Mechanical characterisation of AAA, using 4D ultrasound

Marc van Sambeek

Esther Maas, Frans van de Vosse, Richard Lopata

Catharina Hospital Eindhoven

Eindhoven University of Technology

Disclosure

Speaker name:

Marc van Sambeek

I have the following potential conflicts of interest to report:

Consulting and speakersfee

WL Gore & Associates

Medtronic

Unrestricted research grants

Medtronic

W.L Gore & Associates

Philips Medical Systems

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Evidence based medicine

Evidence-based medicine is based on the outcome of populations and not on individuals.

It is quite possible that a guideline does not always indicate what is best for the individual patient.

Every patient is unique.

Towards patient-specific decision support

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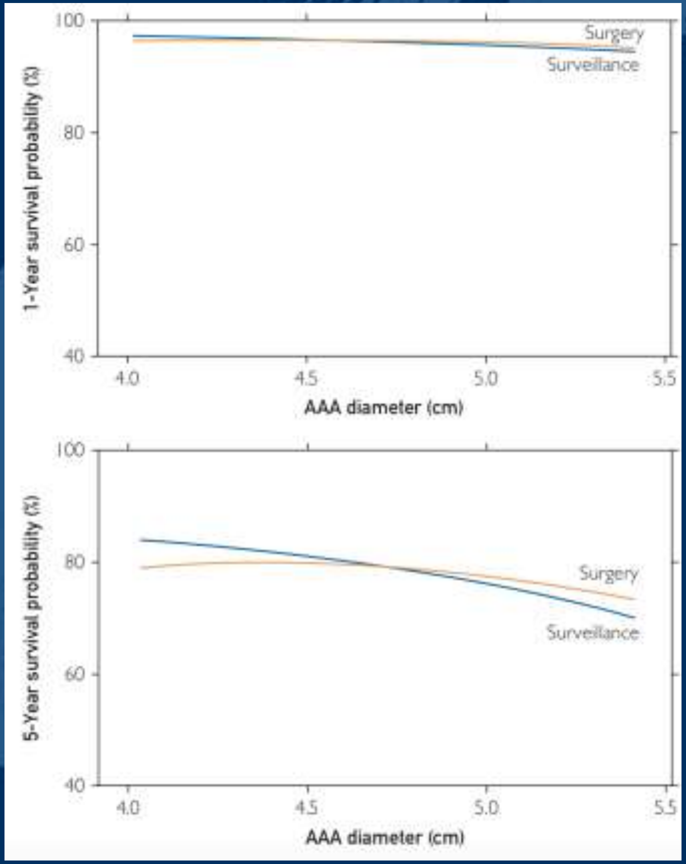
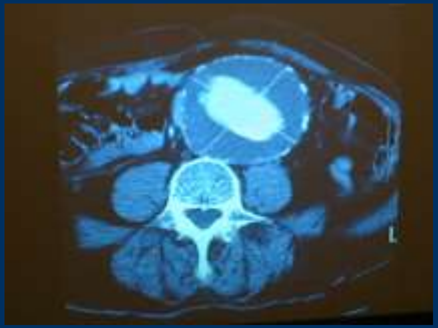
Patient-specific decision support



In 2007, Vorp concludes in his article "Biomechanics of abdominal aortic aneurysm" that about **7%** of the abdominal aneurysms **rupture** before the 50 mm limit is reached, while on the basis of biomechanical analysis about **25%** of the patients are **treated unnecessarily** or too early .

Mayo Clin Proc. 2013;88(9):910-919



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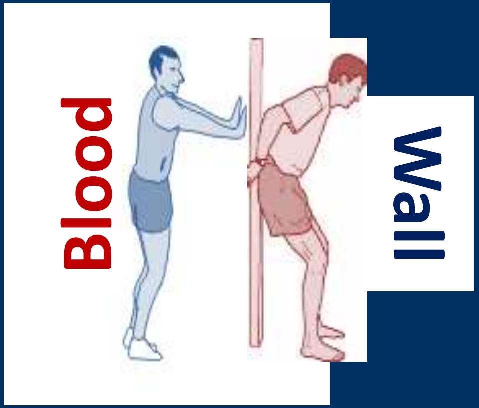
Mechanical properties and wall stress

From a biomechanical point of view, aneurysms will rupture if the mechanical stress exceeds the local strength of the vessel wall.

Therefore,



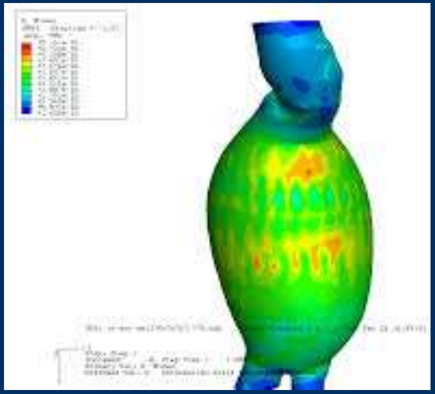
the **state** of the aortic wall
the **mechanical properties** of the wall and
stresses in the wall combined

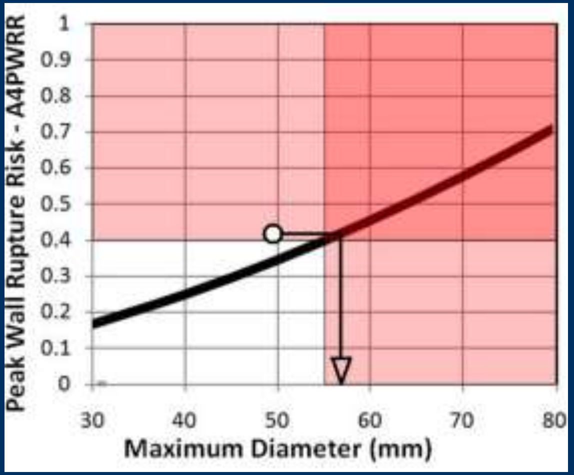
could be a better predictor for rupture risk than AAA diameter.

Finite element analysis

In recent years, 3-D image-based biomechanical models using finite element analysis (FEA) have been on the rise, providing additional parameters such as wall stress.

Wall stress analysis has been introduced to “predict” growth and potential rupture risk of the AAA wall, which is mostly by CT and sparsly MR





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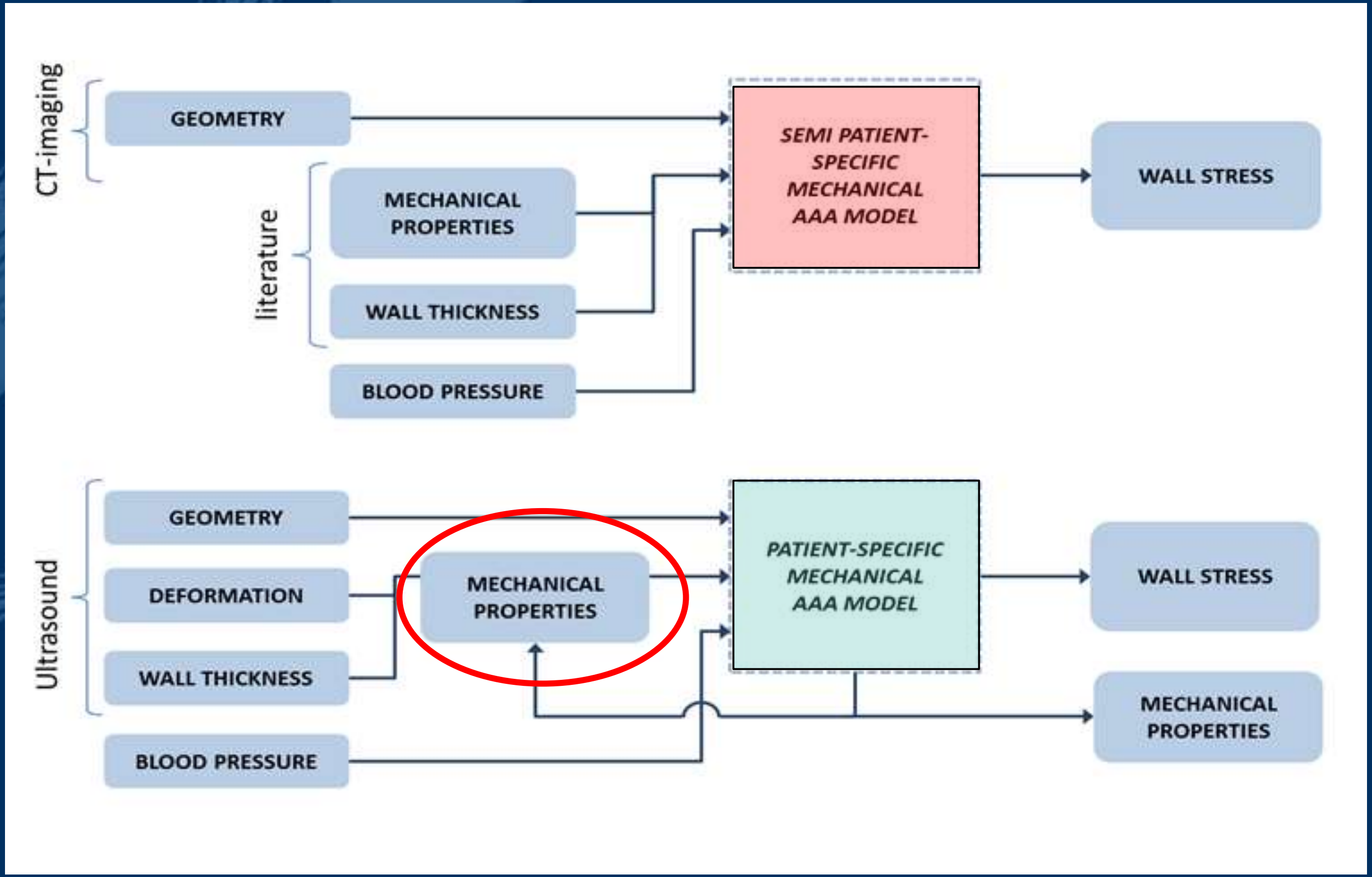
Why ultrasound



There are limitations with CTA and MRI:

Semi patient-specific mechanical AAA model

Unsuitable for longitudinal studies

Therefore these models are not properly validated

Longitudinal clinical study

Large clinical study

Pre-operative monitoring

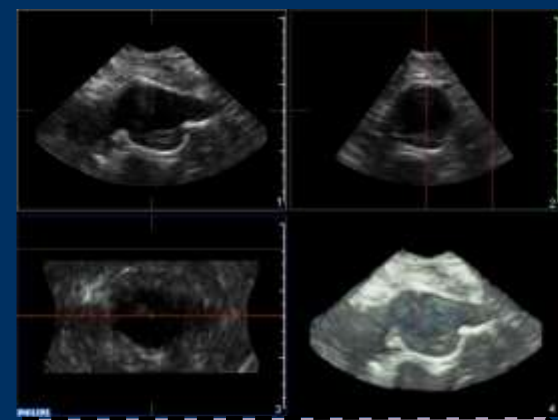
Acquire 3D and 4D (3D+t) US:

- 3D acquisition for geometry
- 4D acquisition for dynamic behaviour

Now: Following > 400 patients

- Longitudinal study
- Clinical CT data for verification

Goal: Develop and validate a patient-specific method using 4D ultrasound



Equipment:

Philips iU22
X6-1 matrix probe
f_c = 3.5 MHz

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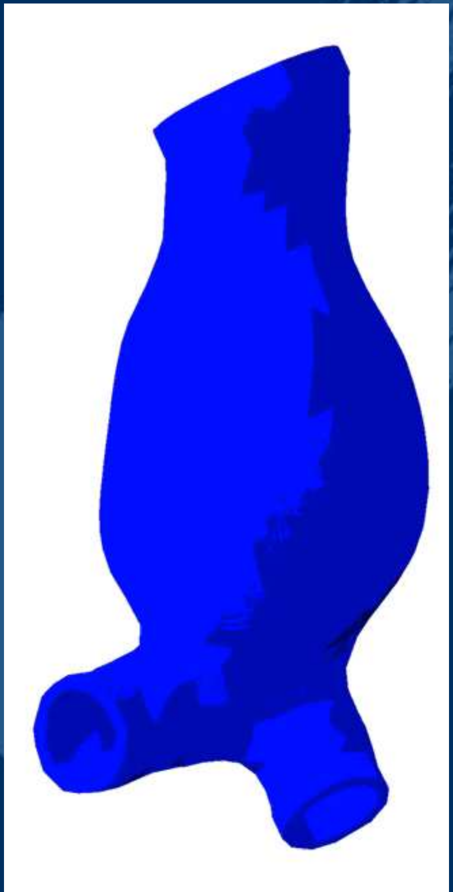
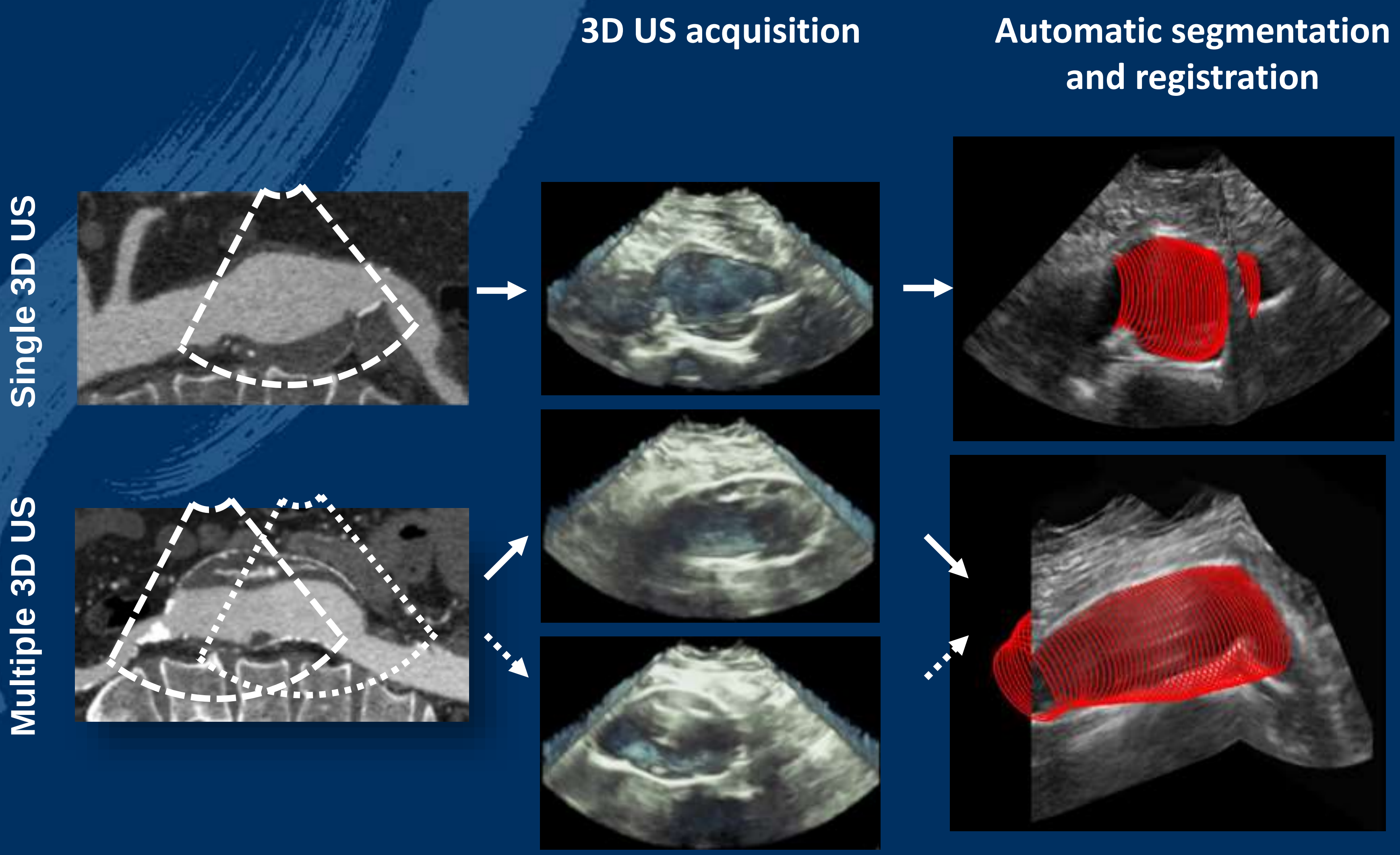
Structured analysis



Structured aortic wall analysis of ultrasound data sets

- increase field of view
- automatic segmentation
- adequate geometrie
- mechanical parameters
- adequate wall stress

Increased field of view and automatic segmentation



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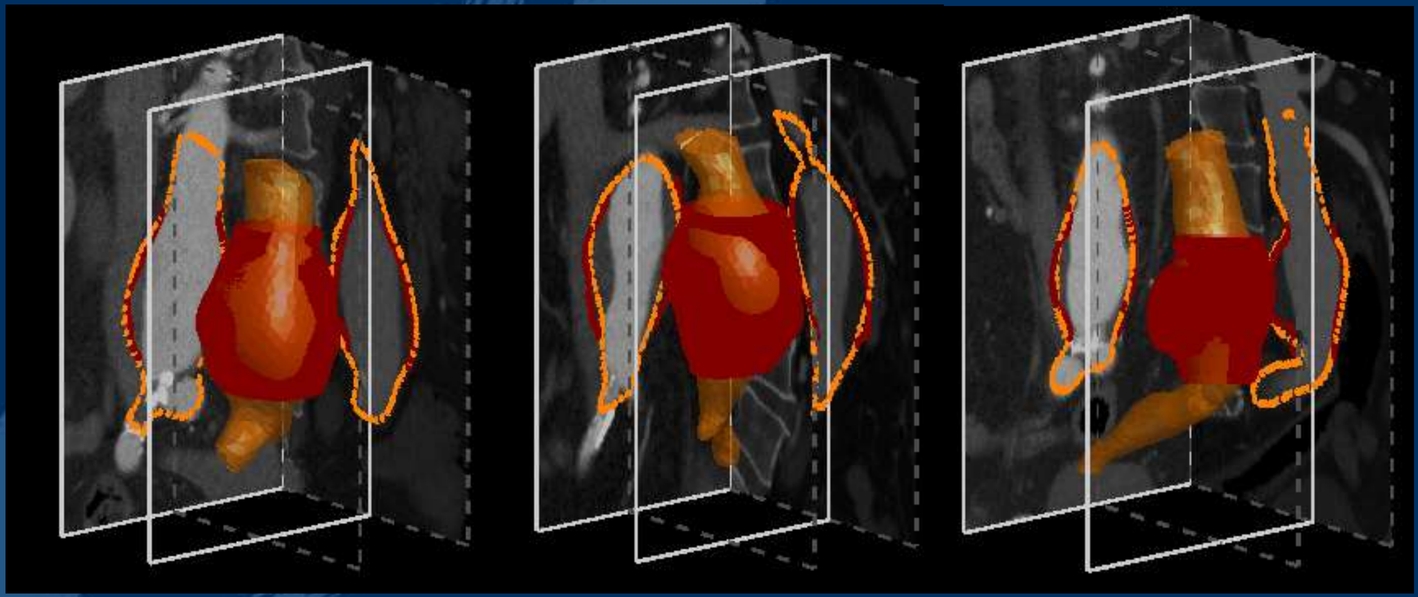
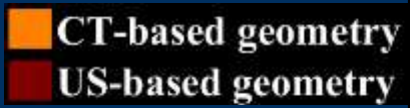
"State-of-the-art geometrie assessment"



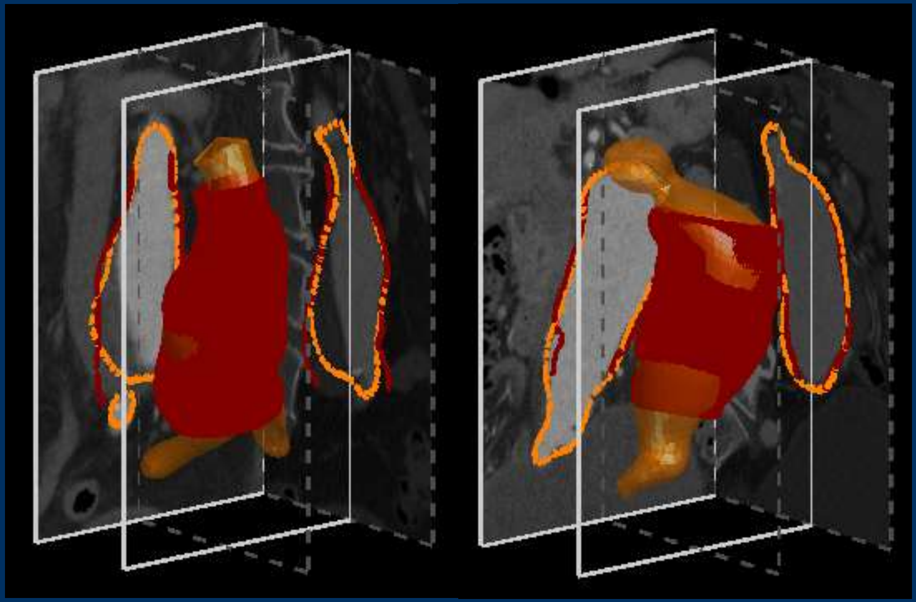


Quantitative results:

SI single: 0.88 – 0.95

SI multi: 0.87 – 0.94

Validation with CT



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van Disseldorp et al. JBM 2016; 49:2405-12

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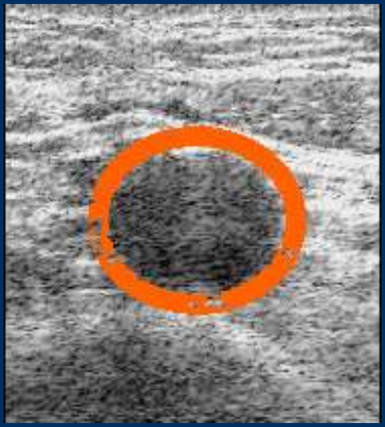
Elastography

Elastography is a medical imaging modality that maps the **elastic properties and stiffness** of soft tissue.

The most prominent techniques use **ultrasound** or **magnetic resonance imaging (MRI**) to make both the stiffness map and an anatomical image for comparison.

To image the mechanical properties of tissue, we need to see how it behaves **when deforme,** e.g. pulse or heartbeat..

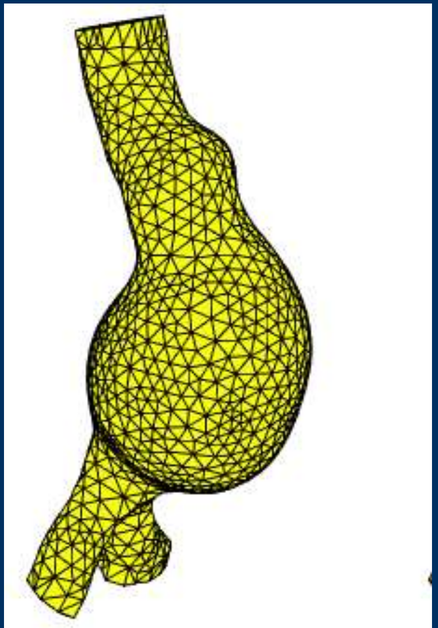


Wall stress assessment using finite element analysis

Straightforward analytic techniques to assess wall stress is not possible with he **complex shape of the aneurysmal wall**

Instead we can use a technique known as **finite element analysis** for computation of the wall stresses in each virtual AAA.

In this technique, a complex shape is divided into smaller, **simpler shaped elements**. The stresses over the individual elements are computed, and the solution is patched together to yield the stress distribution for the entire complex aorta.



Mechanical wall stress in abdominal aortic aneurysm: Influence of diameter and asymmetry

David A. Vorp, PhD, M. L. Raghavan, BS, and Marshall W. Webster, MD, Pittsburgh, Pa.

(J Vasc Surg 1998;27:632-9.)

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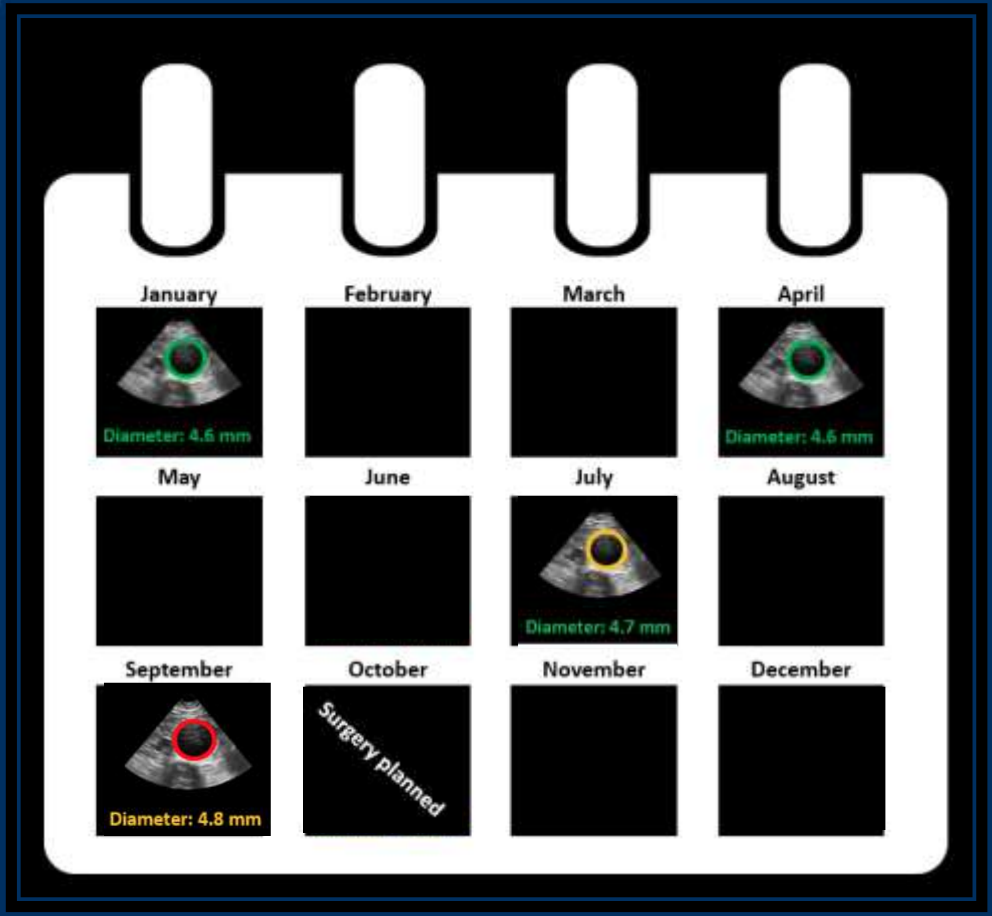
Patient-specific decision support



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