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

Client: Dr. Sonja Tjostheim
Advisor: Dr. Tracy Puccinelli
Team: Hunter Belting, belting@wisc.edu (Team Leader)
Anna Balstad, abalstad@wisc.edu (Communicator)
Rebecca Poor, poor2@wisc.edu (BSAC)
Daisy Lang, dllang@wisc.edu (BWIG & BPAG)
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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 design matrices and is preparing for the preliminary design presentation and report. The presentation is on Friday and the report will be due next week Wednesday. We are currently planning on moving forward with the four piece model design. We received samples of potential materials.

Summary of Weekly Team Member Design Accomplishments

- Team:
    - Prepared for preliminary presentation
    - Began writing preliminary design report
    - Received material samples

- Hunter Belting:
    - Created and practiced presenting preliminary design slides for the presentation Friday.
    - Obtained samples from formlabs for two prospective materials that may be used for the model.
    - Began work on the preliminary report.

- Anna Balstad:
    - Created slides and practiced for preliminary design presentation
    - Started writing preliminary report
    - Researched coefficient of friction of vasculature

- Rebecca Poor:
    - Completed compiling preliminary presentation slides
    - Practiced preliminary presentation
    - Began working on preliminary report
    - Communicated with 3D printing vendor to get sample

- Daisy Lang:
    - Completed preliminary presentation slides
    - Created template for preliminary report
    - Researched coefficient of friction values for our materials

Weekly / Ongoing Difficulties
N/A

Upcoming Team and Individual Goals

- Team:
    - Present on Friday
    - Finish preliminary report for next week
    - Meet with client to receive feedback on material samples

- Hunter Belting:
  - Continue to work on the preliminary report and try to implement feedback from the preliminary presentation.
  - Begin working with the team to segment and compile the CT scan into a CAD model that can be printed.

- Anna Balstad:
  - Work on preliminary report
  - Begin segmenting CT scan

- Rebecca Poor:
  - Present at preliminary presentations
  - Finish preliminary report sections
  - Begin compiling CT scans into CAD model

- Daisy Lang:
  - Write preliminary report section
  - Begin researching techniques on how to compile CT scans
  - Reach out to make space for consultation on our printing ideas

Project Timeline

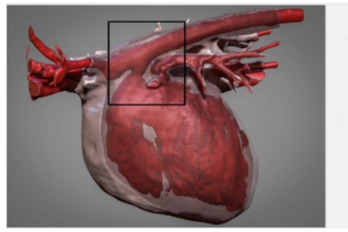
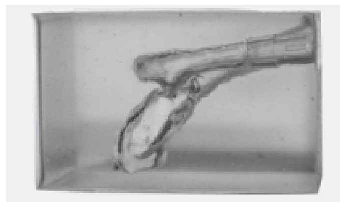
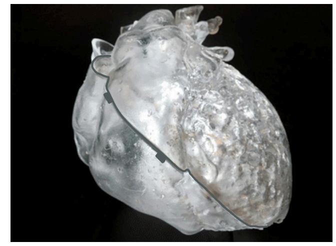
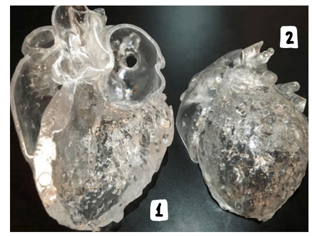
Project Goal	Deadline	Team Assigned	Progress	Completed
PDS	9/20	All	100%	x
Design Matrix	9/27	All	100%	x
Preliminary Presentations	10/4	All	100%	X
Preliminary Deliverables	10/9	All	50%	
Show and Tell	11/1	All		
Poster Presentations	12/6	All		

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**	