ABSTRACT FACE PAGE

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11. **Is this the research presented in this abstract supported by IMAG MSM-related U01 funding? Yes**

12. **If the Presenting Author is a trainee, who is the trainee's primary research advisor?**
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13. **If the Presenting author is a trainee, would the Presenting Author like to enter his/her abstract in the <u>Trainee Poster Competition*</u>? Yes**

14. **If the Presenting author is a trainee, would the Presenting Author like to enter his/her abstract in the <u>Trainee Oral Presentation Competition**</u>? No**

CONSTRUCTION AND INITIAL EXPERIENCE WITH A FOUR-CHAMBERED FLUID-STRUCTURE INTERACTION MODEL OF THE HEART

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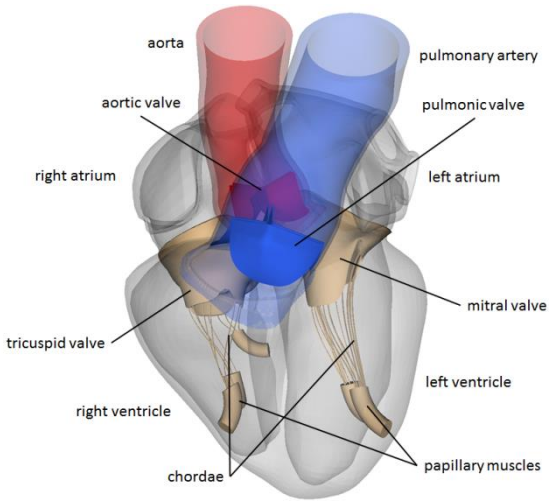

Figure 1: Structure features included in the heart model generated from patient imaging data

BACKGROUND: Cardiovascular disease is the leading cause of death in the United States, and the estimated cost associated with heart diseases in the U.S. alone is over $200B [1]. This work aims to develop a comprehensive heart model that couples realistic descriptions of the biomechanics of the heart and its valves to the blood.

METHODS: We use an immersed finite element method to construct a fluid-structure interaction model of the heart [2, 3]. We use patient MRI data to build the geometries of the myocardium and the valves (Fig. 1). Tissue properties are based on experiments with human cardiac samples, and we include an approximation of the fiber structure of the myocardium and valve leaflets. The governing equations of the structure mechanics are based on the constitutive model equations used in fitting the stress-strain curves during material property parameterization. The blood is modelled by the incompressible Navier-Stokes equations. The structure is approximated using the finite element method, and the fluid is modelled using a finite difference method.

RESULTS: Using the immersed finite element method, we can simulate and observe fluidic and structural dynamics as well as their interaction. We use this model to simulate a full cardiac cycle, and then we generate a corresponding pressure-volume (PV) loop from the left ventricle (Fig. 2). Our results capture the major features of an *in vivo* cycle, including isovolumetric contraction and relaxation.

CONCLUSIONS: Based on our PV loop generation, our model has the potential to simulate realistic cardiac cycles and capture the fluid-structure dynamics of all four chambers. Future work includes using the model study the impact of myopathies on fluid dynamics and running computational investigations for potential surgical interventions and implanted devices.

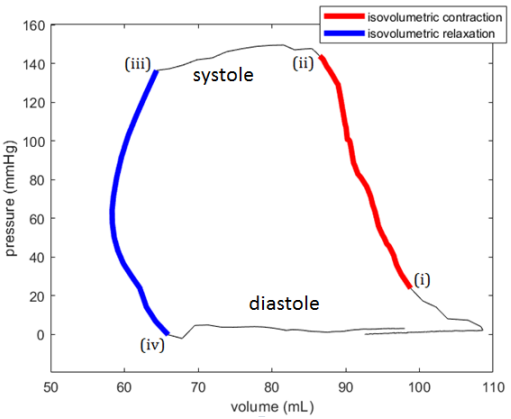

Figure 2: The pressure-volume loop from our simulation is characteristic of *in vivo* loops in which we can see (i) mitral valve closing, (ii) aortic valve opening, (iii) aortic valve closing, and (iv) mitral valve opening, as well as the other labelled features.

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1. https://www.cdc.gov/heartdisease/facts.htm.
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ACKNOWLEDGEMENTS: We gratefully acknowledge research funding through NIH Award U01HL143336. MD is supported by NIH Award T32GM067553.