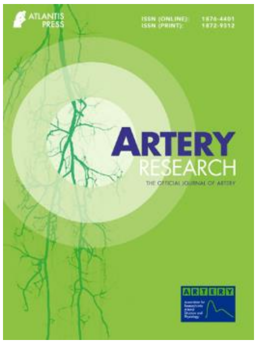

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P5.8: TOWARDS IN VIVO BIAXIAL CHARACTERISATION OF CAROTID ARTERY MECHANICS

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P5.7

A DATABASE OF VIRTUAL HEALTHY SUBJECTS AS A NEW TOOL TO ASSESS PHYSIOLOGICAL INDEXES AND ALGORITHMS BASED ON WAVE PROPAGATION

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Many physiological indexes and algorithms based on pulse wave analysis have been suggested in order to better understand the physiology of arterial hemodynamics (e.g. pulse wave velocity, transfer functions for central blood pressure derivation). Because these tools are most often computed from hemodynamic measurements, their validation is time-consuming and biased by measurement errors.
We present a new methodology to assess theoretically these computed tools. We create a database of virtual healthy subjects using a numerical 1D-0D model of the arterial hemodynamics, which parameters are varied to cover a physiological healthy range. The generated set of simulations encloses a wide selection of possible cases that could be encountered in a clinical study.
We illustrate this new concept by assessing the efficiency of indexes estimating aortic stiffness, such as central and peripheral foot-to-foot pulse wave velocities computed with different methods (foot-to-foot, sum of squares), the stiffness index and the augmentation index. We also apply our methodology to a new algorithm that estimates the central aortic pressure from peripheral measurements. We show that the results of our analysis confirm clinical observations.
Our database of virtual subjects could become a new tool for the clinician: it provides insight into the physical mechanisms that are important when designing large cohort clinical studies, analyzing their results, and explaining the correlations observed in clinical practice.

P5.8

TOWARDS IN VIVO BIAXIAL CHARACTERISATION OF CAROTID ARTERY MECHANICS

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Background: The relative content and loading of collagen and elastin in the arterial wall determine *in vivo* longitudinal pre-stretch. Assessment of arterial distensibility at varying longitudinal pre-stretch could improve characterisation of arterial collagen-elastin matrix properties. We introduce a technique to impose extra longitudinal pre-stretch (Δstretch) to the carotid artery *in vivo* and investigate whether we can predict Δstretch from ultrasound distensibility measurements using a constitutive model.
Methods: In 11 healthy volunteers (22±3 yrs, mean±SD, 6m/5f) we obtained right common carotid artery bifurcation-to-bifurcation length by phase-contrast MR-angiography in two positions: head facing forward (relaxed, R) and head facing up and rotated to the left (stretched, S). We estimated Δstretch from the MR images by two independent operators (Bland-Altman inter-operator bias = 0.5±3%, mean±2SD). Additionally, we obtained brachial blood pressures and carotid diameter-distension (considered as cross-sectional area) by ultrasound echo-tracking. We fitted a constitutive model [Spronck *et al.*, AJP-Heart 2015] to average single-exponential pressure-area curves for both R and S states. We predicted Δstretch using the model, assuming constant axial force over the cardiac cycle.
Results: MRI-estimated Δstretch was +2% while constitutive model-predicted Δstretch was +6%. To check these estimates, we additionally predicted Δstretch based on echo-derived intima-media-thickness measurements, yielding +6%.
Conclusion: Measured and predicted Δstretch values were of the same order of magnitude. Assessment of carotid artery distensibility at varying longitudinal pre-stretch could improve model-based *in vivo* assessment of arterial wall collagen-elastin matrix properties, which are relevant in age- and disease-related arterial remodelling.

P5.9

CARDIAC AND ARTERIAL CONTRIBUTION TO BLOOD PRESSURE CHANGES WITH AGE

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During aging, systolic blood pressure (Ps) continuously increases over time, whereas diastolic pressure (Pd) first increases and then slightly decreases after middle-age. These pressure changes are usually explained by changes of the arterial system alone (increase in arterial stiffness and vascular resistance). However, we hypothesize that the heart contributes to the age-related blood pressure progression as well. In this study we quantified the blood pressure changes in normal aging by using the Windkessel model for the arterial system and the time-varying elastance model for the heart, and validated the results against data from the Framingham Heart Study. Arterial changes during aging were prescribed based on literature values, whereas the cardiac changes were computed through physiological rules (compensated hypertrophy and preservation of end-diastolic volume). Results showed that, when accounting for arterial changes only, the Ps and Pd did not conform to the population data. The computed Ps changed from 100 to 122 mmHg and Pd from 76 to 55 mmHg, respectively. When taking cardiac adaptations also into account, Ps and Pd changed from 100 to 151 mmHg and 76 to 69 mmHg, respectively. Our results show that not only the arterial system, but also the heart significantly contributes to the development of blood pressure during aging. The changes in arterial properties initiate a systolic blood pressure increase, which in turn initiate a cardiac remodeling process, further contributing to the development of Ps and Pd.

P5.10

CHANGES IN MECHANICAL PROPERTIES OF FEMORAL ARTERY WALLS IN PIG MODEL OF ARTERIOSCLEROSIS

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Arteriosclertic lesions leading to increased stiffnes of the walls. The goal of the research was to estimate changes in the mechanical properties of femoral artery in swine with experimentally induced arteriosclerotic changes by western type diet.
Methods: 32 white female pigs (40 kg), were divided into 3 groups: 1) 12 control pigs 2) 10 "diet" pigs fed a "western diet" 3) 10 pigs "regression" – fed a western diet for 9 months and then a standard diet for 3 months. Femoral arteries samples were stained HE method for histopathology, were tested for collagen and elastin content and mechanical properties. Arterioscleraotic changes were classified using 8 class scale (Stary et all. 2000). Mechanical test were conducted using Synergie 100 machine with force sensor MTS (mesurement range 0÷500 N). Thickness of artery wessels was measured by mikroskope SteREO Discovery V20 (Zeiss). Data were analysed statistically using the Statistica 10.0 software.
Results: 2 pigs in Diet group and 4 pigs in Regression group have arteriosclerotic plaque I and II grades. Mechanical indexes: σL Lagrangian stresses, ε Green strain, σ Cauchy stress, ES secant module and Et tangent modulus were not changed.
Conclusion: Despite presence of arteriosclerotic leasions iduced by feeding swine of western type diet, we not seen significant differences in mechanical properties of femoral artery in comparison to standard fed pigs.

P5.11

ROLE OF PRESSURE-DEPENDENT ARTERIAL OMPLIANCE IN MODULATING THE PHASE OF WAVE REFLECTIONS: IMPLICATIONS FOR LV-AS COUPLING

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Background: Arterial compliance is pressure-dependent due to the nonhomogeneous composition of the arterial wall. Wall distending pressure varies within each cardiac cycle, thus arterial compliance is dynamic and time-varying within any given cycle. As compliance is a component of the pulsatile load presented by the arterial system (AS), its dynamic nature is expected to influence the phase of wave reflections. This phase modulation of wave reflection may influence left ventricular (LV) and AS coupling.
Methods: A time-varying elastance-resistance model the LV is coupled to a tube-load model of the AS. The tube, representing a segment of the aorta, is uniform and loss-free, terminating in a complex frequency-dependent load incorporating pressure-dependent compliance (C(P)). Aortic