ValveVision: Creating a 3D Model to Improve Selection of Bioprosthetic Aortic Valve in TAVR Procedures

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Abstract

Transcatheter aortic valve replacement (TAVR) is a minimally invasive procedure to replace a calcified aortic valve as a result of aortic stenosis (AS).[1] Before this procedure, interventional cardiologists request CT scans of the patient, send them to biomedical companies such as Medtronic and Edwards Lifesciences to return proper measurements and suggestions to predict the best bioprosthetic valve to use.[2] However, this is biased towards the companies who suggest the use of their valve and makes it difficult for interventional cardiologists to select the correct valve. Thus, we want to create a way to better visualize the unique vasculature of TAVR patients to improve the ease of deployment and better predict valve sizes. Through the manipulation of the CT scans, we were able to create a MATLAB application called ValveVision for the segmentation and creation of a 3-D model of the aortic valve and aorta. ValveVision allows for the physician to independently create a 3-D model which can be used for valve selection. Our methods show no significant difference between the measurements from biomedical companies such as Medtronic and Edwards Lifesciences and those derived from our model, solidifying it as a novel tool to be used in the aortic valve selection process.

Introduction

- Valvular aortic stenosis is a progressive disease caused by the thickening or calcification of the aortic valve without obstruction to the left ventricular outflow.
- Severe aortic stenosis has a poor prognosis, with a 5-year mortality of 50–60% and a 10-year mortality approaching 90%. With intervention, the life expectancy increases significantly.
- (TAVR) is a minimally invasive procedure to replace a calcified aortic valve as a result of aortic stenosis, but it has greater errors in valve replacement due to use of imaging as the main source of valve selection. [3]

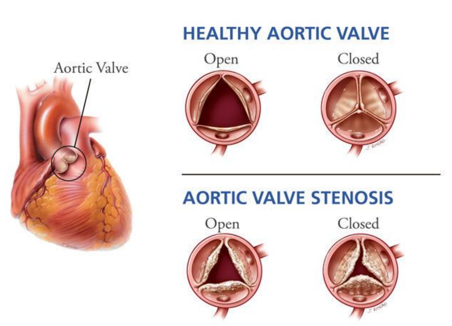

Figure 1. *Depiction of Aortic Valve Stenosis "Aortic Valve Stenosis: Heart Care: Intermountain Healthcare." Intermountainhealthcare.org, intermountainhealthcare.org/services/heart-care/conditions/aortic-valve-stenosis/.*

Methods | Design | Analysis

Project Workflow

Figure 2: *CT scan of the patient file used. Views from left to right: axial, coronal, sagittal.*

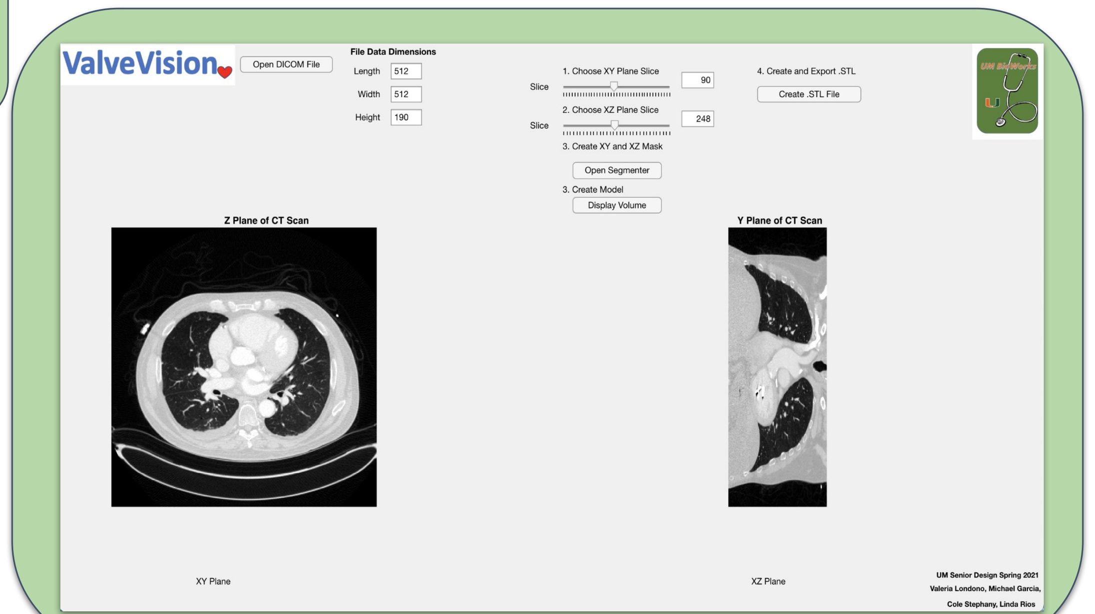

Figure 3. *ValveVision Application Interface.*

Figure 4: *3D model of the Aorta. This model was creating using ValveVision.*

Figure 5: *3D printed model of the Aorta. This model was printed in PLA filament using the Makerbot 3D printer.*

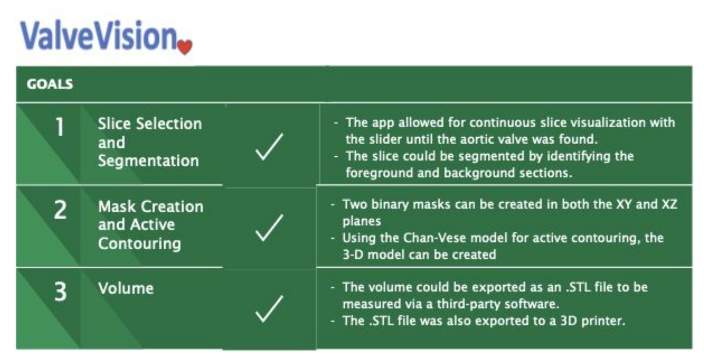

Figure 6. *ValveVision Application Workflow.*

Figure 7. *Measurements used for Valve Selection.*

Results

	Long Aortic Annulus Diameter	Short Aortic Annulus Diameter	Annulus Perimeter	Annulus Area
Medtronic P-Value	0.6366	0.4057	0.0714	0.6435
Edwards LifeSciences P-Value	0.9992	0.8784	0.3280	0.1801

Table 1. *ANOVA Tests for Variance between each phase of our model and the standards of Medtronic and Edwards LifeSciences. Null hypothesis is that there is no difference between measurements.*

Table 1 shows the relationship between our model's measurements at every step in the creation process and both major biomedical standards in the field using the ANOVA test for variance between measurements. These measurements are the major indicators which interventional cardiologists use to select the appropriate valve size. Since all measurements have p-values above 0.05, we can state that our model has physical properties that are not statistically different from the accepted standards.

Conclusion

- We were able to create a user interface that allowed our users, specifically interventional cardiologists, to perform the segmentations and formulate an independent perspective. From our segmentations, we were able to successfully obtain a 3D print of our models in surgical resin.
- Our method of modeling and measuring does not create a statistically significant difference when compared to the measuring methods from Medtronic and Edwards LifeSciences.

Figure 8: Physical Model 3D Printed with Surgical Resin using Formlabs printer

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MATLAB

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