Smart ultrasound device for non-invasive real-time myocardial stiffness quantification of the human heart

Pedreira et al. 2021

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Introduction

1. Myocardial stiffness

Resistance of the heart muscle to stretch during the process of filling with blood

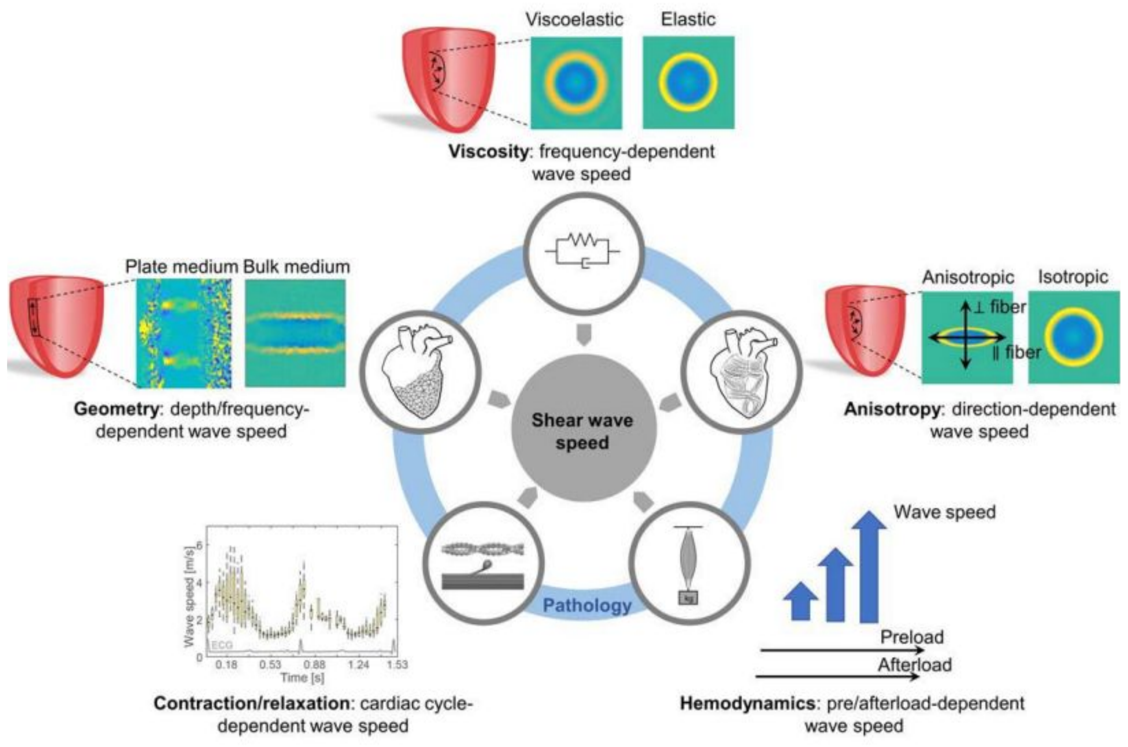


Fig. 1 The challenges of measuring the myocardium stiffness

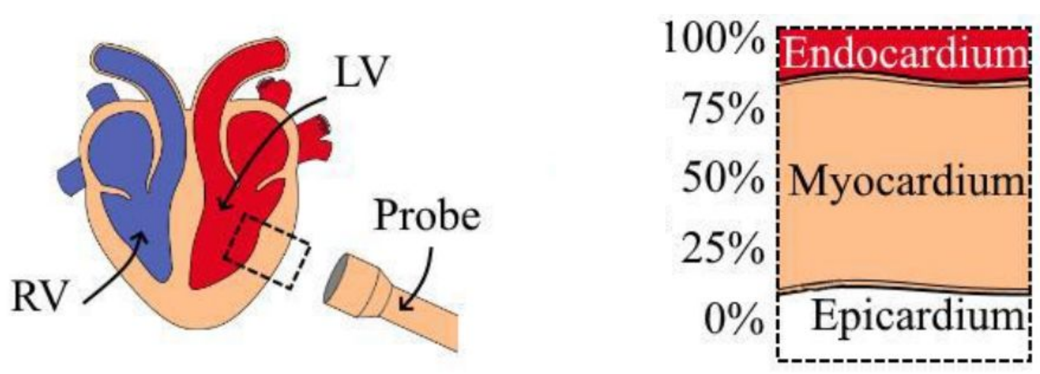


Fig. 2 The thickness of the myocardium and the surrounding layers

2. Smart Ultrasound Probe

Real-time non-invasive measurement of myocardial stiffness taking into account the anisotropic property of the tissue

Material and Methods

1. Shear wave velocity (SWV) parameters calculation using Elastic Tensor Imaging (ETI)

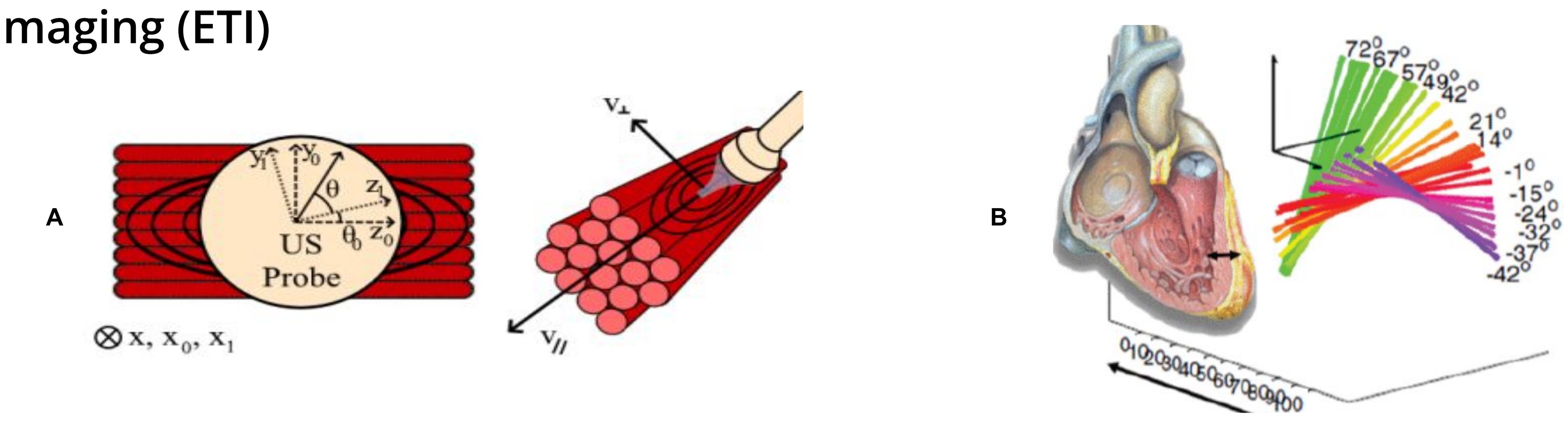
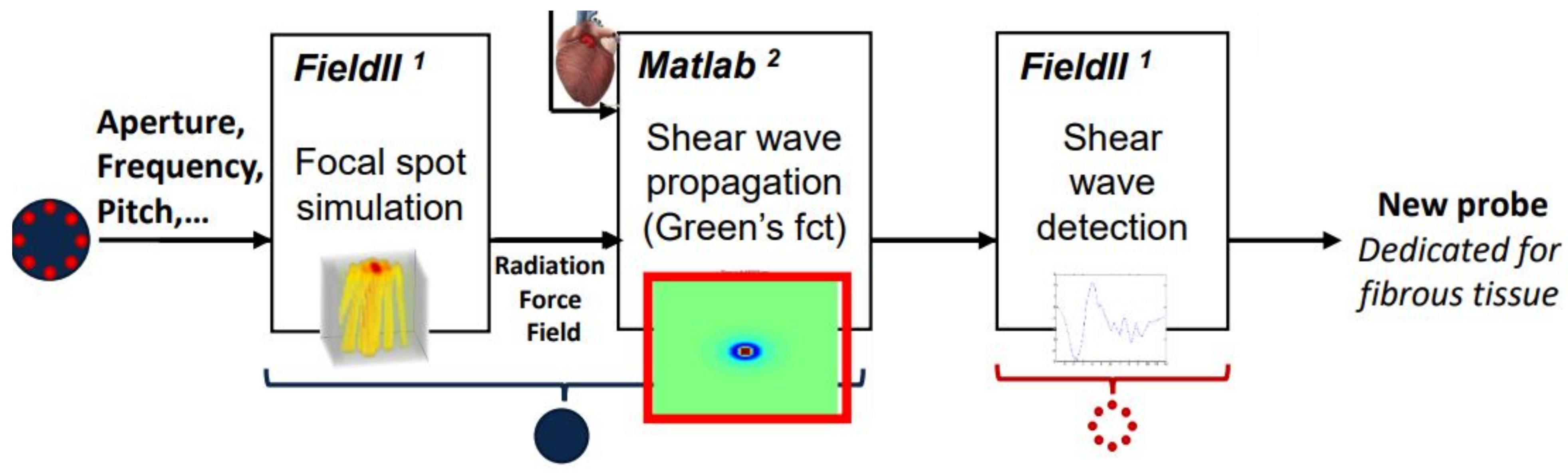


Fig. 3 Shear wave velocity measurement **A)** Direction of SWV measurement: parallel and perpendicular to the fibers **B)** Accounting for the different orientations of fibers with ETI

2. Numerical simulation steps that led to the design of the probe



3. Experimental validation

The probe was tested on in-silico, ex-vivo and then in-vivo on 4 healthy volunteers to validate the simulation results.

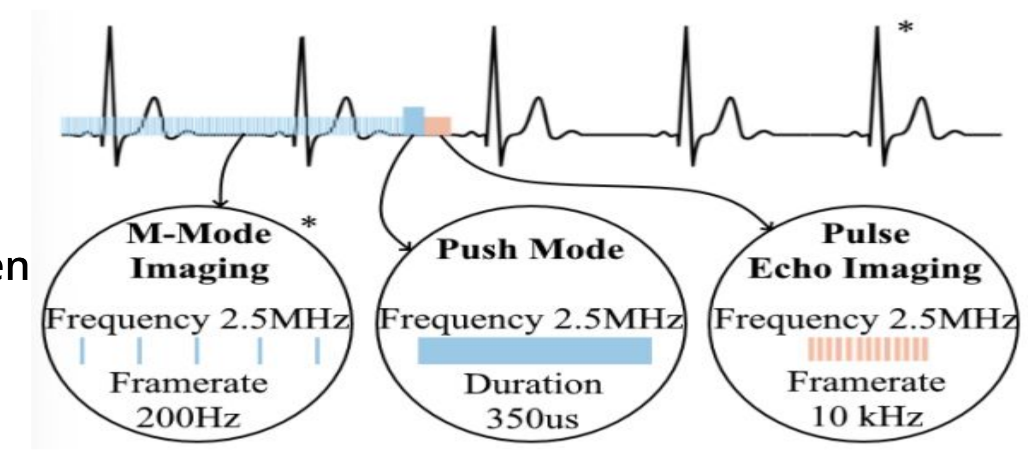


Fig.4 The different US modes using in the in-vivo testing

Results

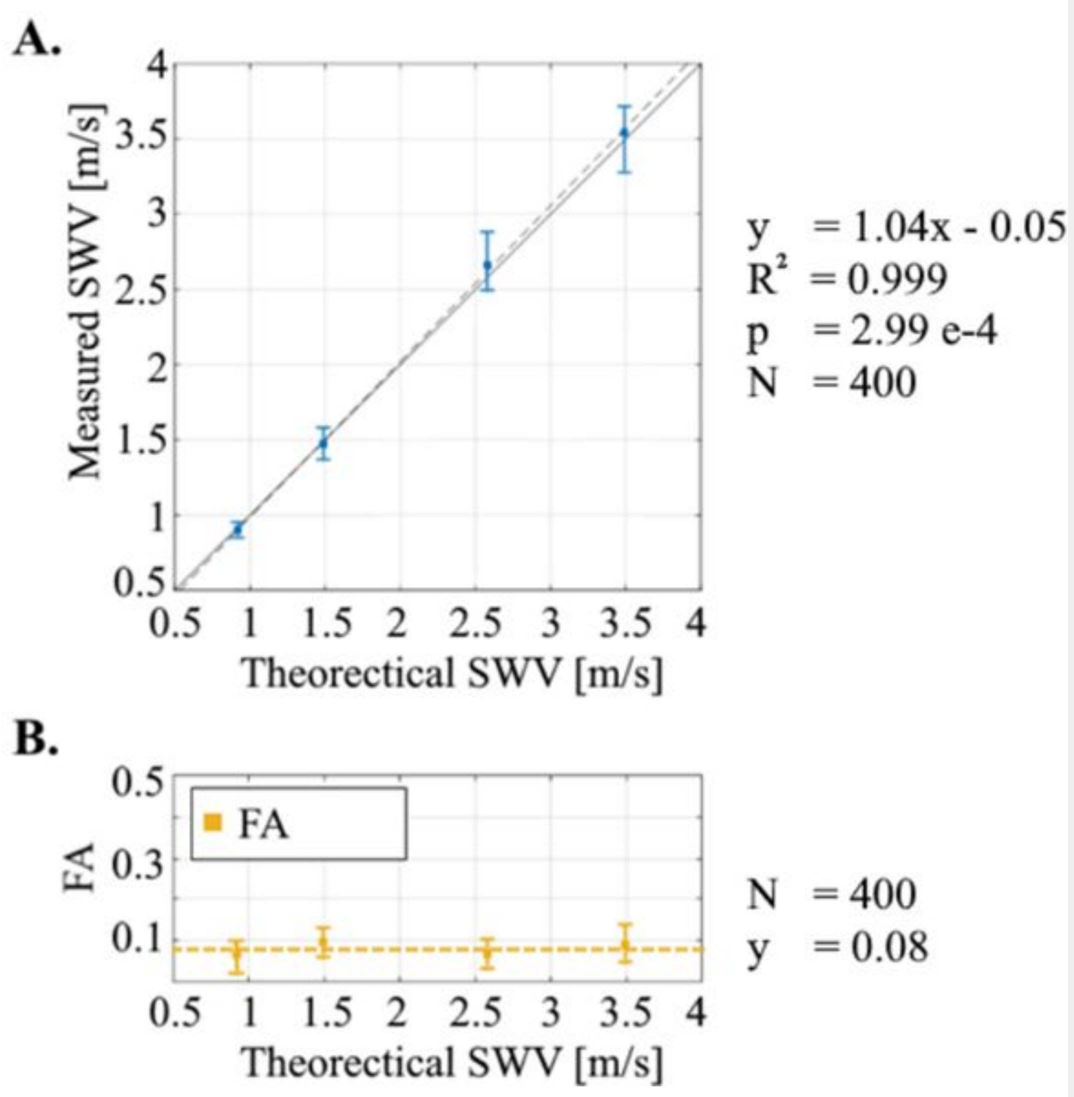


Fig 5

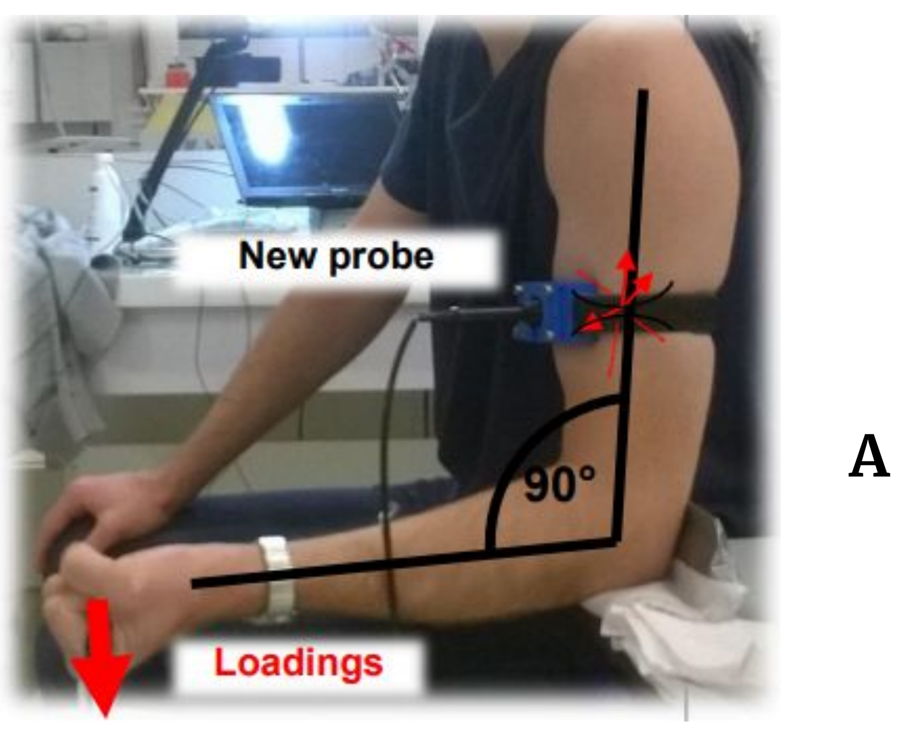


Fig 6. The preclinical testing of the new probe

Fig 5. A Comparison of the theoretical and measured shear wave velocity on 4 phantoms

Fig 5. B Fractional Anisotropy values in an isotropic phantom

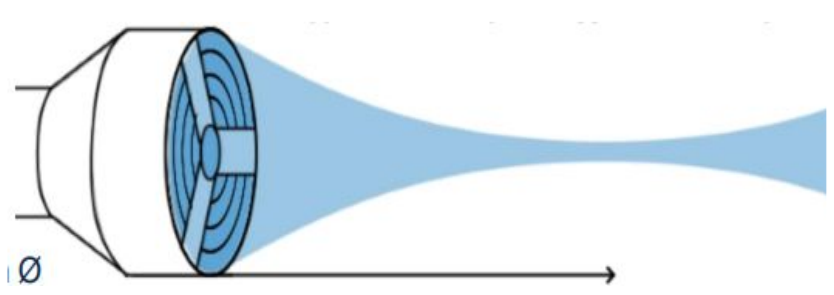
Table 1 HEALTHY VOLUNTEERS MS

Volunteer		RV		Septum
1	$v_\parallel$	1.08 +/- 0.08 m/s	$v_\parallel$	2.44 +/- 0.22 m/s
	$v_\perp$	0.64 +/- 0.17 m/s	$v_\perp$	1.82 +/- 0.08 m/s
	FA	0.35 +/- 0.17	FA	0.20 +/- 0.04
2	$v_\parallel$	1.06 +/- 0.17 m/s	$v_\parallel$	1.68 +/- 0.26 m/s
	$v_\perp$	0.68 +/- 0.15 m/s	$v_\perp$	1.34 +/- 0.29 m/s
	FA	0.31 +/- 0.06	FA	0.22 +/- 0.07
3	$v_\parallel$	0.94 +/- 0.25 m/s	$v_\parallel$	1.20 +/- 0.20 m/s
	$v_\perp$	0.66 +/- 0.09 m/s	$v_\perp$	0.86 +/- 0.11 m/s
	FA	0.22 +/- 0.14	FA	0.22 +/- 0.14
4	$v_\parallel$	1.24 +/- 0.20 m/s	$v_\parallel$	1.64 +/- 0.15 m/s
	$v_\perp$	0.62 +/- 0.08 m/s	$v_\perp$	1.10 +/- 0.12 m/s
	FA	0.44 +/- 0.04	FA	0.27 +/- 0.08

Table 1 Results for parallel and perpendicular SWV of 4 healthy volunteers

Conclusion

- A novel US device for measuring the myocardial stiffness non-invasively in real-time was developed
- Device is currently being integrated into clinical application



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