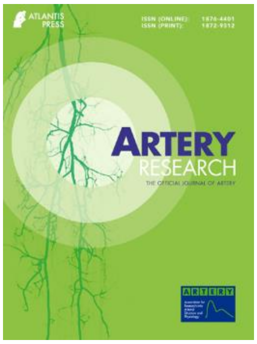

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P2.42: A NEW BLOOD PRESSURE-INDEPENDENT ARTERIAL STIFFNESS INDEX, CARDIO-ANKLE VASCULAR INDEX (CAVI)

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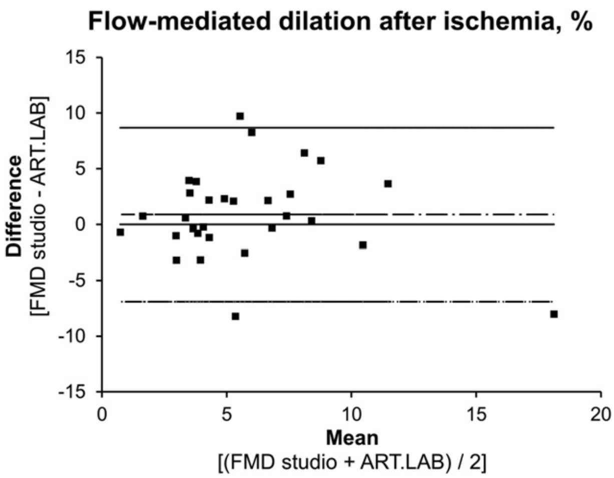

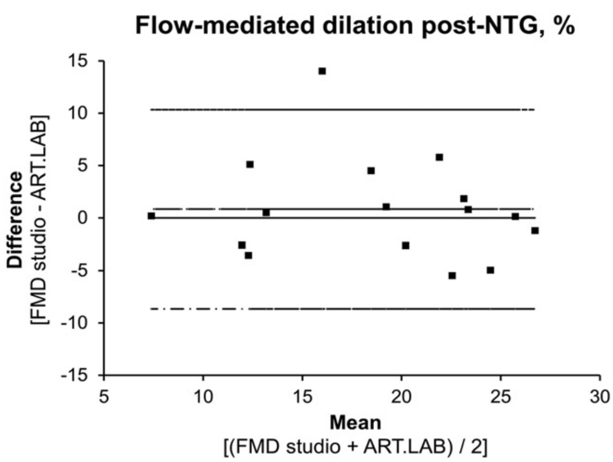

P2.40

TENSILE MEASUREMENTS ON VERY SMALL BLOOD VESSELS AND VASCULAR GRAFTS

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Aims: Biomechanical evaluation of small blood vessels and vascular grafts is an important task. In this work a method is presented for testing mechanical behaviour of very small tubular structures with less than 1mm diameter.
Methods: For the tensile measurements a BOSE ElectroForce system (Bose Corp. MN, USA) with a controllable linear motor for static and dynamic measurements was used. To measure very small ring-shaped specimens the system was modified with a cantilever and a special designed probe fixation.
Firstly, tensile behaviour on thoracic mice aortae after 19 weeks high-fat-diet (group 1) and a control group (group 2) were analyzed. Secondly, on electrospun vascular grafts repeated loading-unloading measurements were performed to obtain the dynamic behaviour in the physiological range.
Results: The modified system allowed measurements on very small specimen (0.7mm inner diameter in case of the mice aortae) and the use of very sensitive load cells of 10N and up to 0.5N.
For the mice aortae significant higher maximum tear forces in group 1 with 0.41 +/- 0.12N, than in group 2 with 0.34 +/- 0.10N were measured. Diverse tear forces and braking strains at different zones of the aorta could be observed. For the vascular grafts hysteresis curves could be recorded with peak-to-valley forces of 0.03 to 0.08N, corresponding to 80 and 120mmHg.
Conclusion: The established method enables a reproducible and sensible measurement of static and dynamic mechanical properties in small ring-shaped specimen of arteries and vascular prostheses.

P2.41

ACUTE RESPIRATORY CHANGES IN AUGMENTATION INDEX ARE RELATED TO AORTIC RESERVOIR FUNCTION

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Background: Augmentation index (AIx) is an independent predictor of mortality. Current theory states augmented pressure (AP) is principally due to wave reflection. Subtle changes in AP occur with respiration, but the mechanisms are not fully understood. This study aimed to determine the possible contribution of wave reflection and aortic reservoir function to respiratory changes in AP.
Methods: Simultaneous invasive pressure and Doppler flow velocity were recorded in the ascending aorta via intra-arterial wire in 24 consecutive participants undergoing cardiac catheterisation or surgery. We performed wave intensity analysis to derive forward and reflected waves, and calculated reservoir pressure in five patients displaying marked respiratory AP changes (see figure). Data was compared between four respiratory cycles of expiration (high AP) with inspiration (low AP) in each individual.
Results: AP and AIx were raised during expiration compared to inspiration (5±6mmHg, 10±13% vs.-1±2mmHg, -6±9%, P<0.001 for both). Despite this, wave reflection was not significantly changed ($-7x10^6 \pm 9x10^6$ vs. $-6x10^6 \pm 5x10^6$ $W.m^{-2}s^{-2}$, P=0.50). However, reservoir pressure was significantly higher during expiration compared with inspiration (95±23 vs. 88±20 mmHg, P<0.001), as were forward compression waves ($41x10^6 \pm 27x10^6$ vs. $36x10^6 \pm 24x10^6$ $W.m^{-2}s^{-2}$, P=0.04). The change in AP between inspiration and expiration correlated with change in reservoir pressure (r=0.81, P<0.001), but not reflected wave intensity (r=-0.19, P=0.41) or heart rate (r=-0.33, P=0.15).
Conclusions: Acute changes in AP and AIx occur during normal respiration. These changes appear related to aortic reservoir function and cannot be explained by conventional wave reflection theory.

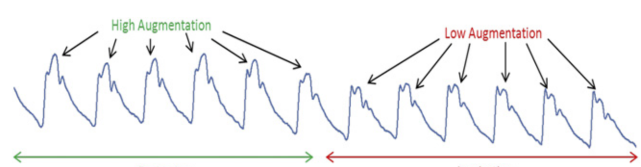

Figure Example respiratory AP changes in a 48 year old male.

P2.42

A NEW BLOOD PRESSURE-INDEPENDENT ARTERIAL STIFFNESS INDEX, CARDIO-ANKLE VASCULAR INDEX (CAVI)

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The Cardio-Ankle Vascular Index (CAVI) is a new indicator of the stiffness of arteries from the origin of the aorta to the ankle of the lower leg. The theory is based on the stiffness parameter β. CAVI is essentially independent of blood pressure at a measuring time. This is confirmed by the study using adrenergic β1 receptor-blocking agent, metoprolol in human. When metoprolol is administered to men, blood pressure decreased and pulse wave velocity is decreased. But, CAVI remains constant. This result was also confirmed by the study on the rabbits using same apparatus.
CAVI increased with aging and showed higher values in males than in females. CAVI showed high value in patients with cerebral infarction, coronary stenosis, and chronic kidney disease.
As for the risks of coronary artery disease, CAVI showed high value in hypertension, diabetes mellitus, dyslipidemia, smoking, and metabolic syndrome. Furthermore, improvement of those risk factors by drugs or lifestyle changes reduced CAVI in most cases. In other words, CAVI is a useful indicator for the management of coronary risk factors.

CAVI is decreased with alfa1 selective blocker, doxazosin. Therefore, CAVI is supposed to be composed of organic stiffness and also of contracture of smooth muscle cells. Moreover, the relationships between CAVI and cardiac functions were reported.
Thus, CAVI may be not only a surrogate maker of arteriosclerosis and vascular age, but, also an indicator of contracture of smooth muscle cells. CAVI might develop a new field of vascular function.

P2.43

DEVELOPMENT OF A NEW MODEL FOR CALCULATING VENOUS COMPLIANCE IN THE LIMBS OF HUMANS

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Venous compliance (Vc) reflects the elastic properties of the venous wall and altered Vc affects venous return as well as hemodynamic stability. Venous occlusion plethysmography (VOP) is used to measure Vc in the limbs. However, capillary filtration from blood to tissue could be a potential confounder. We conducted a series of studies to validate VOP in lower limb. A method was developed to identify fluid filtration and to evaluate whether this is a significant confounder in the study of Vc.
Strain-gauge technique was used to study calf volume changes in 15 healthy females (22.9±3.2 years). A thigh cuff was inflated to 60 mmHg for 8 min with a subsequent linear decrease of 1 mmHg/s in cuff pressure (P). Intravenous pressure (IVP) was simultaneously measured in a foot vein. Vc was determined using the first derivate of a quadratic regression equation describing the volume-pressure relationship [Compliance $= \beta 1 + 2\beta 2(P)$]. The capillary filtration was subtracted from the volume curve to correct for the potential effect on Vc.
The increase in IVP showed 100% transmission and steady state was reached within 3-4 min. The following decrease of 1 mmHg/s in cuff pressure correlated well with IVP reduction ($r=0.99$, $P<0.001$). The volume increase during VOP was augmented further by approximately 60% due to capillary filtration. Without correction of capillary filtration Vc was underestimated with the most marked differences ≥30 mmHg ($P<0.01$).
Capillary filtration is a confounder in the study of limb Vc. The new model seems to be a valuable tool in the future studies of venous wall function as well as hemodynamic regulation.

P2.44

A COMPARISON OF THE CAROTID AND POPLITEAL ARTERIES IN YOUNG AND OLDER CAUCASIAN MEN

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According to Debasso *et al.*, the popliteal artery depicts a muscular artery with wall properties similar to that of the central conduit arteries. Some literature show differences in arterial composition between popliteal arteries and other fellow peripheral muscular arteries and may comprise both central and peripheral properties. The objective was to investigate whether the popliteal artery resemble the carotid artery in structure and function in young and older Caucasian men. Forty one participants were divided in a young-, aged 20-30 years ($n=21$) and an older group aged 40-60 years ($n=20$). Cardiovascular and anthropometric measurements were executed which included blood pressure, carotid femoral PWV (Complior SP Acquisition system) as well as popliteal and carotid IMT (Vivid E9, GE). An inverse association ($r=-0.78$; $p<0.001$) between popliteal IMT and c-fPWV in young men were encountered after adjusted for age, BMI and smoking. Carotid IMT and popliteal IMT differed significantly ($p<0.001$) in both age groups. The mean CSWA of carotid and popliteal arteries also differed significantly when young and older men were compared. In the young men the mean CSWA of the carotid artery differed significantly from the popliteal CSWA (1.83 cm vs. 1.60 cm; $p=0.013$) but not in the older men. To conclude the popliteal and carotid arteries in young and older Caucasian men do not exhibit similar structural or functional properties.

P2.45

ESTIMATING TOTAL ARTERIAL COMPLIANCE FROM AORTIC PULSE WAVE VELOCITY

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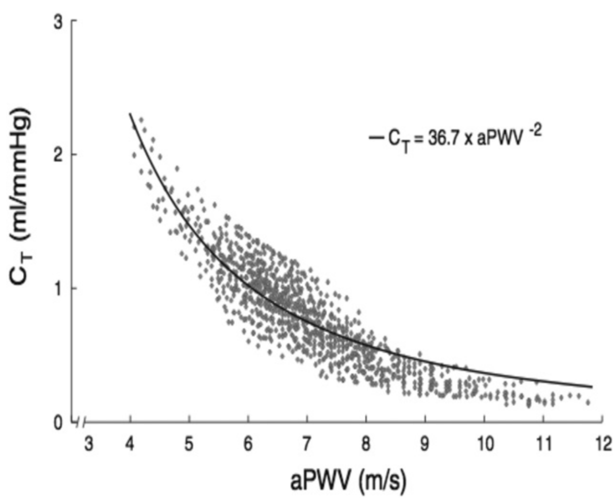
Total arterial compliance (CT) is a main determinant of cardiac afterload, left ventricular function and arterio-ventricular coupling. *CT* is physiologically more relevant than regional aortic stiffness. However, direct, *in vivo*, non-invasive, measurement of *CT* is not feasible. Several methods for indirect *CT* estimation require simultaneous recording of aortic flow and pressure waves, limiting *CT* assessment in clinical practice. In contrast, aortic pulse wave velocity (aPWV) measurement, which is considered as the "gold standard" method to assess arterial stiffness, is noninvasive and relatively easy. Our aim was to establish the relation between aPWV and *CT*. Totally, 1000 different hemodynamic cases were simulated, by altering heart rate, compliance, resistance and geometry using an accurate, distributed, nonlinear, one- dimensional model of the arterial tree. Based on Bramwell-Hill theory, the formula $C_T = k \cdot aPWV^{-2}$ was found to accurately estimate *CT* from aPWV. Coefficient *k* was determined both analytically and by fitting *CT* vs aPWV data (Fig. 1). *CT* estimation may provide an additional tool for cardiovascular risk (CV) assessment and better management of CV diseases. *CT* could have greater impact in assessing elderly population or subjects with elevated arterial stiffness, where aPWV seem to have limited prognostic value. Further clinical studies should be performed to validate the formula *in vivo*.



P2.46

THE "SYSTOLIC VOLUME BALANCE" METHOD FOR THE NON-INVASIVE ESTIMATION OF CARDIAC OUTPUT BASED ON PRESSURE WAVE ANALYSIS

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École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

Cardiac output (CO) monitoring is essential for the optimal management of critically ill patients. Several methods have been proposed for CO estimation based on pressure waveform analysis. Most of them depend on invasive blood pressure recording and calibrations, while they suffer from decreased accuracy under specific conditions. A new Systolic Volume Balance (SVB) method was derived from a volume balance approach on the conservation of mass ejected into and flowed out of the arterial system during systole. The formula was validated by a one-dimensional model of the systemic arterial tree. Comparisons of CO estimates between the proposed and previous methods were performed in terms of agreement and accuracy by using the "real" CO values of the model as a reference. 507 different hemodynamic cases were simulated by altering cardiac period (T), arterial compliance (C) and resistance. CO could be accurately estimated by the SVB method: $CO = C \cdot PP_{ao} / (T - P_{sm} \cdot T_s / P_m)$ where PP_{ao} aortic pulse pressure, T_s systolic duration, P_{sm} mean systolic pressure and P_m mean pressure. SVB applied on aortic pressure waves did not require calibration or empirical correction for CO estimation. An empirical coefficient (k) was necessary for brachial pressure wave analysis. The difference of SVB-derived from model CO, (for brachial