

Shear wave elastography and quantitative ultrasound as biomarkers to characterize deep vein thrombosis *in vivo*

Guillaume Bosio^{1,2}, Nora Zenati³, François Destrempe¹, Boris Chayer¹,
Gilles Pernod^{3,4,5}, Guy Cloutier^{1,2,6}.

- ¹ Institute of Biomedical Engineering, University of Montreal, Montréal, Québec, Canada
- ² Laboratory of Biorheology and Medical Ultrasonics, University of Montreal Hospital Research Center (CRCHUM), Montréal, Québec, Canada
- ³ UGA UFRM - Université Grenoble Alpes - UFR Médecine, Grenoble, France
- ⁴ Centre Hospitalier Universitaire de Grenoble, Grenoble, France
- ⁵ F-CRIN INNOVTE network, Saint Etienne, France
- ⁶ Department of Radiology, Radio-Oncology and Nuclear Medicine, University of Montreal, Montréal, Québec, Canada

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Aucune divulgations

Introduction : Blood clot

Thrombosis and its complications such as deep vein thrombosis, pulmonary embolism or stroke are a major health concern worldwide. ¹⁻²

Blood clots appear following one of these conditions :

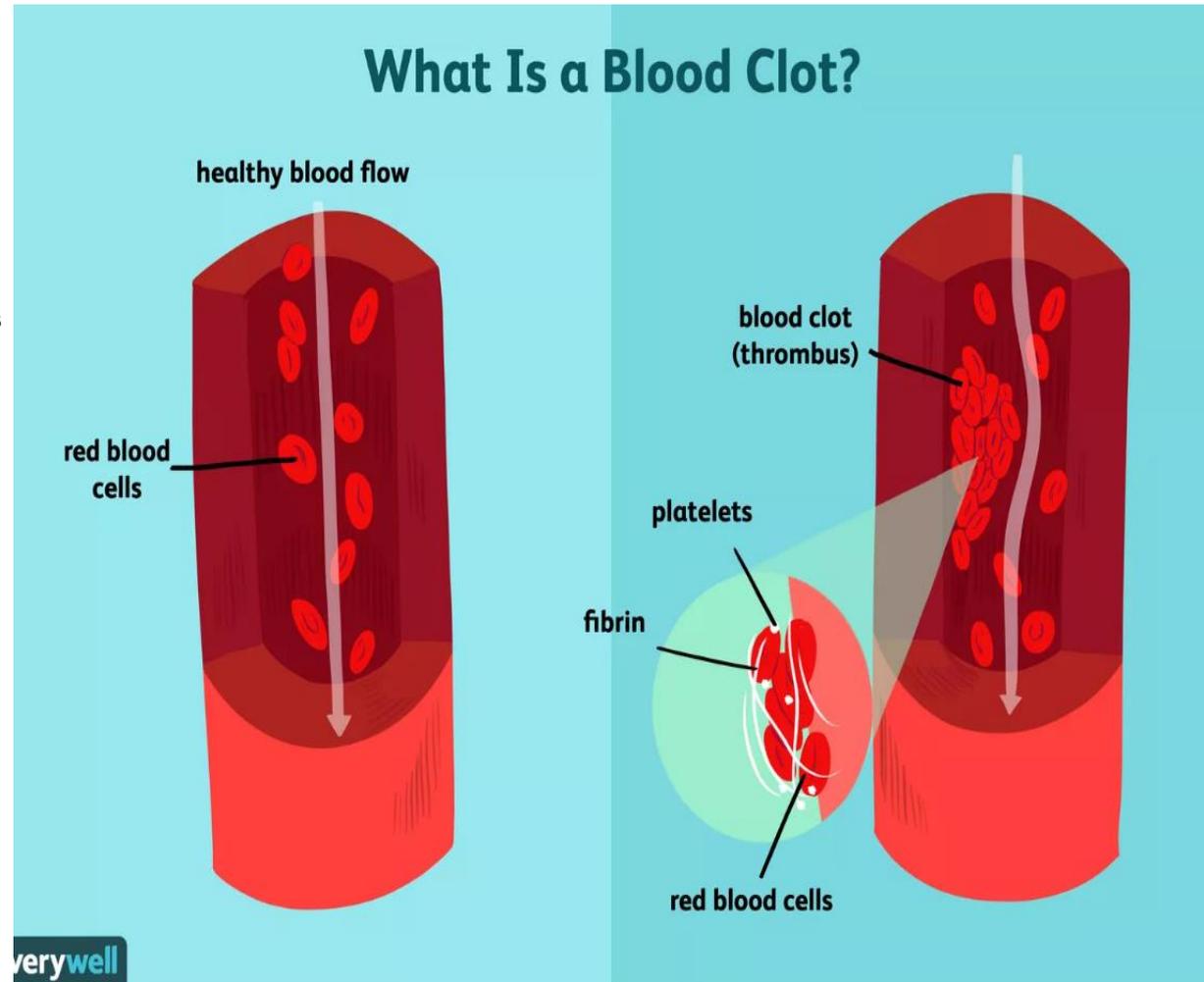
- Vein damage
- Venous stasis
- Hypercoagulability

Anticoagulants are used to stop the clot from evolving. ³

Drawback :

The duration of anticoagulant therapy is uncertain. ⁴

Not all patients respond positively to treatments. ⁵



<https://www.verywellhealth.com/overview-blood-clots-1745326>

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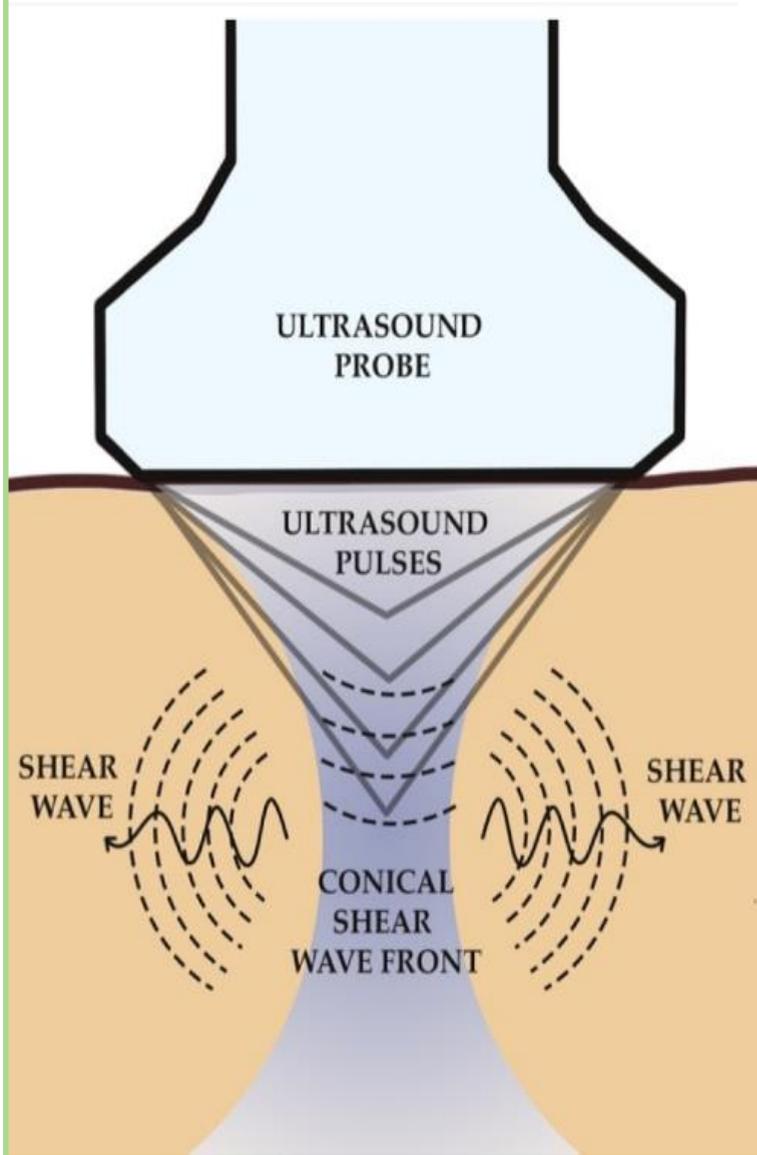
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Introduction : Ultrasound and blood clot

What is shear wave elastography

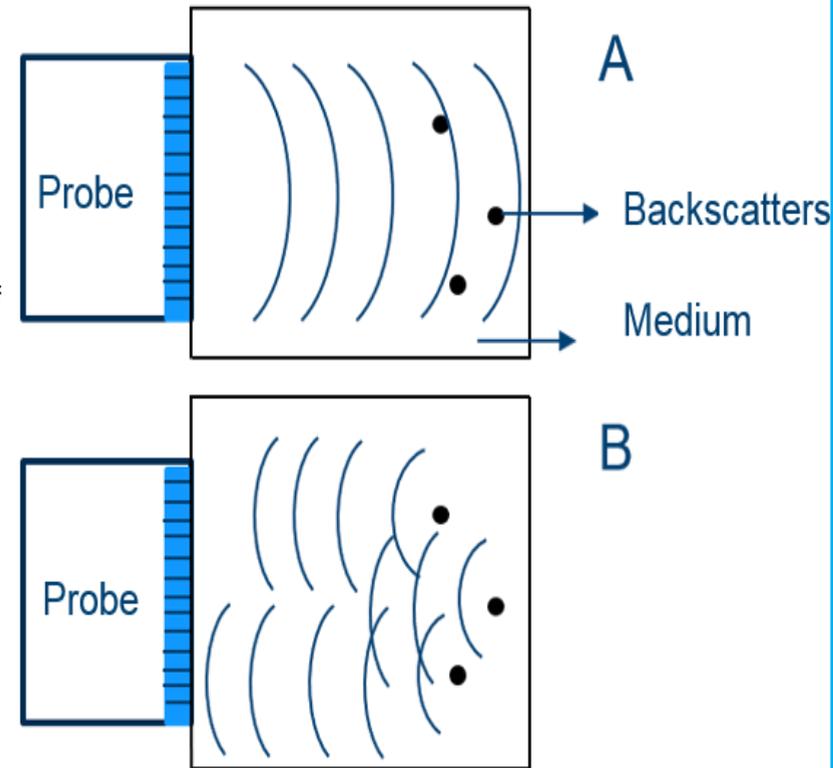


Speed of the shear wave is linked to its Young modulus E , also called elastic modulus. Young modulus of the clot has been investigated to assess clot's age.⁶⁻⁷ Age and composition of the clot are linked and the age has also an impact on the clot's resistance to lysis.⁸

What is quantitative ultrasound

Statistical distribution of backscatters can be analyzed and give information about microstructural arrangement of the scatterers.

A model for statistical analysis of backscatter is the homodyne-K distribution (HKD). HKD is focused on the spatial arrangement of scatterers.^{9,10}



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Objectives and Methods

Objectives :

Investigate the evolution of blood clot in patient presenting deep vein thrombosis (DVT).

Possible futures applications

Better knowledge of blood clotting. Potentially adapt the treatment duration in accordance with clot's E or HKD parameter.

Methods :

Recruitment of patient

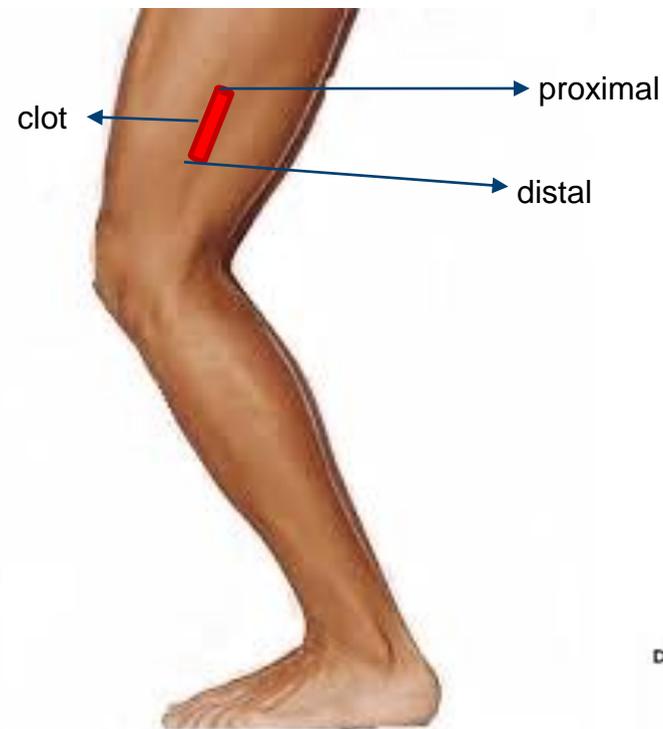
Number of patient = 16

Day 0
SWE and QUS

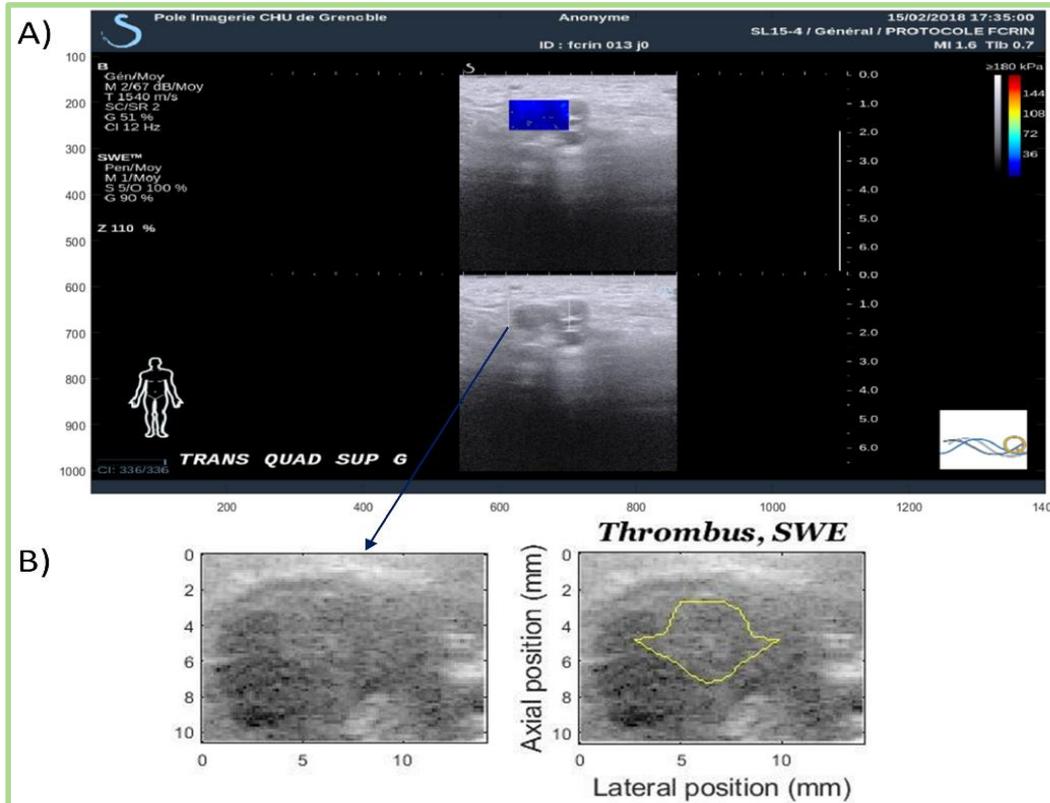
Measurement on the proximal and distal (related to the heart) part of the clot

Day 7
SWE and QUS

Day 30
SWE and QUS



Methods

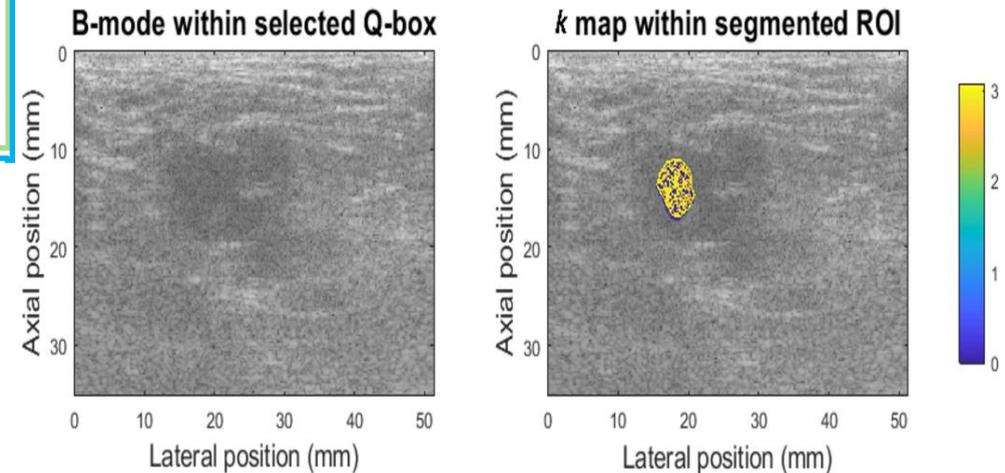


Selection of a zone to performed the SWE (blue rectangle).
Then manual selection of the region of interest inside the blood clot (yellow contour).

Parameter of SWE is the clot Young modulus (E), also called the modulus of elasticity.

Manual selection of the region of interest inside the blood clot (yellow contour) and calculation of the HKD parameters: k , $1/(\kappa+1)$, μ_n and $1/\alpha$.

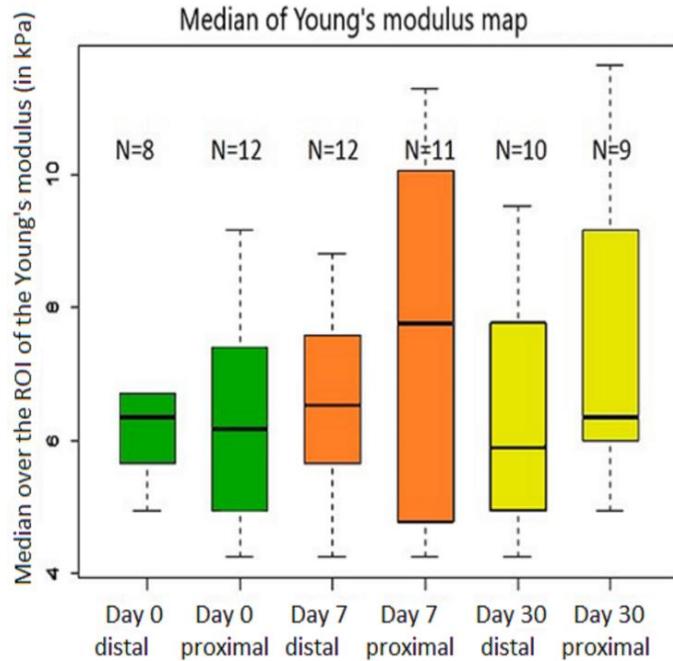
- k and $1/(\kappa+1)$ are associated to the organization of the scatters.
- μ_n gives information the intensity of the signal backscattered, high intensity could be associated with hyper echoic medium
- $1/\alpha$ gives us information about group of scatters and their repartition



Results

Elastography :

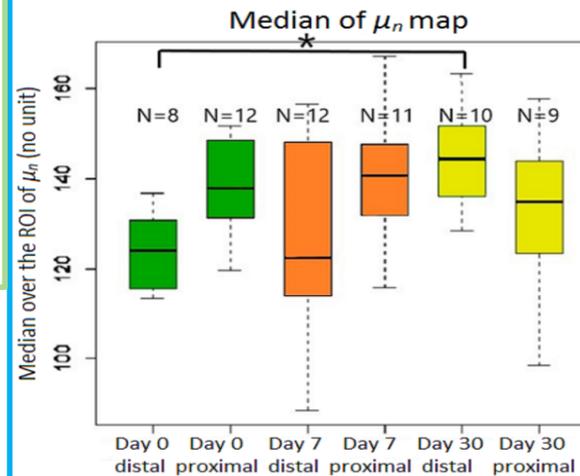
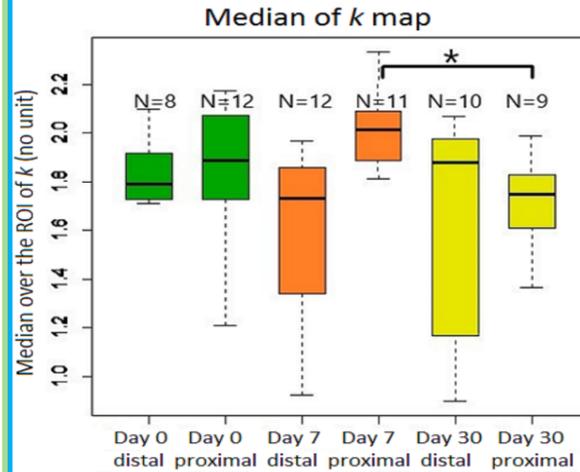
No significant results for the Young's modulus over time



Median values of Young's moduli over segmented ROIs. N represents the number of patients for which acquisitions were available. Test : Kruskal wallis

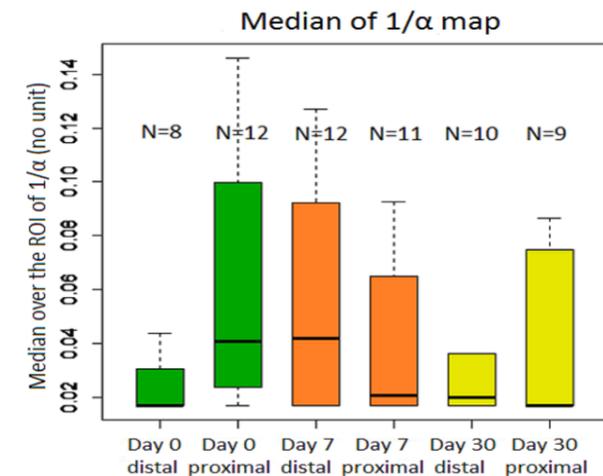
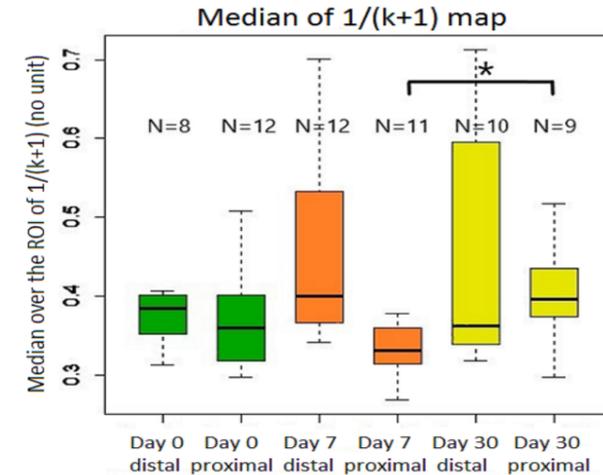
Quantitative ultrasound :

- k decrease between day 7 and day 30
- $1/(\kappa+1)$ increase between day 7 and day 30
- μ_n increase between day 0 and day 30



Median values of HKD parameters over segmented ROIs within clots. Test : Kruskal wallis or ANOVA

* $p < 0,05$.



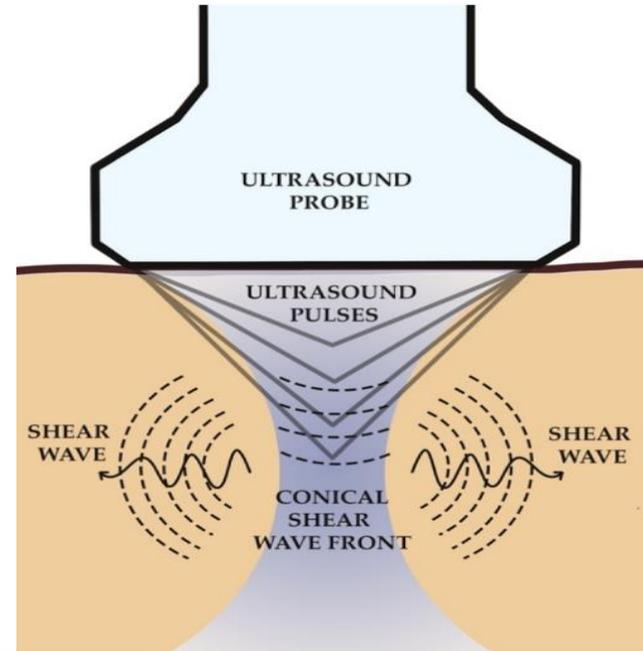
Discussion

- Elasticity

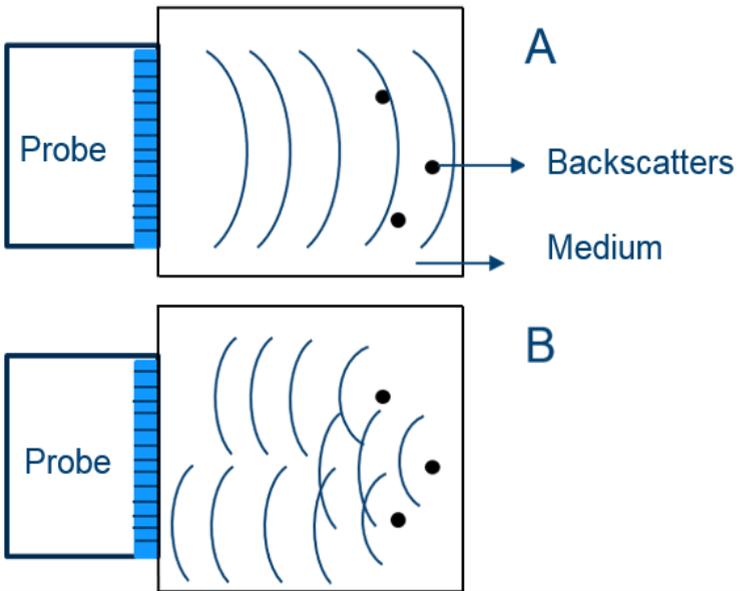
First study to performed SWE on blood clot *in vivo* in human

We expected a change in the thrombus Young's modulus between day 0 and day 30. We though that the effect of the treatment would have decrease the Young's modulus. ¹¹

But it seems that the clot Young's modulus did not evolve much in this period of time, it may be relevant to look on a longer period. Studies are not conclusive yet to assess the effect of lytic treatment on the Young's modulus. ^{12,13}



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Quantitative ultrasound

k decrease and $1/(\kappa+1)$ increase between day 7 and day 30 suggests a special disorganization of scatterers.

- A less organized medium could indicate a higher risk of clot embolization. ¹⁴
- μ_n increase between day 0 and day 30, corresponding to an increase in the normalized intensity of the echo envelop. It could indicate that clots still contain a large amount of fibrin strands and/or red blood cells which are known to be echogenic. ¹⁵ It also indicate that thrombus are not yet to be lysed.

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