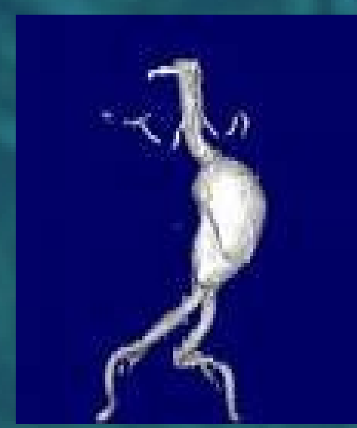
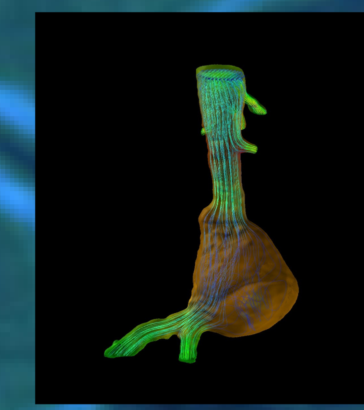
Parametric Study of Mechanical Stress in Abdominal Aortic Aneurysms (AAA)





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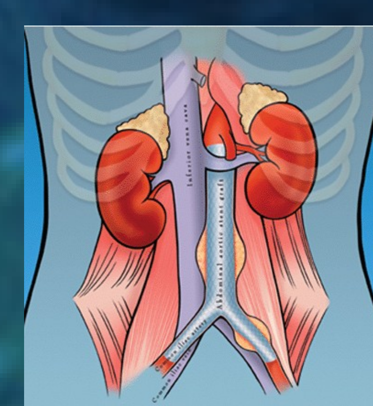
http://www.csm.ornl.gov/Internships/rams_06/abstracts/e_lennartz.pdf

Introduction

- The aorta is the largest human artery, originating from the left ventricle of the heart
- Aneurysms in the aorta typically occur in the abdominal region due to the decrease of elastin in this area and this region does not have a vaso vasorum, which aids in repair
- An abdominal aortic aneurysm (AAA) is a disease where the abdominal aorta loses its structural integrity and dilates in a balloon-like manner



Why is this important?

- Abdominal Aortic Aneurysms (AAA) are a leading cause of death in the United States
- 90% of AAAs that rupture lead to death
- Currently aneurysms are not treated with intravascular or open surgery until they reach a maximum diameter of 5 to 5.5cm
- Aneurysms much smaller than 5cm have ruptured, while aneurysms much larger have not
- An aneurysm ruptures when the stress in the wall exceeds its strength, not when it reaches a certain size

What was done before

Two previously created geometries were used for this sensitivity study. One of the geometries includes the bifurcation of the abdominal aorta into the iliac arteries, while the other does not. In both cases the rupture location is known and is accurately predicted using the patient average parameters.

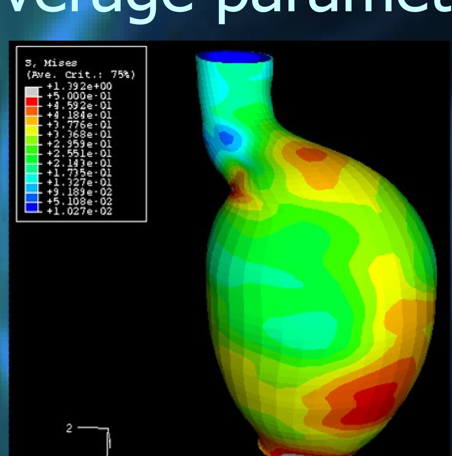


Fig. 1. Abaqus FE analysis of Von Mises stress on the non-bifurcated AAA, with linear elastic properties

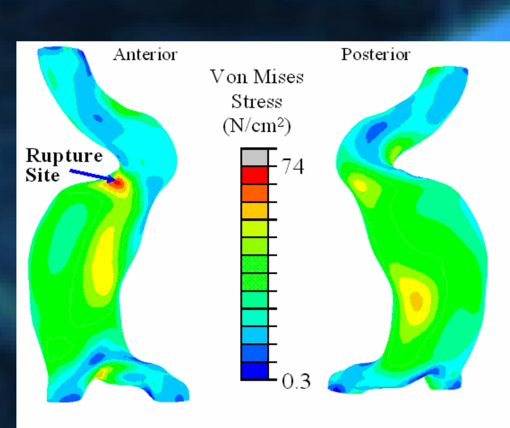


Fig. 2. Abaqus FE analysis of Von Mises stress on the bifurcated AAA , with linear elastic properties

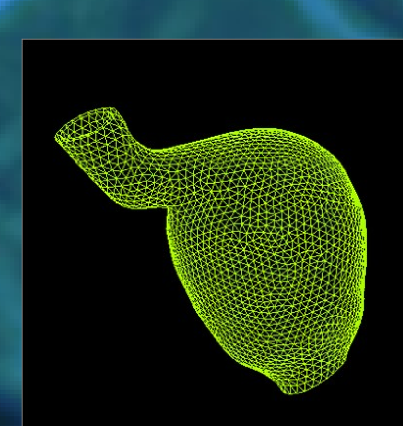
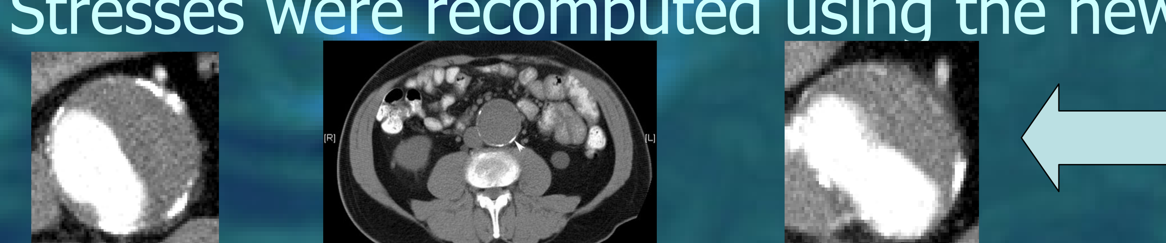


Fig. 3. Abaqus mesh of the non-bifurcated AAA,

Methods

(1) Geometry model was created from segmented CT scans
(2) The AAA geometry model was meshed
(3) Stresses were computed for the meshed mode using the finite element (FE) analysis program Abaqus
(4) Values for the wall thickness, elastic properties and blood pressure were varied
(5) Stresses were recomputed using the new values



CT scans of AAA

Project Goals

- Determine the sensitivity of the mechanical stress calculations to changes in the following parameters: wall thickness, elastic properties of both thrombus and artery wall, and blood pressure
- Determine which parameters affect the stress calculations the greatest
- Develop a hyper-elastic model for both AAA models using Abaqus
- Develop a more realistic model for predicting rupture

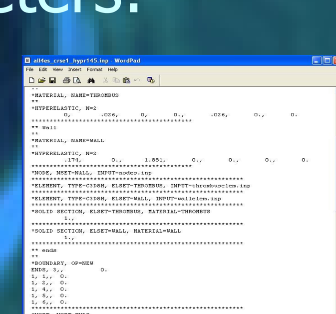


Fig. 4. Example *.inp file for Abaqus input

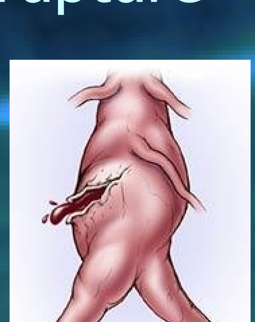


Fig 5.Aortic rupture. Preventing aortic rupture is the ultimate goal of these studies

Conclusions

- The hyper-elastic model resulted in higher stress computations compared to the elastic models
- The von Mises stress was very dependent on the wall thickness and found to be higher and more sensitive in the thinner walls
- While patient-averaged parameters were accurate in determining site of rupture, changes in these parameters resulted in varying mechanical stresses
- Higher resolution CT scanning would provide more accurate, patient specific data for calculating wall stress

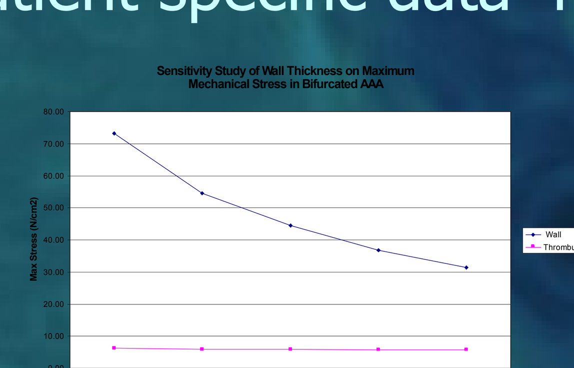


Fig. 6. Sensitivity of the linear elastic model on wall thickness for the bifurcated AAA

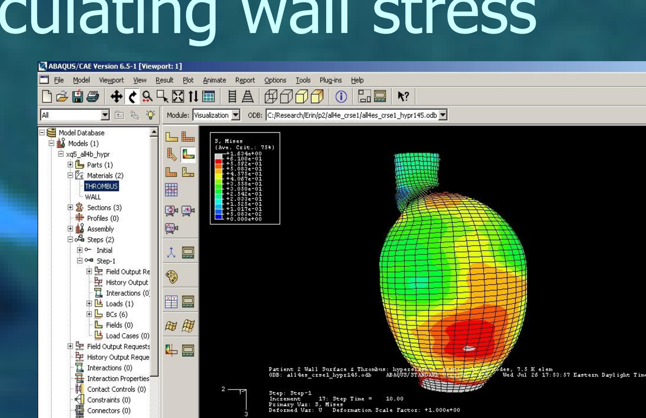


Fig. 7. Abaqus interface during a hyper-elastic analysis

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