Preliminary Presentation BME 402

Multidimensional Imaging-Based Models for Canine Cardiovascular Procedural Skills

Team Members:

Hunter Belting, Daisy Lang, Anna Balstad, Becca Poor

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Client:

Dr. Sonja Tjostheim

Advisor:

Professor Tracy Jane Puccinelli

Overview

- Problem Statement
- Product Impact
- Current Prototype
- Previous Testing
- Spring Semester Prototype Updates
- Spring Semester Testing Plans
- Spring Semester Timeline and Budget

Problem Statement

Goal: Create a 3D model of a canine heart with pulmonary valve stenosis for training simulations of balloon valvuloplasty

Client: Dr. Sonja Tjostheim, DVM, DACVIM (Cardiology)

Specifications:
- Mimic properties of French Bulldog heart anatomy and tissue
- Material must be transparent and non-tacky
- Minimum of 50 uses per year
- Compatible with balloon and stent placement
- Simple user interface

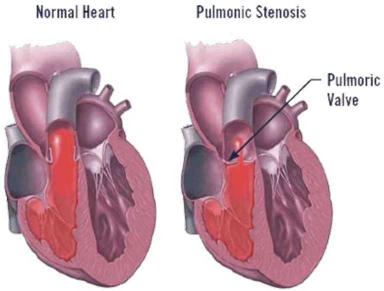

Figure 1:
Pulmonic Stenosis in Canine Heart [1]

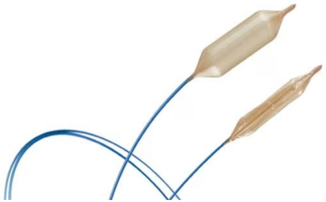

Figure 2:
Balloon Catheter Device [2]

Product Impact

- Pulmonary Valve Stenosis: a congenital heart defect causing narrowing or misshapen pulmonary valve [3]
- Balloon Valvuloplasty: minimally invasive procedure to treat pulmonic stenosis in dogs [4]
- UW School of Veterinary Medicine is experiencing a decrease in caseload of ~ 40 cases a year
- No competing designs for PVS on market

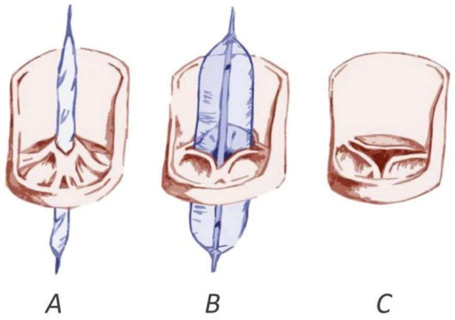

Figure 3: Balloon valvuloplasty [5]

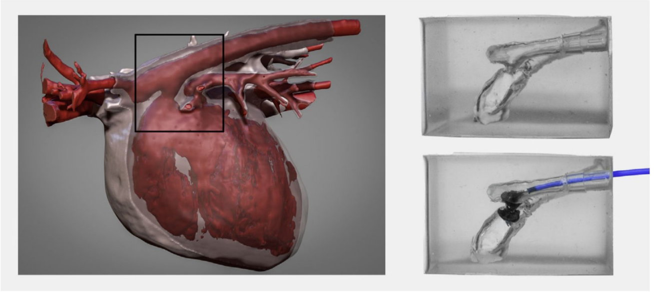

Figure 4: University of Texas Silicon Model of Patent Ductus Arteriosus [15]

Current Prototype

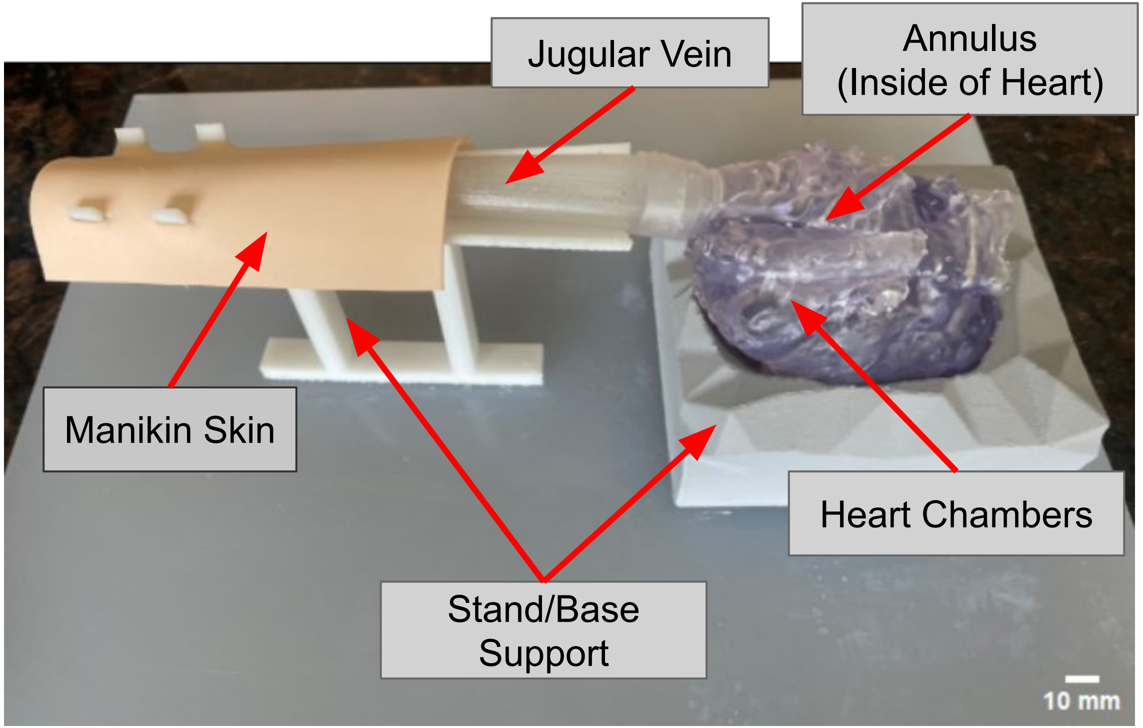

Figure 5: Current prototype

Testing and Results

Material Elastic Modulus:

Myocardium:
0.108 ± 0.229 MPa [6]

Jugular vein:
0.12 ± 0.018 MPa [7]

Elastic 50A:
1.68 ± 0.84 MPa

Flexible 80A:
2.51± 0.32 MPa

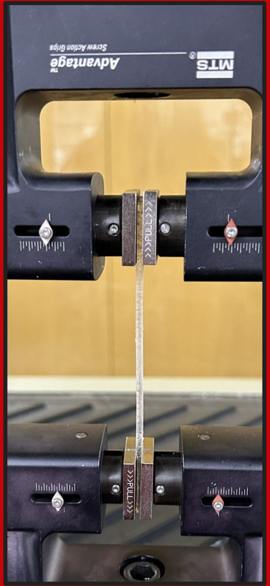

Figure 6: MTS testing of resins

Annulus Valve Fatigue Test:

Measure changes in diameter of annulus over 150 cycles

Top diameter: +13.2%
Bottom diameter: +26.0%
Height: +9.0%

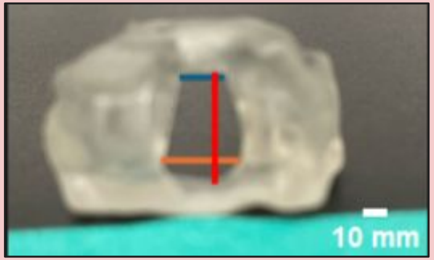

Figure 7: Annulus dimension measurements

Testing and Results

Subjective full model functionality test with client

Leaflet Movement	Meets expectations
Transparency	Meets expectation
Catheter Insertion	Meets expectations
Ease of Use	Partially meets expectations Increase heart mold clearance
Anatomy	Needs improvement Client unable to traverse catheter to valve

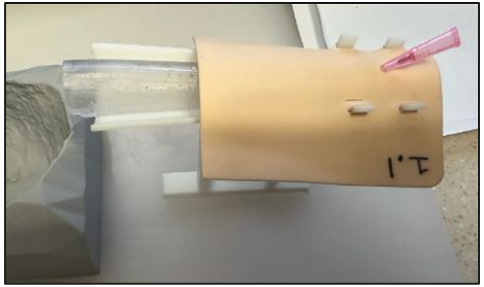

Figure 8: IV needle inserted into jugular vein

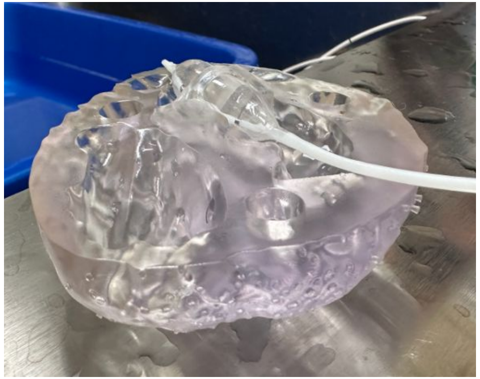

Figure 9: Balloon catheter inflating valve inside model

Prototype Update: Heart Chambers and Heart Box

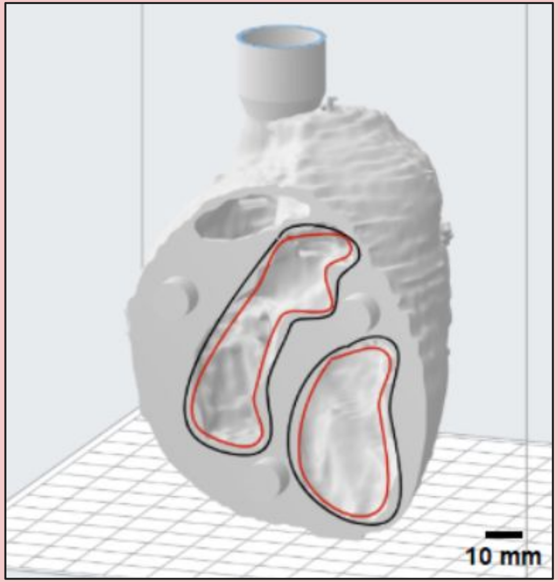

Figure 10: Heart Chamber Enlargement

Heart Chamber Updates

1. Smooth chamber walls
2. Increase chamber volume
3. Change material to Elastic 50A

Heart Box Updates

Increase tolerance from

0.75 to 1.5 cm

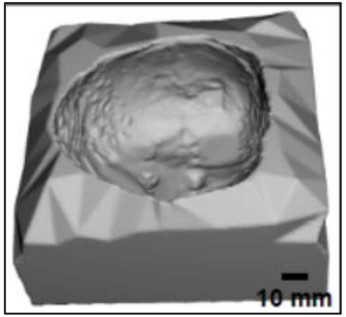

Figure 11: Heart Box

Prototype Update: Video Stand

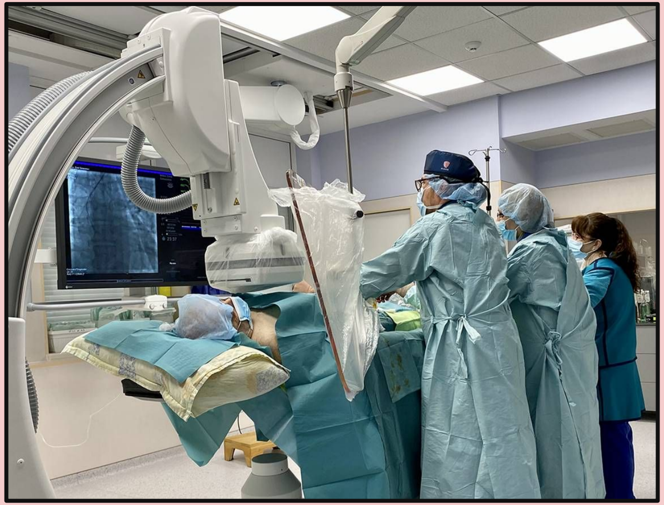

Figure 12: Fluoroscopy in Transcatheter prodecures [8]

Video Stand Development

1. Prevent user from looking at hands
2. Compatible with Cell Phone
3. Project to Monitor via HDMI

Figure 13: Possible Video Stand Designs [9] [10]

Prototype Update: Water Pump and Tank

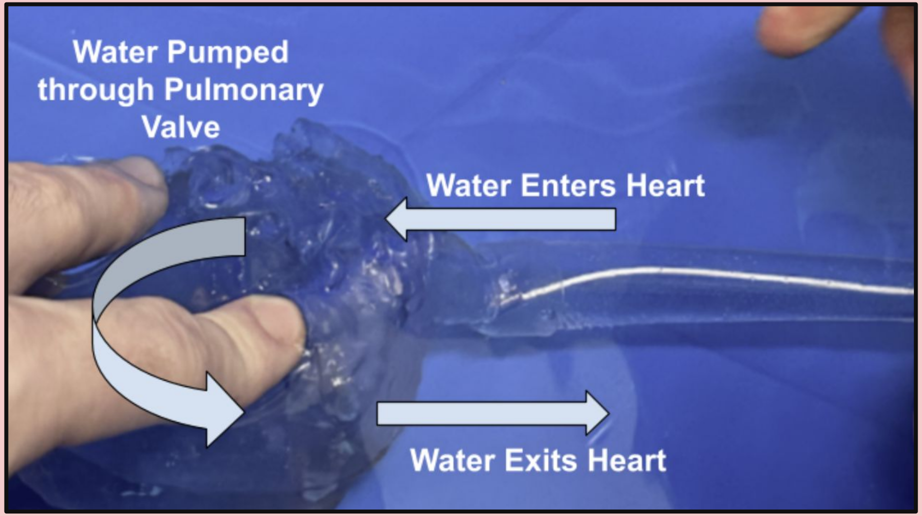

Figure 14: Path of Water Pumped through Heart Chambers

Water Pump Requirements

- 11.04 mL/beat [12]
- 80 beat/minute[11]
- Undisturbed water surface

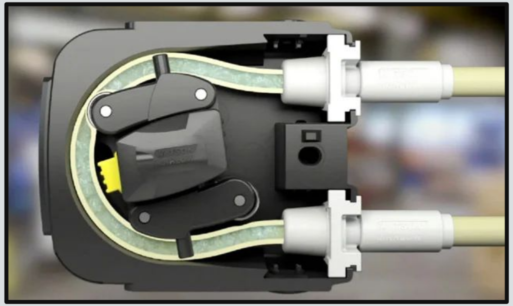

Figure 15: Peristaltic Pump [13]

Testing Plan: Complete Material Characterization

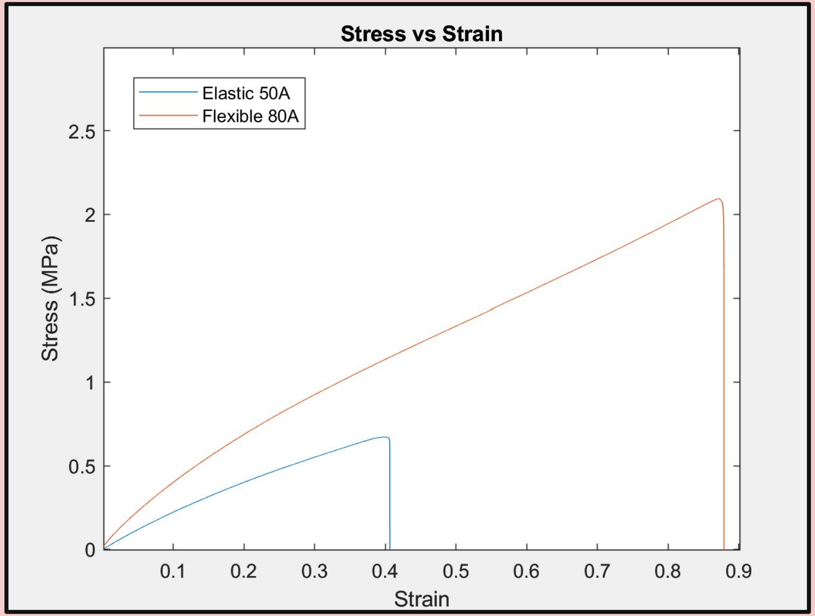

Figure 16: Previous Material Testing - Type I

Elastic 50A Mechanical Properties

- Type IV dogbone for testing
- Verify elastic modulus
- Determine ultimate tensile strength

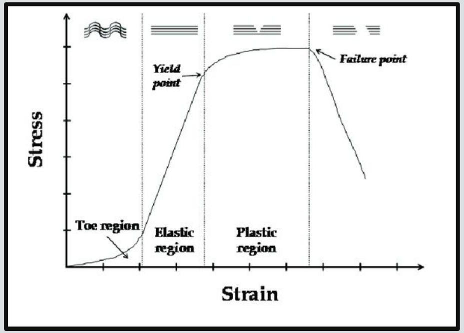

Figure 17: Generalized Stress/Strain Curve of Muscle [14]

Testing Plan: Full Model Functionality Verification

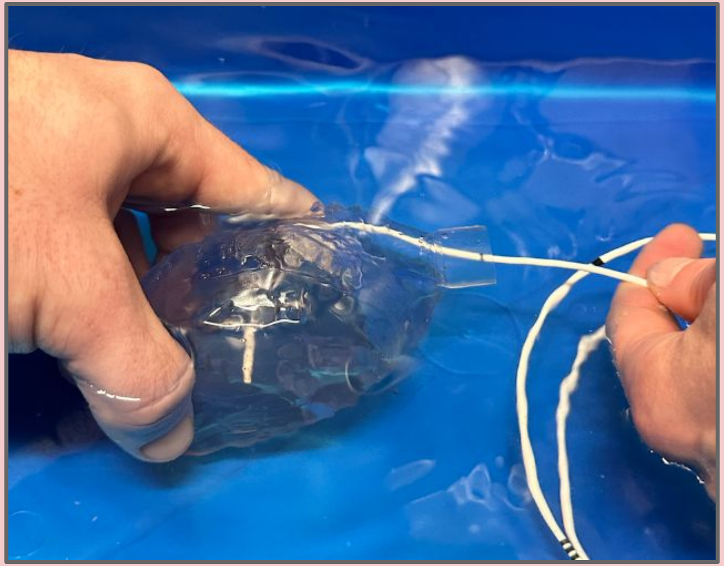

Figure 18: Heart Model in Water Bath

Model Verification Criteria (5)

- Observe movement of leaflets
- Verify full IV insertion process
- Transparency with pump, new material, and through camera
- Ease of use and comparison to native anatomy
- Integration of video stand
- Larger sample size, 5-10 people to evaluate model

Testing Plan: Pump Volume Accuracy Test

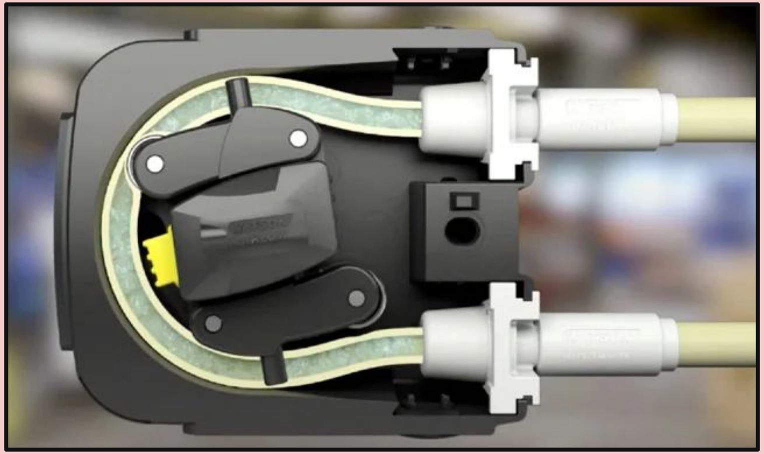

Figure 18: Peristaltic Pump [13]

Pump Accuracy Validation

- Meets pump specifications
  - ~11 mL/beat
  - 80 beats/min
- Measure the amount of water left after a given # of pumps
- Verify water is pumped through the model

Semester Timeline

Month	January				February				March				April				May			
Week	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Heart Model				STL Updates		Print	Evaluate													
Heart Stand						STL Updates		Print												
Pump				Research	Initial Design		Order Parts	Build/Test		Updates	Order Parts	Build/Implement into Model								
Camera System				Research	Initial Design	Order Parts	Build/Test/Redesign													
Water Bath									Initial Design		Print									
User Manual										Initial Draft		Revision/Finalize								

Budget: $1000

Budget

Last Semester	Current Semester

Item	Cost
Elastic 50A Resin	$208.57
Flexible 80A Resin	$208.57
Super Glue	$2.42
Stand Print	$16.00
Pump Components	~$200.00
Video System	~$100.00
Reprint Stand with Updates	~$20.00
Total:	$755.56

Acknowledgements

Dr. Sonja Tjostheim

Dr. Tracy Jane Puccinelli

BME Department

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