COMPUTATIONAL WALL STRESS ANALYSIS OF ABDOMINAL AORTIC ANEURYSM: THE EFFECT OF THROMBUS

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INTRODUCTION

Aneurysm occurs when a section of the blood vessel wall becomes weakened; the force of blood pressure dilates the vessel at a weak spot over a period of time.

AAA sometimes burst, an event in which the patient can die from internal bleeding in a matter of minutes.

HOW ARE AAAs DIAGNOSED AND TREATED?

Detect AAA in the population:
1. by chance
2. by targeted ultrasound screening

“Watchful waiting” Periodic scanning to monitor AAA size
Surgical repair for 5.5 cm max diameter

FIGURE 1: The current clinical method of AAA management

Surgeons make their decision to operate when the maximum diameter of the blood vessel reaches 55 mm.

This method will over estimate or underestimate wall stress

• Hence it is only 73% accurate [1].
  • Larger AAAs can live without symptoms.
  • Smaller aneurysms sometimes rupture.
  • 3000 elective operations in the UK each year.
  • AAA operations are both risky and costly.
  • A better rupture indicator will save lives and cut costs.

Biomechanical Engineers hypothesize rupture is the failure of the wall.
A recent study, conducted by Fillinger et al [1], showed that maximum wall stress of wall models is 80% accurate in a population of 103 patients.

RESULTS

<table>
<thead>
<tr>
<th>Patient ID</th>
<th>Diameter (mm)</th>
<th>Wall Max Stress (Pa)</th>
<th>Wall and thrombus Max Stress (Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>50</td>
<td>851147</td>
<td>305171 % Stress Reduction 64.1%</td>
</tr>
<tr>
<td>2</td>
<td>53</td>
<td>632571</td>
<td>353860 44.1%</td>
</tr>
<tr>
<td>5</td>
<td>45</td>
<td>481382</td>
<td>171742 64.3%</td>
</tr>
<tr>
<td>1</td>
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<td>765729</td>
<td>258441 66.2%</td>
</tr>
<tr>
<td>6</td>
<td>50</td>
<td>377688</td>
<td>313976 16.9%</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>547291</td>
<td>250127 54.3%</td>
</tr>
<tr>
<td>7</td>
<td>57</td>
<td>460545</td>
<td>224546 51.2%</td>
</tr>
</tbody>
</table>

DISCUSSION

• Peak wall stress was reduced by thrombus.
• Wall stress was affected by the thickness of thrombus, and shape of the AAA.
• Some large AAA do not result in higher stress levels nor higher growth rate.

FURTHER WORK

• This method should be clinically tested over a large population to prove its accuracy.

CONCLUSION

This work support the hypothesis that thrombus will reduce wall stress distribution.
Hence, beneficial to AAAs.

However the biological role of thrombus is still unknown and should be the focus of future work.

REFERENCES


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Wall properties obtained from Raghavan et al. [2] and thrombus properties from Wang et al. [3]