The in vitro evaluation of the elastic properties of the ascending aorta

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Contexte

Risk of Ascending aortic aneurysm (AsAA)
- Dilation of the ascending aorta
- Dissection or rupture if diameter increase

AsAA replacement indication (Maximum diameter):
- > 45 mm if connects with tissue disease (Marfan)
- > 50 mm if associates with aortic bicuspid
- > 55 mm
- > 0.5 mm growth per year
Study Flow

- Screening patients with ascending aortic aneurysm
  - Recruitment of 40 patients
  - Preoperative Cardiac MRI

Biomechanical properties study

Calculation of aortic elasticity
MRI
Classical protocol with additional specific sequences for local elasticity evaluation

Specific cine-MRI
- Compliance (mm²/mmHg)

MRI
Classical protocol with additional specific sequences for local elasticity evaluation

- Recording blood pressure during the MRI exam (4 to 6 measurements per MRI)
- Contour Detection: Automatic determination of aortic surface during the cardiac cycle using adapted curvilinear detector
- Aortic compliance calculation formula:

\[
\frac{\text{Surface AsAA (Syst)} - \text{Surface AsAA (Dia)}}{\text{BP(Syst)} - \text{BP(Dia)}}
\]

Study Flow

- Screening patients with ascending aortic aneurysm
- Recruitment of 40 patients
- Preoperative Cardiac MRI
- Surgical intervention of ascending aortic replacement

Biomechanical properties study

Calculation of aortic elasticity
Surgical intervention

- Removal of the ascending aorta
- Removal of the resected aorta
- Replacement with the rigid prosthesis Dacron®
Study Flow

Screening patients with ascending aortic aneurysm

Recruitment of 40 patients

Preoperative Cardiac MRI

Surgical intervention of ascending aortic replacement

Postoperative Cardiac MRI

Biomechanical properties study

Calculation of aortic elasticity

Biaxial tests on AsAA samples
In-vitro Mechanical properties test
Parameter calculation

\[ Tensile\ Stress\ (\sigma(\varepsilon)) = \frac{load}{superficial\ area} \]

\[ Strain(\varepsilon) = \frac{displacement}{initial\ length} \]

\[ Young’s\ modulus(E) = \frac{\sigma(\varepsilon)}{\varepsilon} \]


Nusrat C., etc. Local mechanical and structural properties of healthy and diseased human ascending aorta tissue. Cardiovascular Pathology, March–April 2009, Pages 83-91
Results of the biaxial tests

Elasticity Curve of AsAA (Medial)

Elasticity Curve of AsAA (Anterior)

Elasticity Curve of AsAA (Lateral)

Elasticity Curve of AsAA (Posterior)
Study Flow

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Biomechanical properties study

- Calculation of aortic elasticity
- Biaxial tests on AsAA samples

Correction?
Discussion

- Sufficient AsAA tissue source (40 patients recruitment)
- Classified simples
  Dilated bicuspid aortic valve, tricuspid aortic valve, healthy simples
- Accurate testing and measurement machine
  Litematic VL-50, Mitutoyo

LM1 TestBench, ElectorForce

- A prospective, monocentric, experimental study

Prospection

- Include blood simple study
- In vivo modeling and numerical simulation
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