The Segmentation and Flow Velocity Visualization of Abdominal Aortic Aneurysm

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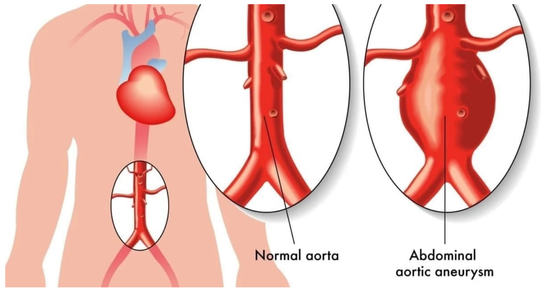
Abstract

Abdominal aortic aneurysms are a swelling of one section of the aorta and is a fairly common condition that can result in many unwanted symptoms including death.
The goal of this experiment was to gain familiarity with the segmentation and flow visualization of a patient with an abdominal aortic aneurysm using 3D Slicer and Ansys Fluent.
The testing results showed that the segmentation and flow visualization represented what would be seen in a real patient situation resulting in a successful learning experience.

Introduction

An abdominal aortic aneurysm is a swelling in the aorta that causes the flow of blood through the aorta to be unconventional. An abdominal aortic aneurysm is often dangerous due to the pressure buildup which can rupture the aorta and cause life-threatening bleeding.
In this project, an example of an abdominal aortic aneurysm is segmented using the 3D Slicer software and then the resulting blood flow through the aneurysm is modeled using the Ansys Fluent software. The motivation of modeling this is to evaluate the flow and resultant pressure issues that may be caused.



Methodology and Figures

Two Main Steps:
1. Using 3D Slicer to Segment
2. Using Ansys Fluent to Visualize Flow Velocity

(1) 3D Slicer (Segmentation):
- A mesh of a CTA abdomen was imported shown in Fig. 1.
- The model was manipulated until only the aorta and resulting abdominal aortic aneurysm were present.
- The flow path was found and modeled.

In the end, we have a simple model of the aorta and the abdominal aortic aneurysm with a visualization of the flow paths.

(2) Ansys Fluent (Flow Velocity Visualization):
- Mesh of aorta and aneurysm is imported
- Flow calculations are found and graphed in Fig. 2 to ensure accuracy.
- Velocity was then calculated and modeled in Fig. 3.
- Vectors of velocity were calculated and modeled in Fig. 4.
- Shear stress at the walls of the aorta were calculated and modeled in Fig. 5.

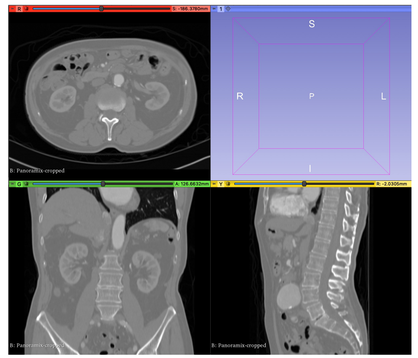


Figure 1: Example CTA Abdomen

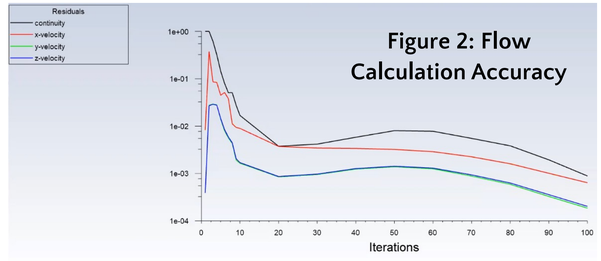


Figure 2: Flow Calculation Accuracy

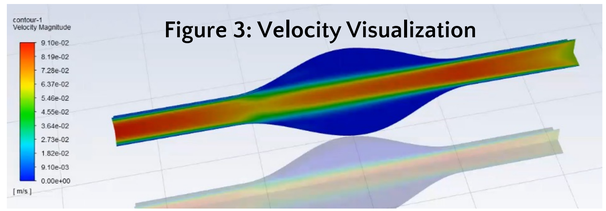


Figure 3: Velocity Visualization

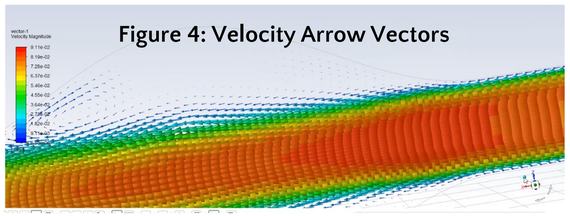
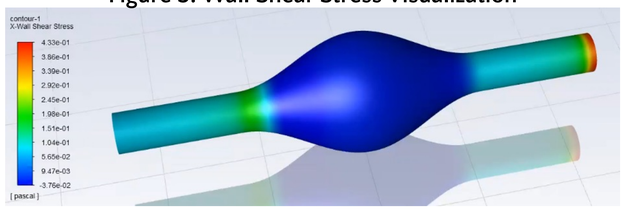


Figure 4: Velocity Arrow Vectors

Figure 5: Wall Shear Stress Visualization



Bibliography
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Staff, Familydoctor.org Editorial. "Abdominal Aortic Aneurysm (AAA)." *Familydoctor.org*, 18 Apr. 2022, https://familydoctor.org/condition/abdominal-aortic-aneurysm/.

Results

(1) The velocity is different at the end of the abdominal aortic aneurysm as shown in Fig. 6.

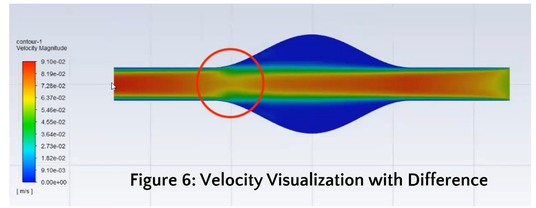

Figure 6: Velocity Visualization with Difference

The velocity difference causes blood to build up in this area of the aorta, which causes an expansion and increased pressure.

(2) The shear stress is greater at the outlet (left) of the aneurysm as shown in Fig. 7.

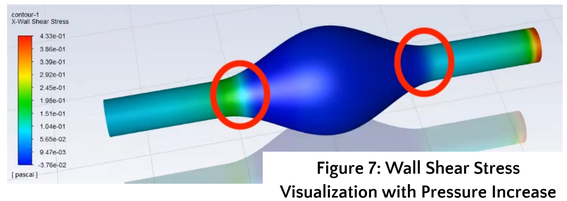

Figure 7: Wall Shear Stress Visualization with Pressure Increase

The shear stress is greater which indicates that the aneurysm is causing the outlet wall to be pushed out and is more susceptible to bursting.

Conclusion

Overall, I was able to fully section an aorta, find the velocity profile of the blood flow throughout the aorta, and show the shear stress on the walls of the aorta with a given abdominal scan.
It is important to note that the data that I worked with were prepared in a way to make it easy to manipulate, but in real life data, the final result will be much messier despite following the same general trend.