MR Elastography to characterise the aortic wall: implications for the design and sizing of ascending aortic devices

R Clough, A Hertault, T Martin-Gonzalez, R Spear, R Azzaoui, J Sobocinski, S Haulon

Associate Professor
Aortic Centre, Hôpital Cardiologique, CHRU, Lille

The arch and ascending aorta

22 patients
Type I endoleak 6 (27%)
Distal migration 1 (5%)
Re-intervention 6 (32%)

Introduction

Radial force of the stent graft

\[ F_{rad} = f(Vessel_{m}, Plaque_{m}, Stent_{o}, Blood_{p}, Stent_{m}) \]

- \( Vessel_{m} \) = vessel properties
- \( Plaque_{m} \) = plaque properties
- \( Stent_{o} \) = oversized stent graft
- \( Blood_{p} \) = blood pressure
- \( Stent_{m} \) = stent material properties
1. **Vessel wall properties**

**Radial force of the stent graft**

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- \( \text{Vessel}_{m} \): vessel properties
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- \( \text{Stent}_o \): oversized stent graft
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- \( \text{Stent}_m \): stent material properties

**Outline**

1. Vessel wall properties
2. Stent graft over-sizing

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**Introduction: Measurement**

**Expert consensus document on arterial stiffness: methodological issues and clinical applications**

- **POSITION STATEMENT**
  
  Carotid-femoral pulse wave velocity (PWV) is the gold-standard measurement of arterial stiffness

\[ PWV = \frac{\Delta L}{\Delta t} \]

**LIMITATIONS OF PWV**

1. Poor assessment of ascending aorta
2. Indirect measurement of the material properties of the vessel wall

**MR elastography**

- **Propagation of shear waves**
  
  - **Elasticity**

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**Eur Heart J 2006;27:2588-2605**
MR elastography

**PROBLEMS**
1. Expensive
2. Uncomfortable
3. Not available in majority of centres


Young Investigator Award, Society for Cardiovascular Magnetic Resonance, 2015

\[
l = 32\text{mm} \Rightarrow \frac{\lambda}{vt} = 0.032 \times 165 = 5.3 \text{m/s}
\]

\text{Aortic valve closure}
2. STENT GRAFT OVER-SIZING

MRE: Applanation tonometry

Aortic elasticity

Aortic stiffness is greatest in patients with dissection

Sizing

Fixation force
- > Radial force
- oversizing 10 - 20%
- 2-3mm

Through-plane movement

18 % difference in diameter between systole to diastole
Conclusion

- Migration and endoleak are important complications that compromise the durability of endovascular ascending aortic repair.
- These occur due to poor fixation of the device to the aortic wall.
- MR imaging techniques are now available which can accurately measure vessel wall material properties and stent graft oversizing.
- Wide-spread use of these techniques should improve the outcome of endovascular ascending aortic repair and aid the development of patient-specific treatments.