# Experimental Study of Approaches for Repair of Aortic Arch Aneurysm

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## Background

### Aortic Arch Aneurysm:
- Enlarge faster and have higher risk of rupture than other aneurysms (42% – 74% rupture).
- 15-30% five-year survival rate of untreated patients.
- 97% overall mortality when rupture occurs.
- Thromboembolism & stroke.

## Purpose and scope

### Primary objective:
Explore and compare hemodynamics in the aortic arch aneurysm and three approaches for repair.

### Secondary objectives:
- Characterize and compare: flow rate, flow patterns, velocity and shear stress
- Correlation between HR and Perfusion
- Analysis of clotting mechanism in the gutter

## Experimental study

### Cases studied:
12 different cases studied (4 models, 3 elevated HRs).

### Planning and designing experimental systems:

#### A) Mock circulation loop (MCL)
- hydraulically simulates the normal human systemic circulation
  - Measuring perfusion to brain and upper body.
  - Comparing three elevated HR- Stress condition values.

#### B) Particle image velocimetry (PIV)
- flow visualization and data analysis
  - 36 PIV experiments
  - 1500-2200 images per experiment
  - 166 fps → 6-8 cardiac cycles visualized
  - Analyzing phase averaged data
  - Developing a particle tracking algorithm

## Conclusions

1. Perfusion to brain and upper body is effected by HR.
2. Surgery shows the higher perfusion, with the strongest decline with increased HR:
   - Change of perfusion with HR is affected mainly by angle of IA branch.
3. Gutter in the chimney has less potential to clot.
4. Flow patterns:
   - Aneurysm: large and dominant vortex
   - Surgery: streamlines show a smooth flow without vortices
   - Chimney: relatively high velocities and shear stress

## Results and Discussion

### Perfusion to the three upper branches, under elevated stress HRs

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<th>Total IA flow rate vs. HR</th>
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Changes in perfusion with HR is affected mainly by the innominate artery arises from the aortic arch.

### Streamlines and critical hemodynamic parameters

- **Peak Systole**
- **Middle-diastole**
- **Peak systole**

### Chimney gutter - coagulation mechanism analysis

Using the over time PIV flow realizations, tracking individual blood palate in the gutter region.

At any point in time, calculating palate stress histories along its Lagrangian trajectories:

Implementing level of activation (LOA) function:

\[
\text{LOA} = \sum T \cdot \Delta t
\]

Max. Level of activation is: 1.26 dyn-s/cm²
- Platelets may not exceed the threshold for activation (of 35 dyne-s/cm²)

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