL model of the jugular vein that can be tested for repeatable use along with the annulus.

- Anna Balstad:
    - Finish segmenting the heart
    - Test a 3D print using a cheaper material

- Rebecca Poor:
    - Meet with resources and other graduate students to gain help in segmenting
    - Make updates to STL to upload to OnShape

- Daisy Lang:
    - Print jugular vein in cheap material to test with tape options
    - Order tape options
    - Print the jugular vein in correct material to start material testing

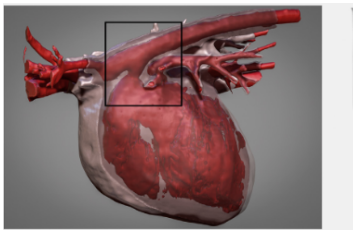
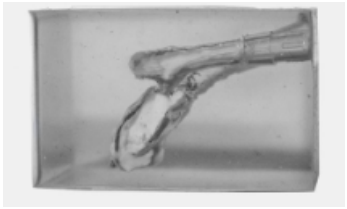
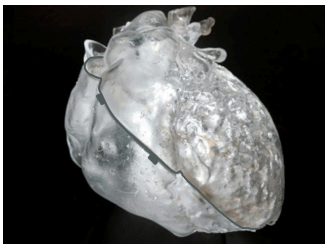
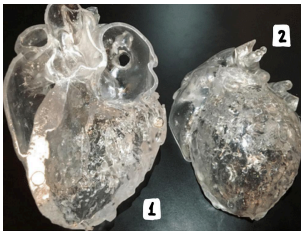
Project Timeline

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	20%	
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**	