

33rd Annual CSULB Student
Research Competition

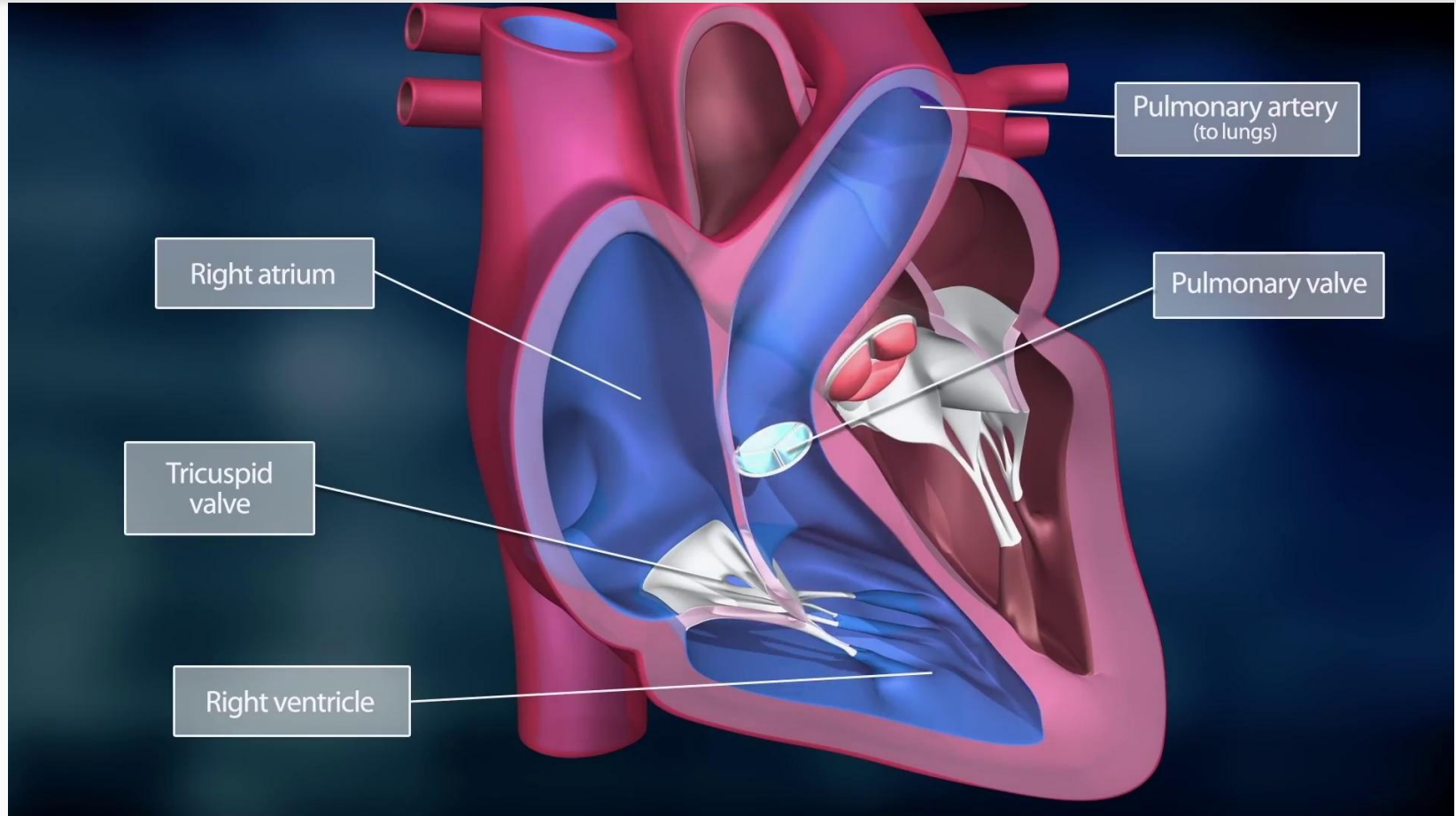
Computational Modeling of Patients Undergoing Aortic Valve and Mitral Valve Replacement Along with Tricuspid Repair

Presented by: Jessica Blair & Nia Sanchez

March 19, 2021

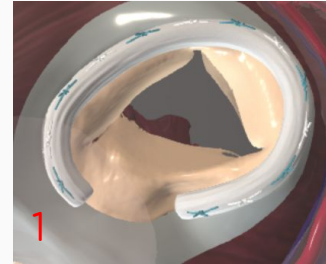


Introduction to the Heart



Introduction to Issue

- Heart valve dysfunction leads to abnormalities in circulation
- Surgical bioprosthetic valve replacement is one strategy to replace the native valve and recover normal circulation
- It is not well understood if bioprosthetic valves comply with physiological environments with blood flow and dynamic motion
- We aim to analyze blood flow and valve motion during the cardiac cycle in a patient who had undergone double valve replacement and single valve repair



Edwards Lifesciences
MC3 Tricuspid
annuloplasty ring



St. Jude Medical
Trifecta Aortic
Valve



Edwards Lifesciences
Magna Mitral Ease

Methods

ITK-SNAP

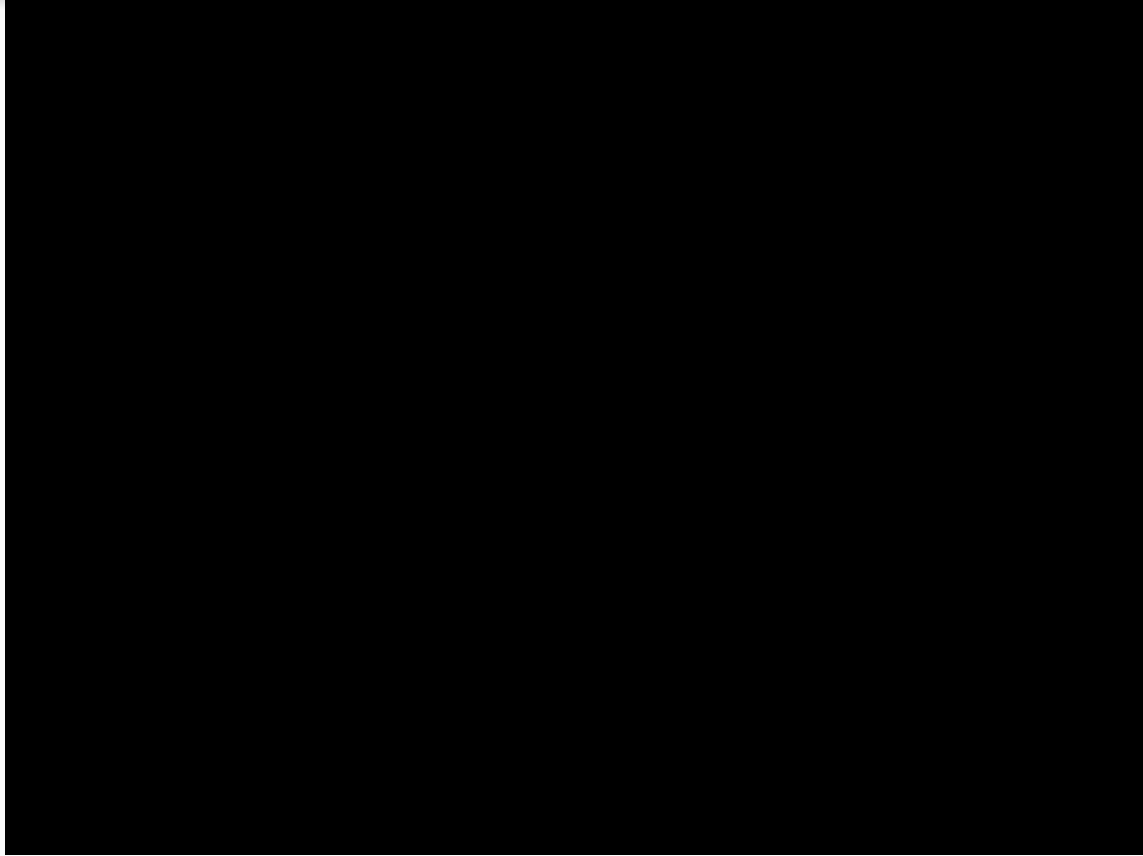
The screenshot displays the ITK-SNAP software interface with the following components:

- ITK-SNAP Toolbox (Left Panel):**
 - Main Toolbar:** Contains icons for navigation and editing.
 - Cursor Inspector:** Shows cursor position (x,y,z) as 189, 397, 109. Below it is a table for intensity under the cursor:

Layer	Intensity
TAV40converted	872
Speed Image	0.9944
Evolving Contour	-4
 - Label under cursor:** Shows 0 and a 'Clear Label' button.
 - Segmentation Labels:** Shows 'Active label: Left Atrium' and 'Paint over: All Labels'.
- Central Viewport:** A 2x2 grid of images. The top-left is an axial CT scan with a red contour. The top-right is a sagittal CT scan with a red contour. The bottom-left is a 3D surface model of the heart in magenta. The bottom-right is a coronal CT scan with a red contour. Each image has a '1 cm' scale bar and 'zoom to fit' button.
- Segment 3D Panel (Right Panel):**
 - Current Stage:** Step 3/3 Evolution.
 - Actions:** Includes a 'Set Parameters...' button and a description: 'Configure the parameters of the contour evolution differential equation'.
 - Execute and control the evolution:** Includes navigation buttons (back, forward, stop) and input fields for 'Step size: 1' and 'Iteration: 73'.
 - Press 'Finish' to accept the result:** Includes 'Back' and 'Finish' buttons.

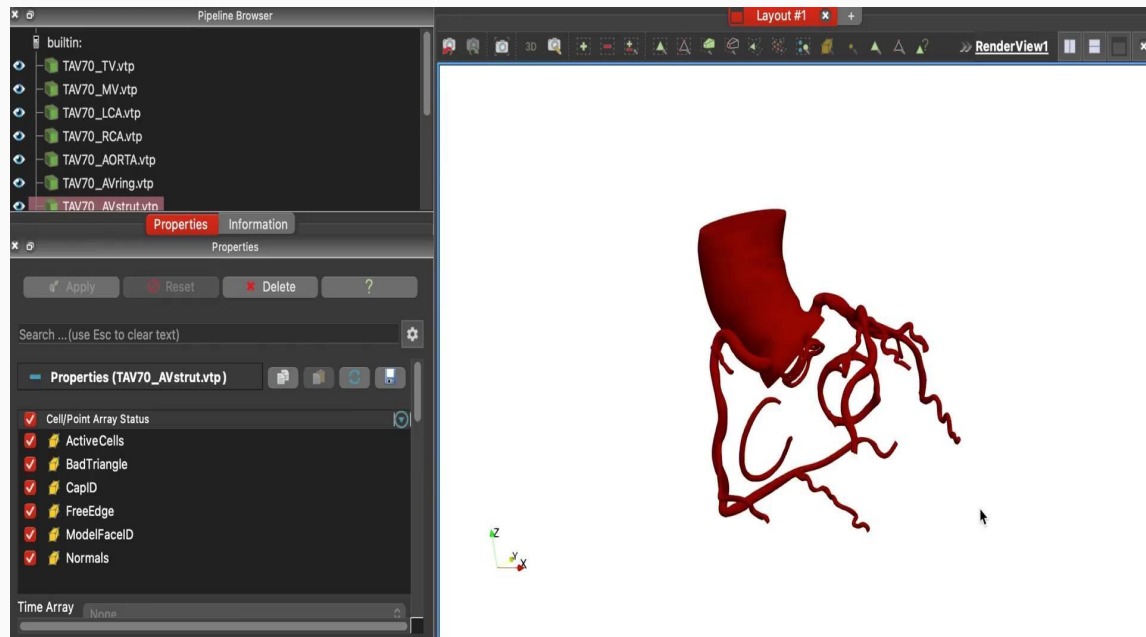
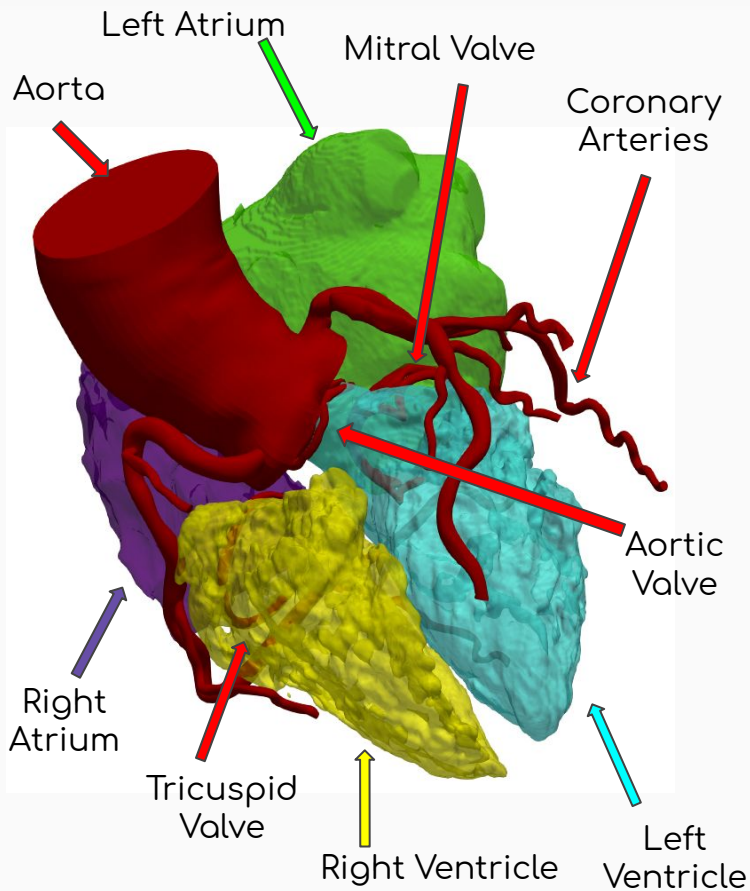
Modeled: Right Atrium, Right Ventricle, Left Atrium, Left Ventricle

SimVascular



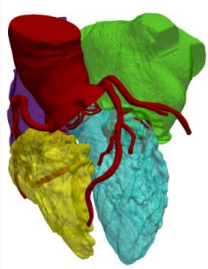
Modeled: Aorta, Left Coronary Artery, Right Coronary Artery, Circumflex Artery, Branches of Arteries, Mitral Valve, Aortic Valve, Tricuspid Valve

Paraview

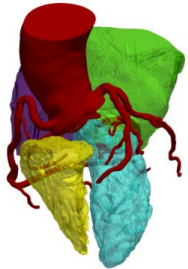


Results & Discussion

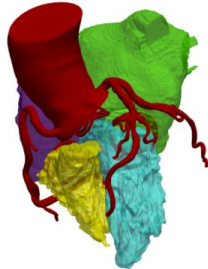
Combined Models for a Cardiac Cycle



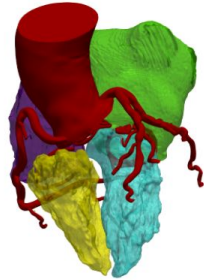
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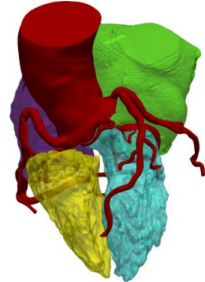
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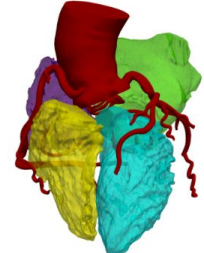
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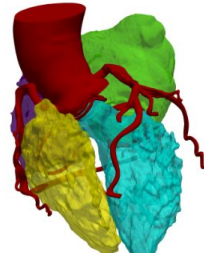
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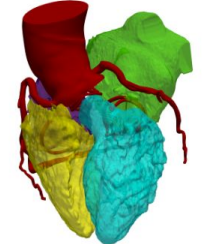
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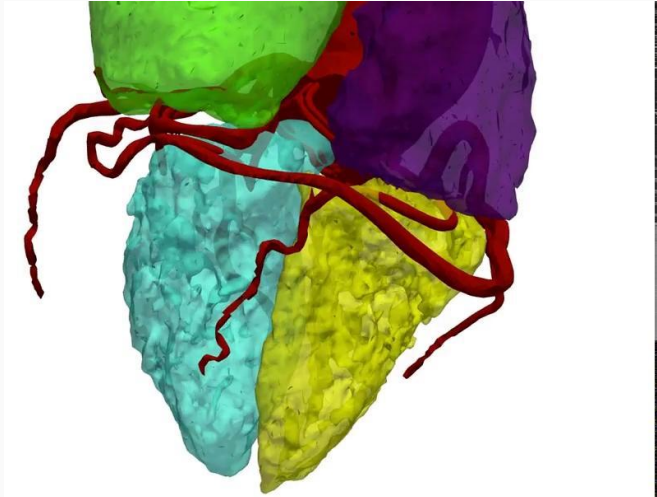
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90



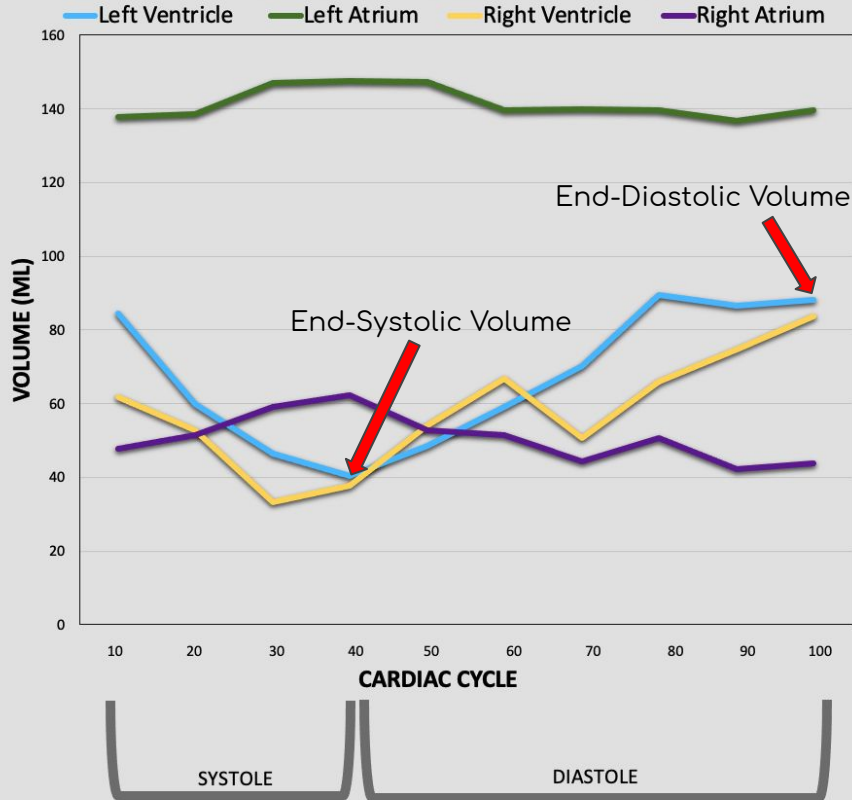
100



100

Comparison to Past Research

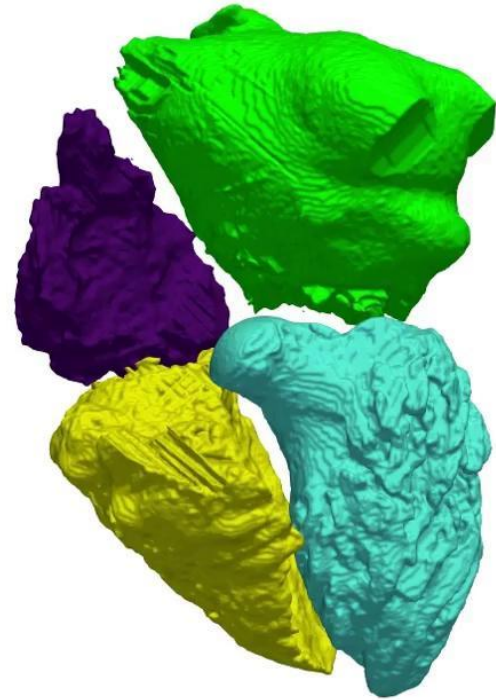
Volume of Four Chambers



- Stroke volume was 48 mL (versus healthy cases, 82 mL; Cain et al)
- Ejection fraction was 54% (versus healthy cases, 67%; Cain et al)
- Our patient exhibited low stroke volume and ejection fraction as compared to healthy cases (Schwartzenberg et al)

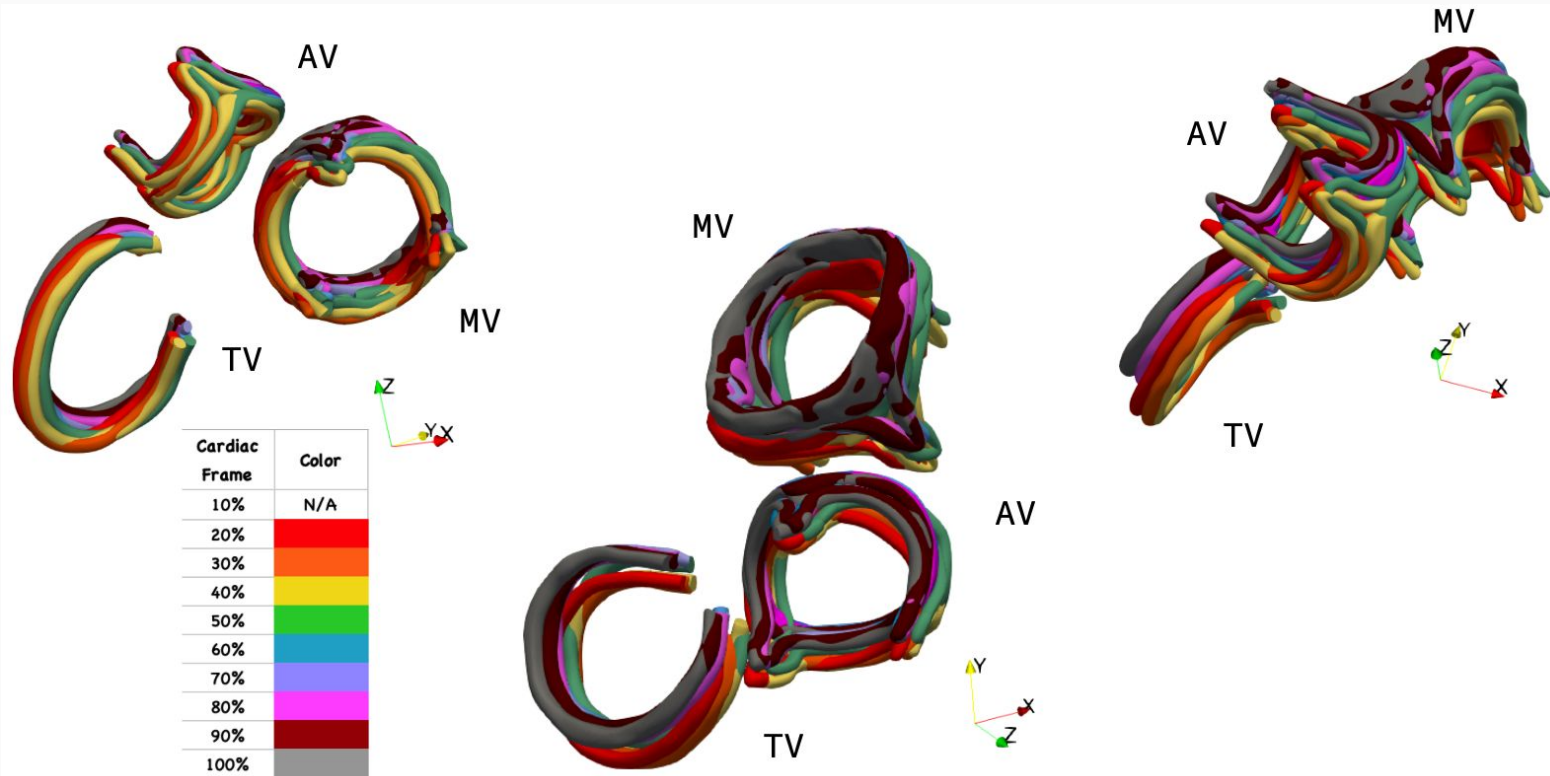
Comparison to Past Research

- Maximal left atrial volume:
 - 97.4 (± 27.3) mL
(Truong et al)
- Minimal left atrial volume:
 - 57.9 (± 21.8) mL
(Truong et al)
- Our patient's left atrial volume ranges from 130–150 mL throughout the cardiac cycle, corresponding to left atrial enlargement

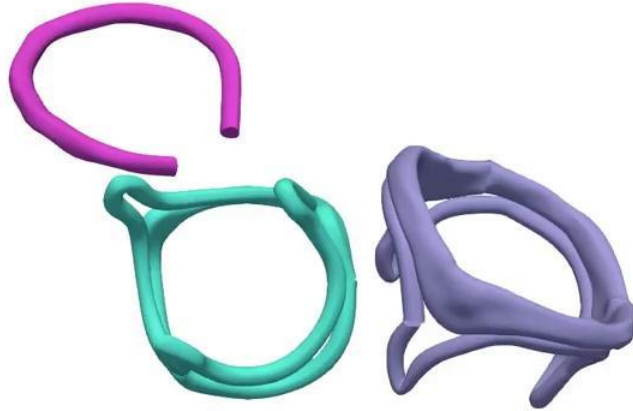


*Cardiac Cycle was repeated 3 times
in this video*

3 Valves in all Cardiac Frames



Valve Translation



Pink: Tricuspid Valve

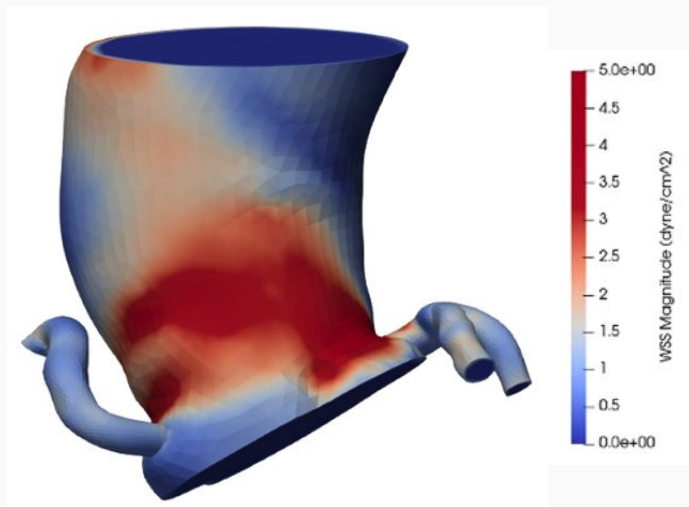
Blue: Aortic Valve

Purple: Mitral Valve

Conclusion

- Decreased stroke volume and ejection fraction was found in our patient
- Elevated volume of the left atrium preludes to left atrial enlargement
- Three artificial valves underwent 3D translation during a cardiac cycle

Future Work



- Gather additional patient data
- Simulations are being conducted via SimVascular to observe wall shear stress and velocity in our patient
- Quantitative geometric analysis with MATLAB is initiated to extract geometric parameters of valve translations

References

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Thank you for your attention and time!

Allotted Q & A Time

Stay Healthy!