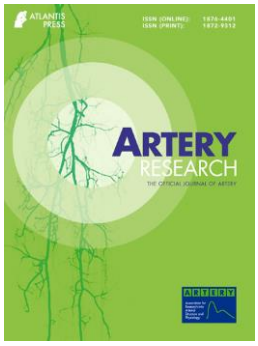

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Invited Speaker Abstracts

NEW INSIGHTS IN ULTRASOUND IMAGING FOR CARDIOVASCULAR DISEASES AND LARGE ARTERIES PROPERTIES

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Recent developments of ultrafast ultrasound imaging scanners open very exciting possibilities in the field of cardiovascular imaging. Thanks to the new design of the most recent ultrasound scanners that uses a fully software-based ultrasound platform, frame rates as large as 20.000 frames/s are reached today. Compared to classical ultrasound scanners that delivered some 100 frames/s these new possibilities represent a complete breakthrough. We will describe at least three innovations that leverage ultrafast ultrasound imaging. The first one is a new imaging mode that provides quantitative viscoelastic analysis of arterial wall by following the propagation of both pulse waves and shear waves with a spatial resolution and precision that were never obtained with classical techniques. The second one allows to image in a very quantitative way the cardiac elasticity anisotropy by studying shear wave propagation in different directions. The last innovation is new way to perform Doppler flow analysis, from ultrafast scanners, changing completely the performances and workflow paradigms of Color and PW modes. Various results obtained with these techniques in the field of cardiovascular imaging will be presented.

VASCULAR BIOMECHANICS: CONSTITUTIVE MODELLING AND CHARACTERISATION OF THE ARTERIAL WALL

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Insight into the mechanical properties of the arterial wall can give valuable information concerning the understanding of pulse wave propagation in the arterial tree, the genesis and progress of atherosclerosis, vessel wall adaptation and remodelling, and the prediction of the effects of medical intervention, such as blood-pressure regulating drug admission, balloon angioplasty, and bypass surgery. A widely used approach to characterize the mechanical properties of arteries is based on a mixed experimental–numerical method, in which parameters of mathematical constitutive models are fitted to experimental stress–strain data. For wall remodelling studies (Machchyn et al., 2010) these parameters preferably are based on micro-structural information such as collagen content and morphology (Rezakaniha et al.,2011). A generic set of parameters can be obtained from ex-vivo experiments where stress-strain relations can be obtained for transmural pressures ranging from a non-physiological unloaded to physiological fully loaded configuration (van den Broek et al., 2011). If only clinical data at physiological loading are available, extra constraints on the parameter set can be used to obtain a unique characterization (van der Horst et al., 2011). Several aspects regarding the above mentioned micro-structural based models will be discussed during the presentation. For predictive models of pulse wave propagation, micro-structural based constitutive models must be casted into pressure-area relations, whereas, for prediction of adaptation and arterial wall remodeling, the dynamics of smooth muscle cell behavior must be taken into account. Both facets will be shed light upon and illustrated by results recently obtained.

- Machyshyn, I.M., Bovendeerd, P.H.M., van de Ven, A.A.F., Rongen, P.M.J., van de Vosse F. N., "A model for arterial adaptation combining microstructural collagen remodeling and 3D tissue growth", Biomech. Model. Mechanobiol.,9:671–687, (2010)
- Rezakhaniha R., Agianniotis A., Schrauwen J.T.C., Griffa A., Sage D., Bouten C.V.C., van de Vosse F.N., Unser M., Stergiopulos N., "Experimental investigation of collagen waviness and orientation in the arterial adventitia using confocal laser scanning microscopy". Biomech. Model. Mechanobiol., on-line (2011)
- van den Broek C.N., van der Horst A., Rutten M.C.M., van de Vosse F.N., " A generic constitutive model for the passive porcine coronary artery". Biomech. Model. Mechanobiol. 10(2):249–258, (2011)
- van der Horst A., van den Broek C.N., van de Vosse F.N., Rutten M.C.M., "The fiber orientation in the coronary arterial wall at physiological loading evaluated with a two-fiber constitutive model", Biomech. Model. Mechanobiol., on-line (2011)

NEW INSIGHT IN CORONARY VULNERABLE PLAQUE MECHANICAL PROPERTIES

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Vulnerable coronary atherosclerotic plaque rupture is a recognized major cause of acute coronary syndrome. Such vulnerable plaques can be detected clinically by various techniques, including intravascular ultrasound (IVUS) and optical coherence tomography. Detecting lesions vulnerable to rupture is a major issue, as it could lead to the development of specific treatment strategies for the prevention of acute thrombotic events. Clinical and biomechanical studies performed recently by our group have originally identified new morphological factors as the key predictors of vulnerability to rupture. Moreover, it is now recognized that prediction of the vulnerable coronary plaque rupture requires not only an accurate quantification of fibrous cap thickness and necrotic core morphology but also a precise knowledge of the mechanical properties of plaque components (IVUS Modulography of Atheroma Plaque). We demonstrated why, in clinical practice, biomechanical plaque instability is not a consequence of Cap_{tick} alone, but rather of a subtle combination of Cap_{thick}, $Core_{thick}$ and $Remod_{index}$. Moreover, Residual Stress/Strain (RS/S) present in a vulnerable coronary plaque dramatically influences the spatial stress distribution and spotlights some new sites of stress concentration. RS/S could play a major role in the biomechanical stability of vulnerable coronary plaque and in the growth process of the lipid core. Additionally, we showed that plaque rupture is to be viewed as a consequence not of external pressure alone but rather of a subtle combination of external loading and intraplaque RS/S.
Recent publications of our group in this field

1. Ohayon J, Gharib AM, Garcia A, Heroux J, Yazdani SK, Malvè M, Tracqui P, Martinez MA, Doblare M, Finet G, Pettigrew RI. Is arterial wall-strain stiffening an additional process responsible for atherosclerosis in coronary bifurcations?: an in vivo study based on dynamic CT and MRI. Am J Physiol Heart Circ Physiol. 2011 Sep;301(3):H1097-106.

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