Fabrication of Percutaneous Transvenous Mitral Annuloplasty Testing Device

Team 19
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Client: Dr. Wei Sun
Dr. Sun has requested a testing device that will allow his research team to obtain physical evidence regarding the response of cardiac tissue to implantation of the Percutaneous Mitral Annuloplasty System for the Treatment of Mitral Regurgitation (aka. “stent bridge constriction device”)

Figure 1: Summary of Theoretical Analysis Obtained by Tissue Mechanics Lab
Mitral Valve Regurgitation

The Constriction Device

The Testing Device
  - Water Bath
  - Marker Tracking System
  - Force Detection System
  - Ultrasonic Detection

Budget
Mitral valve regurgitation is the backwards flow of blood through the mitral valve.

It is caused by mitral valve prolapse (widening of the mitral valve annulus). This leads to a gap between the anteromedial and posterolateral leaflets of the mitral valve.

The condition is predominate in the elderly. Therefore, clinicians are turning to non-invasive methods to better address the condition.

Figure 2: Difference Between Healthy and Prolapsed Heart Valve
Implanted percutaneously

Catheter guides the device into the coronary sinus

Distal anchor is deployed first followed by proximal anchor

Nitinol bridge between stents constricts coronary sinus, thus closing the mitral valve annulus

Figure 3: PTMA Device Deployment and Effect on the Mitral Valve
Required project components:

- Water Bath
- Marker Tracking System
- Force Determination System
- Ultrasonic Detection

Figure 4: Compilation of Project Components
Purpose: support heart and simulate naturally occurring environmental conditions such as temperature, pressure, and heart orientation

3 main components:
- Water bath
- Heart mount
- Heart pressure system
Secure enough to hold heart stable

Loose enough to allow heart to move naturally in response to the stent bridge constriction device

Aluminum base will squeeze the base of the heart to provide structural support

Aorta tube must securely hold heart and maintain internal pressure of heart without effecting the integrity of the system
Note proximity of the aortic valve and anteromedial mitral leaflet.
Water Bath and Camera Mount System

- **Water Bath**
  - 8”x 8”x 10”
  - Clear cast acrylic sheets

- **Camera Mount**
  - Aluminum
  - Adjustable (height, angle and horizontal location)

Figure 8: Water Bath and Camera Mount
Purpose: Understand mechanical changes experienced by heart during stent deployment

- 15-20 small graphite markers on mitral annulus plane
- 2 cameras 30-45 degrees apart to capture image
- Calibration Cube in field of view of each camera
Direct linear transformation (DLT) MATLAB code

- Recreate image with reference to the three-dimensional plane
- Determine the 3-D position of each marker
- Keep track of each marker and its movements from frame to frame
- Recognize if a marker leaves the frame of view of one of both cameras
- Calculate stress, strain, and deformation
Figure 10: View From Camera of Mitral Annulus Plane
Purpose: Determine relationship between force applied on the mitral annulus by stent and the decrease in mitral valve prolapse

FlexiForce Sensors
- Force measured at specific point as opposed to continuous
- Use 6 sensors in an attempt to get more thorough data
Figure 13: Location of Coronary Sinus (where FlexiForce Sensors will be Applied)
Purpose: Capture Image of the coronary sinus before and after stent deployment

Ultrasound Machine has 2 probes but can only process information from one port at a time

Probe attached to machine will be changed between deployment of stents

Figure 14: Locations of Ultrasonic Probes
Ultrasonic Detection

- Stent penetration
- Change in coronary sinus diameter
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<th>Material</th>
<th>Estimated Number/Size</th>
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<td>Metal supports within chamber</td>
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Acknowledgements

- Dr. Wei Sun
- Thuy Pham
- Dr. Enderle
- Sarah
- Daniel Ruscansky