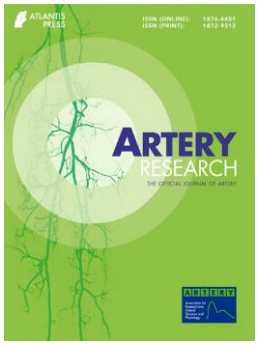

Artery Research

ISSN (Online): 1876-4401 **ISSN (Print): 1872-9312**
Journal Home Page: https://www.atlantis-press.com/journals/artres

P2.20: ACOUSTIC LOCALISATION OF CORONARY ARTERY STENOSIS: WAVE PROPAGATION IN SOFT TISSUE MIMICKING GELS

S.E. Greenwald, H.T. Banks, M.J. Birch, M.P. Brewin, S. Hu, Z.R. Kenz, C. Kruse, D. Mehta, J. Reeves, S. Shaw, J.R. Whiteman

To cite this article: S.E. Greenwald, H.T. Banks, M.J. Birch, M.P. Brewin, S. Hu, Z.R. Kenz, C. Kruse, D. Mehta, J. Reeves, S. Shaw, J.R. Whiteman (2013) P2.20: ACOUSTIC LOCALISATION OF CORONARY ARTERY STENOSIS: WAVE PROPAGATION IN SOFT TISSUE MIMICKING GELS, Artery Research 7:3_4, 124–124, DOI: https://doi.org/10.1016/j.artres.2013.10.081

To link to this article: https://doi.org/10.1016/j.artres.2013.10.081

Published online: 14 December 2019

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Flow in the wake of a coronary artery stenosis induces a bruit in the 300-1500 Hz range that can be heard at the chest wall. It has been hypothesised that this sound is caused by turbulence-induced shear waves which travel through the soft tissue of the thorax. This contribution describes a computational mathematical 'forward solve' method to simulate these shear waves in a virtual chest of tissue mimicking agarose gel. As the first stage in the development of a noninvasive diagnostic tool we also describe initial results towards the solution of the mathematical inverse problem. That is: to identify the source of the bruit given the surface measured signal.
Objectives: To demonstrate proof-of-concept of a novel biotechnology that will use mathematical simulations to provide a non-invasive screening tool for coronary artery disease.
Methods: Finite element based forward solvers for soft tissue response (given the source, generate the signal); optimisation-based inverse solver (given the signal, determine the source).
Results: For a simple, small scale, and axisymmetric cylindrical gel configuration, and for a source at 500 Hz, the forward solve generates signals that agree with experimental data (using Kelvin-Voigt viscoelasticity). Also, with surface signals generated by simulated sources in this virtual environment the inverse algorithm is able to identify this source given only chest surface measurements, and an adequate initial datum from which to start the computation.
Conclusions: While enormous challenges remain we have shown that this approach offers considerable promise in delivering a noninvasive diagnostic or screening tool.

P2.19
ASSESSMENT OF AORTIC PULSE WAVE VELOCITY BY ULTRASOUND: A FEASIBILITY STUDY IN MICE

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Pulse wave velocity (PWV) is considered a surrogate marker of arterial stiffness and could be useful for characterizing cardiovascular disease progression even in mouse models. Aim of this study was to develop an image process algorithm for assessing arterial PWV in mice using ultrasound (US) images only and test it on the evaluation of age-associated differences in abdominal aorta PWV (aaPWV). US scans were obtained from six adult (7 months) and six old (19 months) wild type male mice (strain C57BL6) under gaseous anaesthesia. For each mouse, diameter and flow velocity instantaneous values were achieved from abdominal aorta B-mode and PW-Doppler images; all measurements were obtained using edge detection and contour tracking techniques. Single-beat mean diameter and velocity were calculated and time-aligned, providing the lnD-V loop. aaPWV values were obtained from the slope of the linear part of the loop (the early systolic phase), while relative distension (relD) measurements were calculated from the mean diameter signal. aaPWV values for young mice (3.5$\pm$0.52 m/s) were lower than those obtained for older ones (5.12$\pm$0.98 m/s) while relD measurements were higher in young (25%$\pm$7%) compared with older animals evaluations (15%$\pm$3%). All measurements were significantly different between the two groups ($P<0.01$ both). In conclusion, the proposed image processing technique well discriminate between age groups. Since it provides PWV assessment just from US images, it could represents a simply and useful system for vascular stiffness evaluation at any arterial site in the mouse, even in preclinical small animal models.

P2.20
ACOUSTIC LOCALISATION OF CORONARY ARTERY STENOSIS: WAVE PROPAGATION IN SOFT TISSUE MIMICKING GELS

S. E. Greenwald [1], H. T. Banks [2], M. J. Birch [3], M. P. Brewin [3], S. Hu [2], Z. R. Kenz [2], C. Kruse [4], D. Mehta [1], J. Reeves [3], S. Shaw [4], J. R. Whiteman [4]
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Background: Turbulent flow downstream of atherosclerotic plaques produces low amplitude shear waves which travel through the chest and can be measured by skin sensors. This acoustic signature may provide a cheap non-invasive way to diagnose arterial disease. We report measurements of shearing oscillations and flow-induced turbulence in soft tissue-mimicking gels which provide input to a numerical model of soft tissue behaviour described in a companion presentation.
Methods: Cylindrical specimens of 3% agarose gel were cast around an axial rod and bead connected to an electromechanical vibrator (figure 1), to generate shear-waves of known characteristics and location (frequency 250-750 Hz, amplitude 10-50 μm). Displacement was mapped optically by tracking the movement of carborundum particles on the surface. In the flow study (figure 2) a silicone rubber tube (i.d. 4.5mm) containing a stenosis was embedded in a cuboidal gel phantom and lateral displacement of the gel surface was mapped by a piezo-electric accelerometer.
Results: Forced oscillations produced movement in the same direction at the gel surface, amplitude 10-50% of the bead's movement. Amplitude modulation ($\approx$5%) at around 40Hz, probably due to resonance in the gel, was also seen. Lateral movement (200-800Hz) of the gel surface caused by flow-induced turbulence increased monotonically with turbulence magnitude.
Conclusions: The methods described above provide internally consistent and repeatable data, validating the numerical models. The next steps will compare computational results with measurements in progressively more realistic representations of the chest aiming ultimately to produce a device suitable for screening/diagnosis of coronary artery disease.

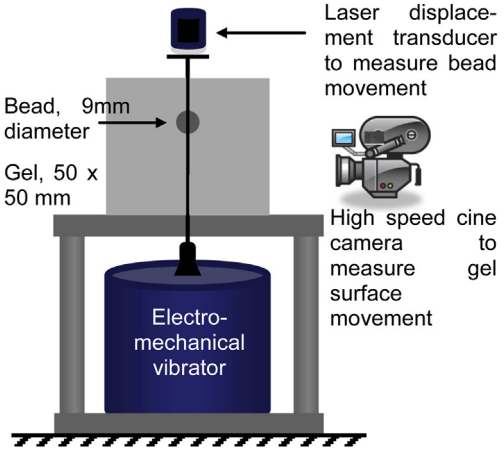

Figure. 1. Forced vibration rig. Gels cast with bead in various positions. Laser measures bead movement; camera measures surface movement

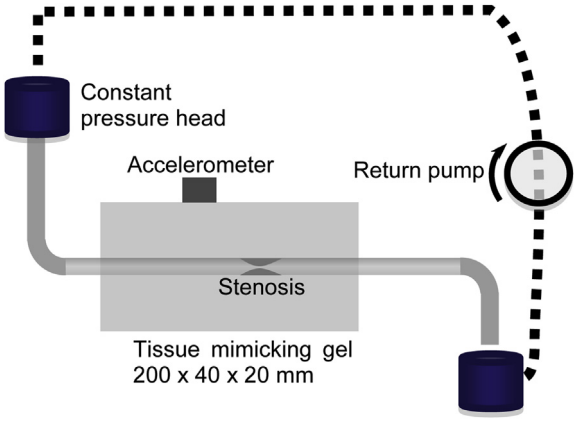

Figure 2. Steady flow rig. Measurements made at various flow rates, tube depths and stenosis severity. Accelerometer position varied.