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

K. Shirai

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P2.40
TENSILE MEASUREMENTS ON VERY SMALL BLOOD VESSELS AND VASCULAR GRAFTS
M. S. Stolber 1, 2, C. G. Granit 1, 3, K. K. Kessler 3, B. M. Messner 3, D. B. Bernhard 3, V. G. Gschladl 1, 2, H. S. Schima 1, 2, 4
1Center for Medical Physics and Biomedical Engineering, Medical University of Vienna, Vienna, Austria
2Department of Cardiac Surgery, Medical University of Vienna, Vienna, Austria
3Cardiac Surgery Research Laboratories, Department of Surgery, Medical University of Vienna, Vienna, Austria
4Ludwig-Boltzmann-Cluster for Cardiovascular Research, Vienna, Austria

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
M. G. Schultz 1, J. E. Davies 2, A. D. Hughes 3, J. E. Sharman 1
1Menzies Research Institute Tasmania, Hobart, Australia
2International Centre for Circulatory Health, Imperial College, London, United Kingdom

Background: Augmentation index (Alx) 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 intraarterial 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 Alx were raised during expiration compared to inspiration (5.6±4mmHg; 10±13% vs.-1±2mmHg; -6±9%; P<0.001 for both). Despite this, wave reflection was not significantly changed (-7x10^{-6}±9x10^{-6} vs. -6x10^{-6}±5x10^{-6} W.m^{-2^2}, 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}±2x10^{-6} vs. 36x10^{-6}±4x10^{-6} W.m^{-2^2}, 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 Alx occur during normal respiration. These changes appear related to aortic reservoir function and cannot be explained by conventional wave reflection theory.

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)
K. Shirai
Sakura Hospital, Toho University, Sakura, Chiba, Japan

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 using adrenergic β1 receptor-blocking agent, metoprolol in rats. 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 alpha1 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 marker 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

J. Skogö 1, M. Ekman 1, H. Zachrisson 1, M. Lindenberger 1,2, L. Ewerman 1, T. Lanné 1
1 Department of Medicine and Health Sciences, Division of Cardiovascular medicine, Linköping University, Sweden
2 Division of Cardiology, Linköping, Sweden

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 derivative of a quadratic regression equation describing the volume-pressure relationship. Compliance = TP+C2. (P).

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

J. M. van Rooyen 1,2, L. J. Kotzee 2, C. M. C. Meis 2, R. Kruger 1,2, A. Burger 2
1 North-West University, Potchefstroom, South Africa
2 HART, Potchefstroom, South Africa

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 resembles the carotid artery in structure and function in young and older Caucasian men. Forty one participants were divided in a young- and older group 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 (Compilo 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-PWV in young men were encountered after adjusted for age, BMI and smoking. Carotid IMT and popliteal IMT differed significantly between age groups. 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 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

O. Vardoulis, T. G. Papaoannou, N. Stergiopulos
École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland

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 CT = k aPWV 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.