Ultrasound elastography of abdominal aortic aneurysms

Ultrasound Elastography of Abdominal Aortic Aneurysms

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Aim of our Research

The aim: Growth prediction of Abdominal Aortic Aneurysms (AAA) by combining functional ultrasound imaging (US) and patient-specific finite element (FE) modeling.

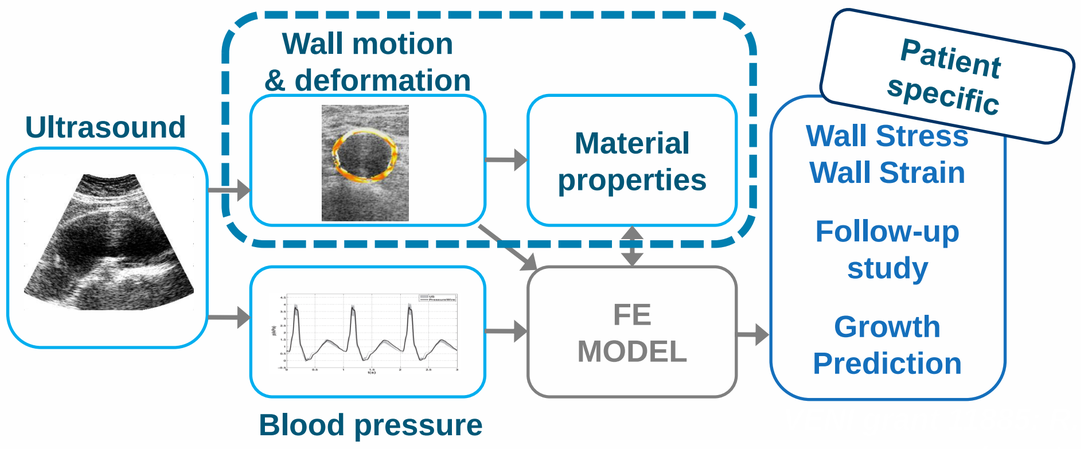

Fig. 1: Towards patient-specifc modeling and growth prediction of AAAs using non-invasive ultrasound measurements.

The first step: measuring the material properties of healthy and diseased vessels using non-invasive, 2D ultrasound imaging.

Methods

2D ultrasound imaging (Esaote) was performed in 10 healthy volunteers and 20 AAA patients **(I)**. For five patients, 3D (+t) MRI data were available for comparison **(II)**. The Young's modulus (E) was estimated from the raw US and MRI data. The US data were processed using a 2D tracking algorithm. Volume over time was estimated by assuming axis-rotational symmetry. MRI data were processed with Hemodyn (Philips).

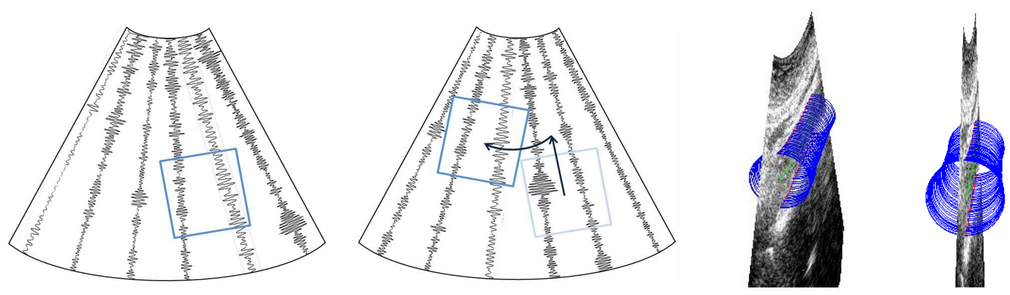

Fig. 2: RF-based 2D displacement estimation (left) and volume estimation using axis-rotational symmetry (right)

In a separate study, 2D and 3D US-data (RF) were acquired in 11 healthy volunteers. Again, the average E was obtained **(III)** using both 2D and 3D tracking data.
Finally, the stress-strain relationship of the aortic wall was assessed using 2D US and finger pressure measurements over the entire cardiac cycle **(IV)**. The E-moduli of elastin and collagen were determined by fitting the slopes at high and low stress.

Results

I

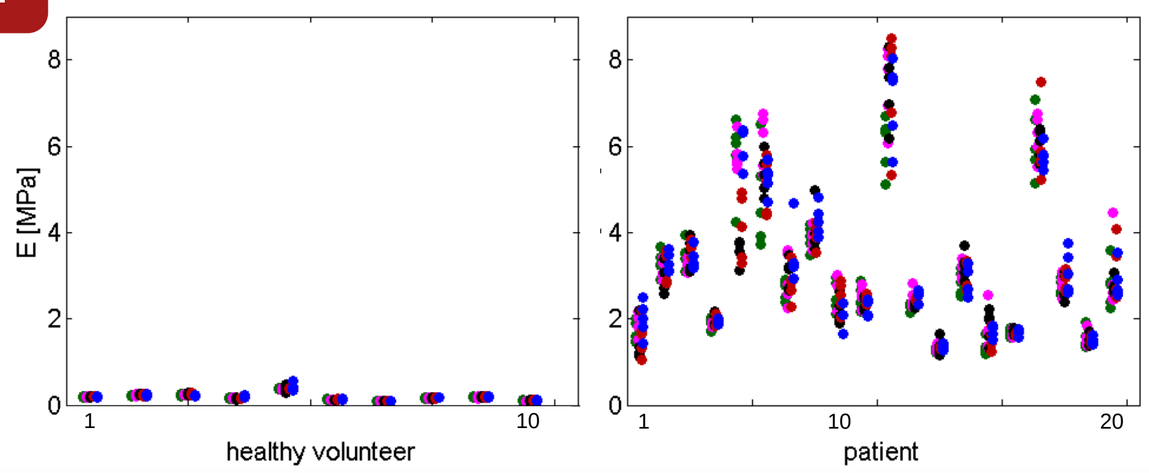

Fig. 3: Young's modulus (E) for normals (left) and AAA patients (right).

II

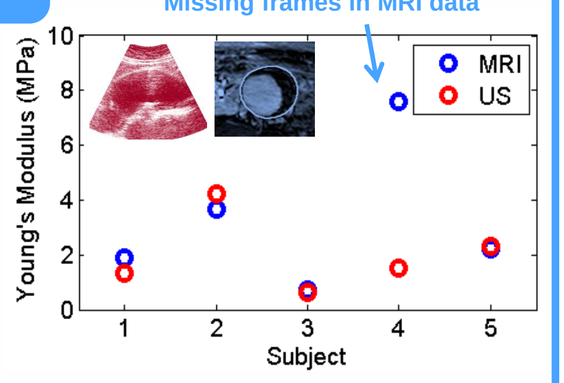

Fig. 4: E-modulus of five AAAs for 2D US & 3D MRI.

III

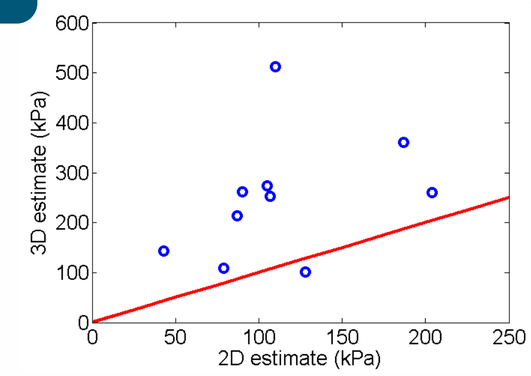

Fig. 5: E-modulus determined with 2D and 3D US.

IV

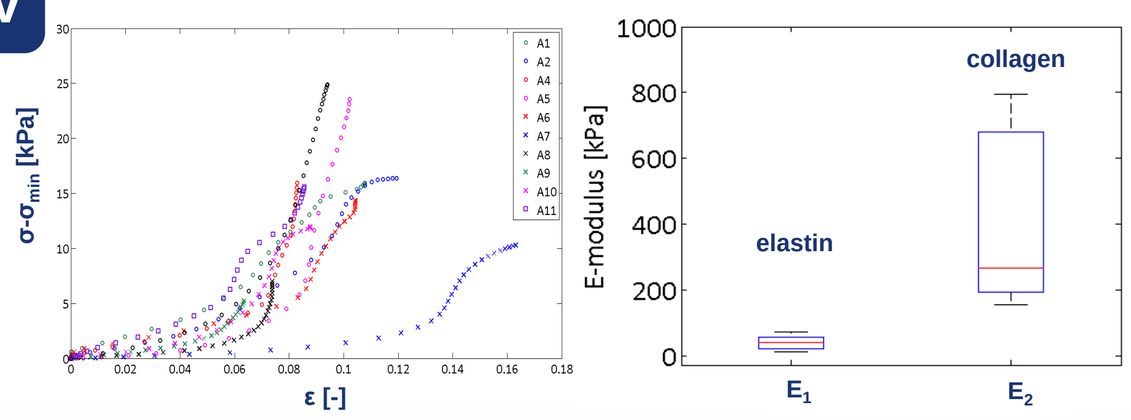

Fig. 6: Non-linear stress-strain curves (left) and boxplots of the estimated E-moduli for elastin and collagen (right).

Conclusion

Non-invasive assessment of the E-modulus *in vivo* distinguishes patients from normals **(I)**. The 2D US results are in good correspondence with MRI **(II)** but seem low compared to 3D US **(III)**. A next step will be combining 3D geometry, motion and material properties into patient-specific FE models.
Stress-strain measurements yield elastin and collagen properties **(IV)**. The latter might enable growth prediction based on elastin degradation or collagen deposition in the future.

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