

Three-Dimensional Model of Heart with Atherosclerosis

First Year Engineering Design Project

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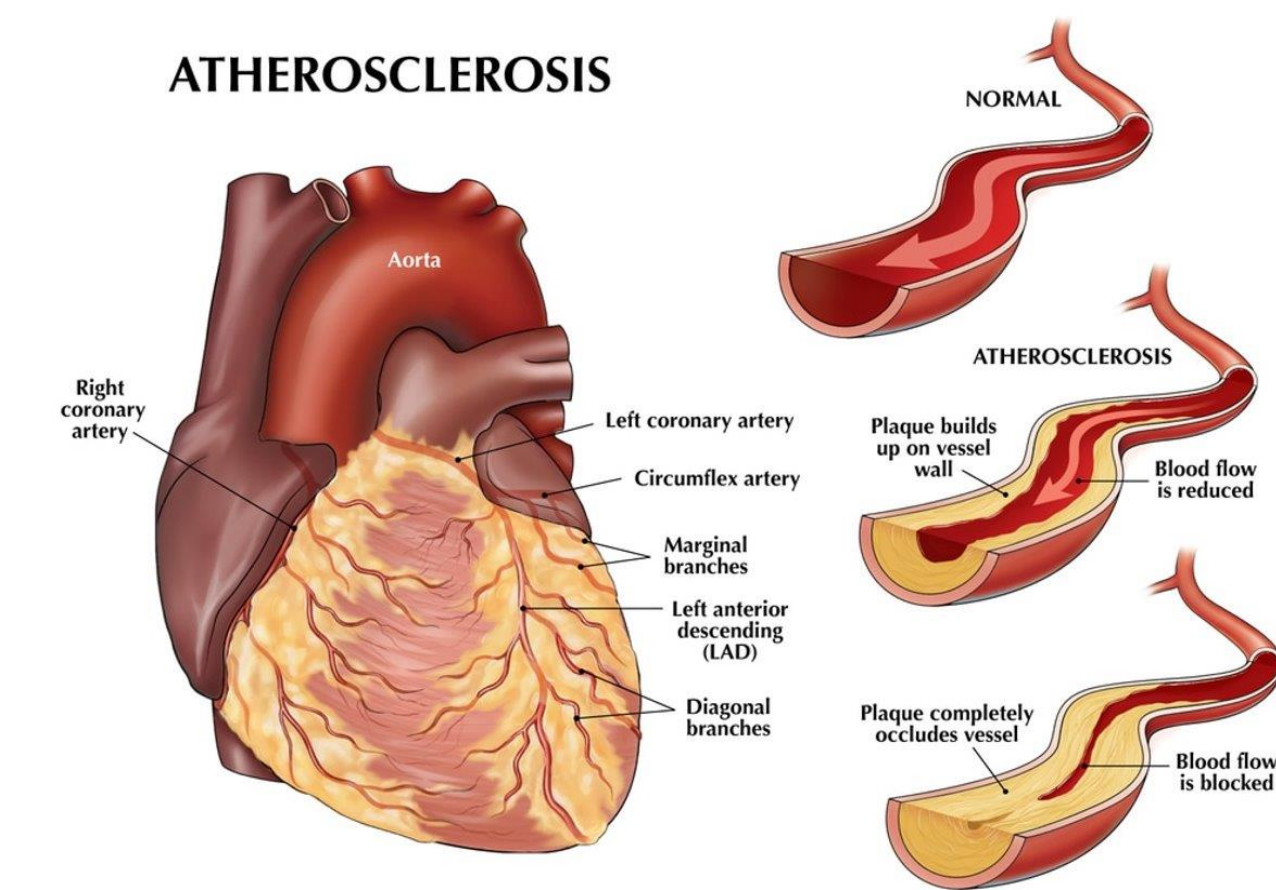
Sponsor: Dr. Kostovich

Abstract

The sophomore nursing students need a learning device to demonstrate a patient with Atherosclerosis to help aid in their understanding of the disease and treatment. The goal of this project is to design a 3D dynamic model of the heart showing more than one artery, Atherosclerosis present in the left main coronary artery, and the model remain proportional to a real heart for the students. In order to accomplish this the project team designed a two-part 3D model of half of a heart in SolidWorks. The model portrays an enlarged textured display of the main arteries, as well as a cross section of the plaque buildup in the artery to mimic Atherosclerosis. Many design models and strategies were attempted before reaching a final design; the final design consists of all the requirements given by our sponsor, feedback from the students, and material/price constraints. Scaling calculations along with surveys from current day nurses were used to test the final design model to ensure that it was accurate and suitable for students understanding. The outputs confirmed that the final design would be a beneficial and supportive learning device for the sophomore nursing students.

Introduction

Background on Atherosclerosis



Atherosclerosis occurs when cholesterol or fat buildup as plaque within the walls of an artery this buildup can lead to restriction of oxygenated blood flow to the heart which turn can lead to heart attacks, cardiovascular disease, coronary artery disease, heart attack, stroke, or rupture of the artery.

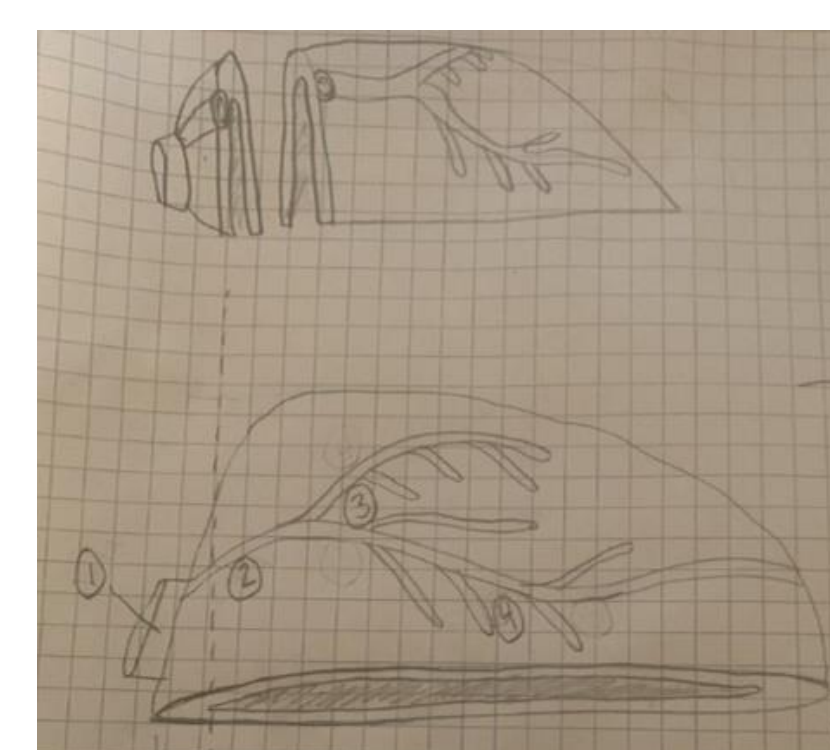
Requirements

The model must depict a cross section of the left main coronary artery upon request of the nursing student's instructor. Visible plaque buildup and a clear narrowing effect on model to demonstrate Atherosclerosis. Proportionality of cross section being greater than .25 inches and the model length and width to that of an average male human heart to maintain anatomical perspective. The model must not cost greater than budget of \$100 to print and cannot exceed 3D printer capacity of 8 by 8 by 6 inches.

Methods

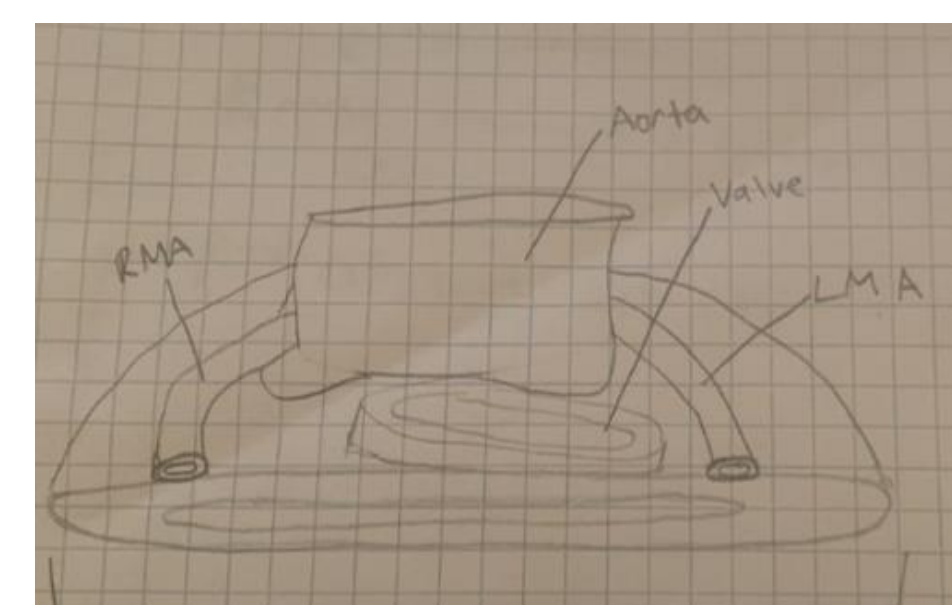
Design Strategy

When beginning this project our team created multiple designs that fit the requirements and budget constraints. After analyzing the options were sorted into our top two possible model ideas. These two options are present to the right and through careful evaluation within our team as well as our sponsor, the final design model was chosen. The birds eye view of the heart was not chosen due to the fact the model wouldn't mimic that of a real heart which would be a disadvantage to the sophomore nursing students. Also, this view would demonstrate Atherosclerosis only internally as opposed to both external and internal viewpoints.



Left View

Bird's Eye View



Survey Testing

In order to receive feedback, from the target audience, a google forum was created where nursing students could leave their opinions on the model. Also, our team members shared this forum link to some nurses we knew of for their feedback as well. We received constructive criticism to aid in our construction process of the model in SolidWorks. The main issue that arose was the amount of plaque within the artery and the diameter of the artery being too small for Atherosclerosis to be properly illustrated.

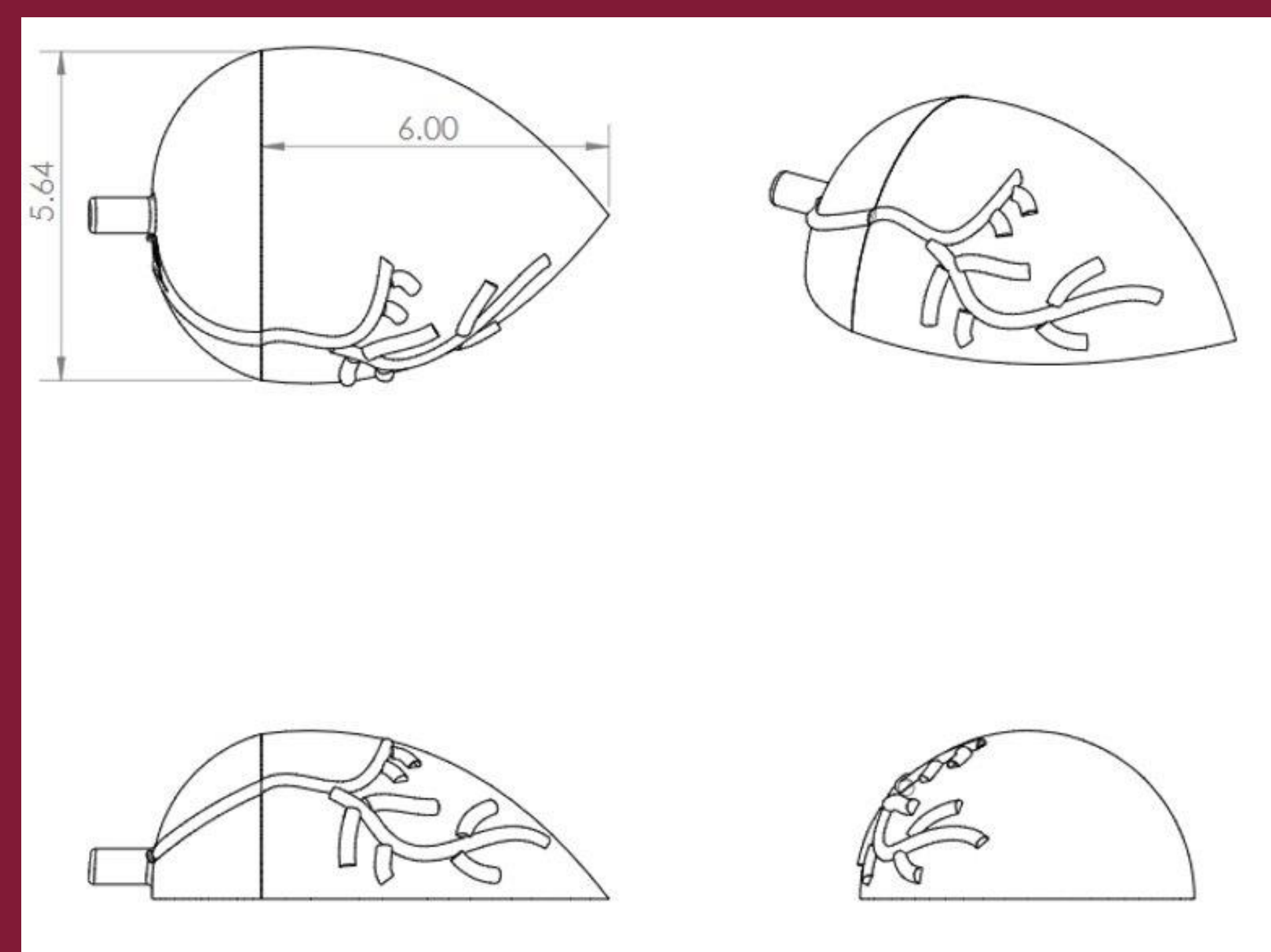
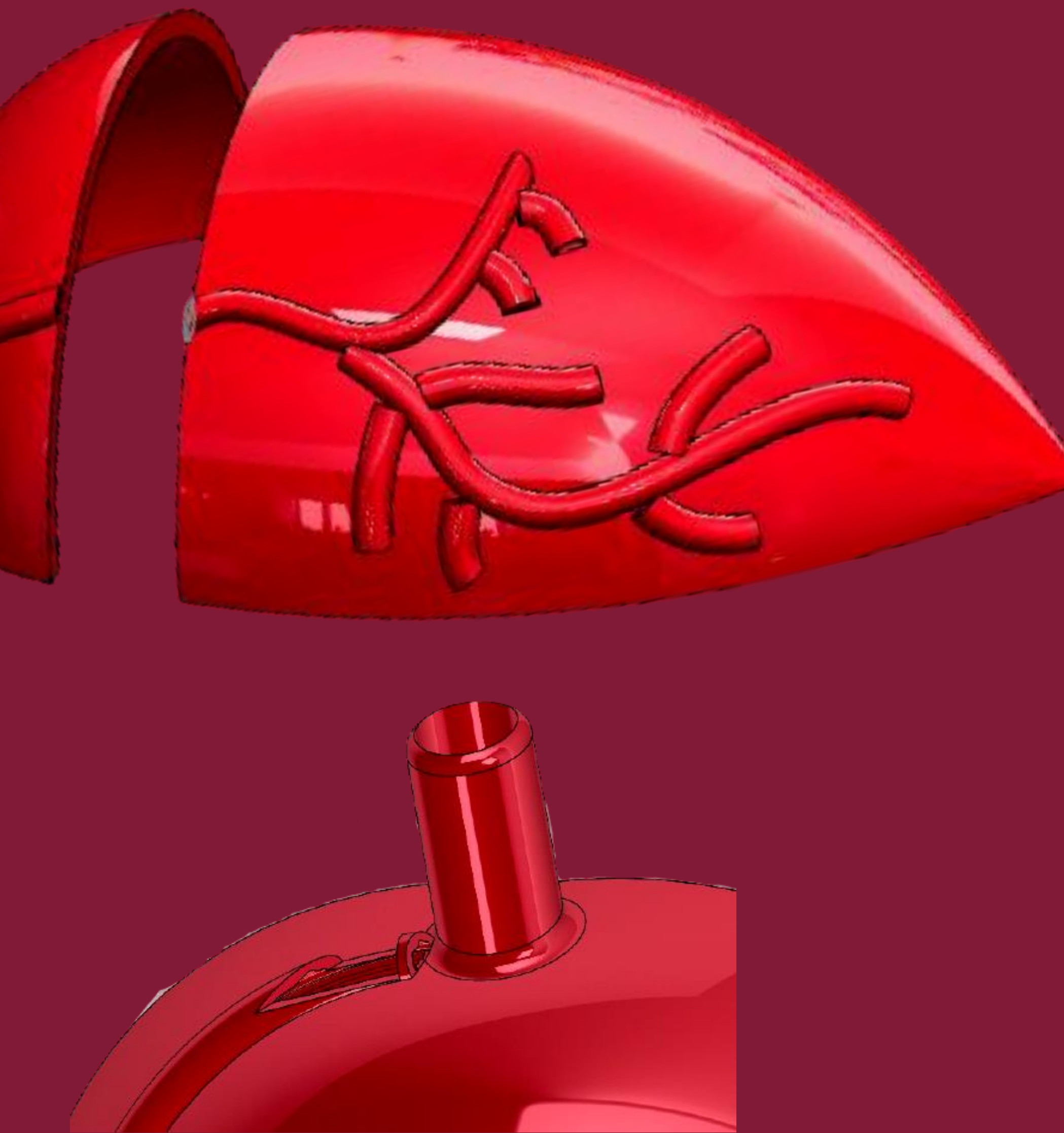
Discussion

The heart model offers a clear view of plaque buildup that leads to atherosclerosis in the left main coronary artery of the heart. We chose to have to have a cross section on the left main coronary artery on the top half of the heart so two individuals may look at the model. Along with the left main coronary artery, other arteries are also present on the surface of the heart, so the impression of a human heart stays present.

Results

The model heart we created was to have proportional measurements to an actual human heart. The human heart is approximately 1.75x the measurements we used in our model. The measurements of the model were set to be as large as possible without exceeding the printer capacity or \$100 budget established prior while remaining proportional. On the model heart we display a diagonally cut artery on the top half of the model which clearly shows a layer of plaque building on the walls of the artery. Along with this, on the bottom half of the detachable model there is another view of the left main coronary artery that shows a direct view into it.

Two registered nurses viewed our model design and liked the idea of showing the entire heart despite the requirement being of just the arteries. We also received feedback from a nursing student at Loyola University who said a model like this would help a lot in their unit of heart disease. The students can now see an in-hand model that can help them understand atherosclerosis better,



Final Design Drawing

Average Adult Male Heart

- 4mm diameter of artery
- 114mm length of heart
- 81mm width of heart

Model Heart

- 0.276 mm diameter of artery
- 7.86in length of heart
- 5.66in width of heart

References

Our group would like to thank Professor Streeter, Dr. Baura, and our sponsor Dr. Kostovich for guiding and supporting us through this process. Also, we would like to thank the nursing students and nurses who administered important feedback during the design process.

[1] Gupta, Chandni. A Morphometric Study of Measurements of Heart in Adults and Its Relation with Age and Height of the Individual: A Post-Mortem Study. webcache.googleusercontent.com/search?q=cache%3AxmQvOcZeJWlJ%3Ahttps%3A%2F%2Fcihr.org%2Farticle.asp%3Fissn.

[2] Mohammadi, Shabnam, et al. "Study of the Normal Heart Size in Northwest Part of Iranian Population: a Cadaveric Study." Journal of Cardiovascular and Thoracic Research, Tabriz University of Medical Sciences, 2016, www.ncbi.nlm.nih.gov/pmc/articles/PMC5075360/.