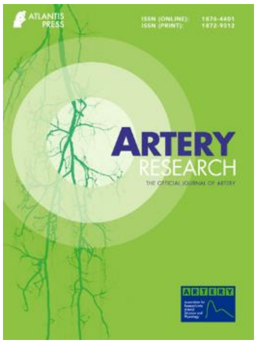

Artery Research

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

P6.02: IN-VIVO ASSESSMENT OF THE ACCURACY OF CAROTID STRAIN ESTIMATES DERIVED FROM ULTRASONIC WALL TRACKING

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To cite this article: A. Swillens, L. Lovstakken, J. Degroote, G. De Santis, J. Vierendeels, P. Segers (2011) P6.02: IN-VIVO ASSESSMENT OF THE ACCURACY OF CAROTID STRAIN ESTIMATES DERIVED FROM ULTRASONIC WALL TRACKING, Artery Research 5:4, 171–172, DOI: https://doi.org/10.1016/j.artres.2011.10.088

To link to this article: https://doi.org/10.1016/j.artres.2011.10.088

pulse timing in a raised arm and a control arm kept at heart level. The artery expands in the raised arm leading to a decrease in blood velocity. An estimate of the dilation of the brachial artery is obtained from the assumption that the flow in the raised arm is unchanged due to the position of the arm. The pulse timing difference measured at similar points in the two arms (index finger or wrist) is due to the dilation of the artery. The square of the radial dilation d is given by the length of the brachial artery divided by the product of the systolic blood velocity in the control arm times the observed pulse timing difference. Measurements were obtained by placing transducers on the index fingers of both hand and the lower leg of the subject. Measurements are recorded at a 1 kHz rate using a laptop computer. Initially, the subject places both hands at heart level. After a period of 1 minute, the right hand is raised at an angle of 45° and supported by a platform. Pulse timing measurements are computed using the two sensors on the hands and the pulse wave velocity is computed using the left hand and leg sensors. Simultaneous measurements of pulse wave velocity are inversely correlated with the pulse timing difference.

P5.30

VASCULAR EXPLORATIONS OF PATIENTS WITH ERDHEIM CHESTER DISEASE

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Objectives: To study structural and functional alterations of arteries in patients with Erdheim-Chester disease, a rare acquired idiopathic histiocytosis characterized by a circumferential fibrosis of the aorta and its main branches.

Methods : Fifteen patients underwent peripheral arteries assessment with measurement of intima media thickness (EIM), carotid femoral pulse wave velocity (PWV) by Complior®, radial augmentation index (AI) by Sphygmocor® and OMRON HEM9001®, and ankle brachial index (ABI) by SCVL®. Blood pressure was assessed by 24h measurement.

Results: Our population consisted in 85% of men from 30 to 76 years old. There was 45% of treated and controlled hypertensive, 57% of formers smokers and 14% of diabetics. One third was under interferon, 30% under corticosteroids and the rest were untreated. IMTs were all normals but a periarterial carotidal fibrosis was noted in 28% who also had aortitis on PET scan. An augmentation of the global aortic stiffness (PWV) was present in 90% of the patients. According to the nomograms, the radial distensibility was altered in 30% of the patients, especially in the youngest and the carotidal distensibility was normal in 90% of the patients. The mean difference between central blood pressure and brachial blood pressure was -18 mmHg and -23.5mmHg for those with aortitis. All ABI were normal.

Conclusion: Arterial explorations of Erdheim-Chester patients unravel a periarterial fibrosis in 28% of the patients but an increased aortic stiffness in 90%. The absence of carotidal augmentation indexes abnormalities suggests that those alterations may not influence central blood pressure

P5.31

RELATIONSHIP BETWEEN WAVE REFLECTION AND RENAL VASCULAR DAMAGE IN HYPERTENSIVE PATIENTS

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Background: Arterial stiffness reduces buffering capacity, exposing the microcirculation to increased pulsatility. Wave reflection could be protective by reducing pulsatility transmitted to low resistance vascular beds such as the brain or the kidney, as suggested by recent data in retinal circulation. Therefore we explored the relationship between wave reflections, arterial stiffness, and renal resistive index.

Methods: We searched our databases of hypertensive patients for subjects who underwent both measurement of arterial stiffness and renal arteries ultrasound. Augmentation index (AIx) and carotid-femoral pulse wave velocity (PWV) as measures of wave reflection and arterial stiffness, respectively, were recorded using the SphygmoCor system. Intraparenchimal renal resistive index (RI), a measure of vascular damage, was obtained in the interlobar arteries by Duplex ultrasound.

Results: Analysis was performed in 175 hypertensive patients (52.9±11.7 yrs), without renal artery stenosis or primary kidney disease. Mean RI was 0.630±0.065, PWV 8.41±1.74 m/s, AIx 26.7±11.5 %. RI was positively associated with AIx ($r=0.31$, $p<0.001$) and PWV ($r=0.43$, $p<0.001$). Neither AIx nor PWV remained significant predictors of RI in a model including age, gender, body mass index, blood pressure, heart rate, glucose, cholesterol, glomerular filtration rate. Stratifying patients according to tertiles of AIx and PWV, IR was not different between low AIx / high PWV and high AIx / low PWV (0.633±0.062 vs 0.632±0.059, p=ns).

Conclusions: This cross sectional analysis failed to demonstrate an independent relationship between wave reflection and renal resistive index, suggesting that wave reflection could not have a beneficial effect in the renal circulation of hypertensive patients.

P6 — Techniques and Mechanisms 1

P6.01

THE METHOD OF DISTANCE MEASUREMENT AND TORSO LENGTH INFLUENCES THE RELATIONSHIP OF PULSE WAVE VELOCITY TO CARDIOVASCULAR MORTALITY

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Background: The method of estimating distance traveled by the pulse wave, used in the calculation of pulse wave velocity (PWV), is not standardized. Our objective was to assess whether different methods of distance measurement influenced the association of PWV to cardiovascular mortality in hemodialysis patients.

Methods 98 chronic hemodialysis patients had their PWV measured using three methods for distance estimation; PWV1: suprasternal notch-to-femoral site minus suprasternal notch-to-carotid site, PWV2: carotid-to-femoral site, PWV3: carotid-to-femoral site minus suprasternal notch-to-carotid site. Carotid-to-femoral distance was used to approximate torso length. Patients were followed for a median of 30 months and the association of PWV and cardiovascular mortality was assessed using survival analysis before and after stratification for torso length.

Results: The three methods resulted in significantly different PWV values. During follow up 50 patients died, 32 of cardiovascular causes. In log-rank tests only tertiles of PWV1 was significantly related to outcome (p-values 0.017, 0.257, 0.137, for PWV1, PWV2 and PWV3, respectively). In adjusted Cox proportional hazards regression only PWV1 was related to cardiovascular mortality. In stratified analysis, however, among patients with below median torso length all PWV values were related to outcome, while in patients with above median torso length none of the PWV methods resulted in significant relationship to outcome.

Conclusions PWV calculated using suprasternal notch-to-femoral distance minus suprasternal notch-to-carotid distance provides the strongest relationship to cardiovascular mortality. Longer torso weakens the predictive value of PWV, possibly due to more tortuosity of the aorta hence more error introduced when using surface tape measurements.

P6.02

IN-VIVO ASSESSMENT OF THE ACCURACY OF CAROTID STRAIN ESTIMATES DERIVED FROM ULTRASONIC WALL TRACKING

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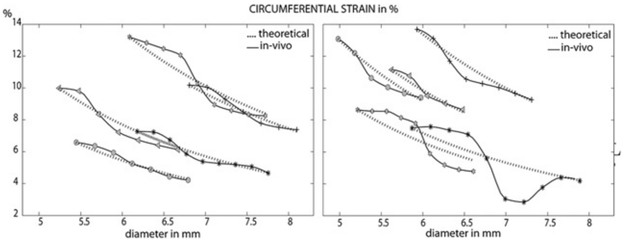
Background: Ultrasonic wall tracking is a common tool in cardiovascular screening, where it is applied to assess arterial diameter distension waveforms. However, using multiple tracking points within the arterial wall and under the assumption of planar deformation, circumferential and radial strain can be obtained as $\varepsilon_{\theta\theta}=D/D$ and $\varepsilon_{rr}=\partial D/\partial D$.

Methods: We investigated the accuracy of these arterial strain estimates, using 10 representative data sets of the Asklepios population study . Tracking was done using a scanline perpendicular to the common carotid artery, far enough from the bulbus and showing clear intima-media and media-adventitia transitions. We started tracking from a designated point on the media-adventitia transition and from there on every 100 micrometer towards the lumen.

Results & Discussion: Data revealed an S-shaped curve of $\varepsilon_{\theta\theta}$ throughout the wall for all 10 subjects (fig.1, solid line), which was different from D/D calculated from conservation of mass (dashed line: $1/D^2$-trend). Radial strain strongly varied from inner to outer wall, limiting its use as strain or compressibility measure. Using a multiphysics simulation incorporating blood flow, arterial wall deformation and ultrasound physics and imaging of a physiological realistic common carotid artery, it was revealed that this S-shape finds its origin in so-called specular reflections, arising at tissue-transitions (tissue/wall and wall/lumen), clouding the measurement in their neighbourhood.

Conclusion: We demonstrated using in-vivo data and simulations that the physics behind ultrasonic wall tracking hamper the precision of distension and derived strain estimates in the common carotid artery.



P6.03

THE PRESSURE DEPENDENCE OF ARTERIAL STIFFNESS AS A NOVEL VASCULAR MARKER DETERMINED FROM PWV AND BRACHIAL BP TAKEN AT DIFFERENT ARM HEIGHTS

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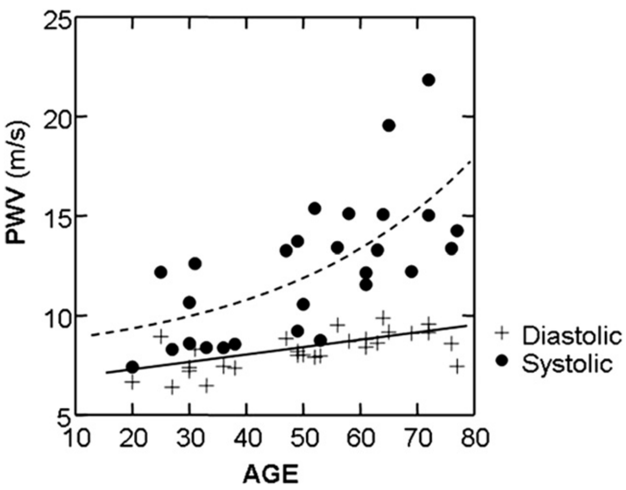
Background: The increase of arterial stiffness with blood pressure (BP) reflects the nonlinear increase of arterial pressure with volume. Stiffness can be represented by the square of the pulse wave velocity (PWV), and is currently measured for diastolic BP (DBP). By analyzing the changes in DBP and diastolic PWV (PWVd) induced by changing arm position, we evaluated a linear relation between stiffness and DBP in an individual subject.

Methods: In 27 healthy subjects (66% men, age 51±17 years, BP 134/78±17/12 mmHg), we measured brachial BP and carotid-radial PWVd in supine position with arm supported at 3 postures: below-, at- and above the heart level. PWVd^2 was expressed by the model $0.127\times\beta(\mathrm{DBP} - \alpha)$, where β and α were best fitted for each subject, and then used for determining the systolic stiffness PWVs^2 from the SBP, according to the model $0.127\times\beta(\mathrm{SBP} - \alpha)$. β ("stiffness constant") expresses the steepness of the pressure-volume exponential curve.

Results: PWVd^2 highly correlated with DBP for individual subjects ($r=0.95\pm0.03$). The mean β was 13.1±11.7 and increased significantly at older age ($r=0.49$). While diastolic PWV increased linearly with age with $r=0.64$, calculated systolic PWV increased with age exponentially with $r=0.65$ that became steep over age 50 years (Figure; all $p<0.001$).

Conclusions: (1) The gravity effect on brachial DBP induces linear changes in diastolic PWV, which increase with age. (2) The dynamic changes of PWV and DBP may provide a novel and simple determination of systolic PWV, which shows greater age sensitivity than diastolic PWV.



P6.04

RELATIONSHIP BETWEEN AORTIC STIFFNESS AND A LOCAL PULSATILE INDICE FROM THE PERIPHERAL CUTANEOUS MICROVASCULATURE

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Purpose: Increase in arterial stiffness could increase the transmission of pulsatile flow energy and potentially damage the downstream microcirculation. The study of changes in the microcirculatory pulsatility could help to improve our understanding on the deleterious effect of the upstream arterial stiffness. To achieve this goal, we studied the relationship between aortic stiffness, local stiffness (β indice) and distensibility (Ep) of carotid and a local microcirculatory pulsatility index (μFP).

Methods: Aortic stiffness was determined from the carotid-femoral pulse wave velocity (PWV) measured by tonometry (Pulse Pen). Carotid stiffness was measured by echotracking (e-tracking, Aloka) and forearm skin blood flow was recorded by laser Doppler flowmetry (LDF). Data were recorded in subjects ($n=17$, 15 men, mean age 45±SD8 years) without hypertension, diabetes or obesity. The μFP index was calculated as: (LDF max − LDF min) / mean LDF over 35 cardiac cycles.

Results: A significant positive correlation was found between PWV, μFP and age ($R^2= 0.42$, $p<0.01$ - $R^2= 0.32$, $p<0.05$) and between PWV and the μFP index ($R^2= 0.32$, $p<0.05$ adjusted by age). No significant correlation was found between β stiffness indice ($R^2 = 0.0002$), Ep ($R^2=0.03$) and μFP.

Conclusion: Our data show that the pulsatility of the microvascular flow, an easily determined indice, is highly correlated to the aortic stiffness but not to medium-sized artery. These preliminary data have important implication for the further understanding of the deleterious effects of the segmental arterial stiffness on the end-organ microvasculature.

P6.05

VALIDITY AND REPRODUCIBILITY OF A NEW METHOD TO ESTIMATE CENTRAL BLOOD PRESSURE FROM THE UPPER ARM CUFF OSCILLOMETRIC SIGNAL

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Background: Central BP is an independent predictor of mortality. Current methods for non-invasively estimating central BP are operator-dependent and require skill to obtain quality recordings. The aims of this study were firstly, to determine the validity of an automatic, upper arm oscillometric cuff method for estimating central BP (O_{CBP}) by comparison with the non-invasive reference standard of radial tonometry (T_{CBP}). Secondly, we sought to determine the intra-test and inter-test reproducibility of O_{CBP}.

Methods: To assess validity, central BP was estimated by O_{CBP} (R6.5B Vascular Monitor) and compared with T_{CBP} (SphygmoCor) in 47 participants aged 57±9 years in supine, seated and standing postures. Brachial mean arterial pressure and diastolic BP from the O_{CBP} device was used to calibrate both devices. Duplicate measures were recorded in each posture on the same day to assess intra-test reliability and participants returned within 10±7 days for repeat measurements to assess inter-test reliability.

Results: There was a strong correlation (ICC=0.987, $p<0.001$) and small mean difference (1.2±2.2 mmHg) for central systolic BP determined by O_{CBP} compared with T_{CBP}. Ninety-six percent of all comparisons ($n=495$ acceptable recordings) were within 5 mmHg. With respect to reproducibility, there were strong correlations but higher limits of agreement for the intra-test (ICC=0.975, $p<0.001$, mean difference 0.6±4.5mmHg) and inter-test (ICC=0.895, $p<0.001$, mean difference 4.3±8.0 mmHg) comparisons.

Conclusions: Estimation of central systolic BP using cuff oscillometry is substantially equivalent to radial tonometry and has good reproducibility. As a non-invasive, relatively operator-independent method, O_{CBP} may be useful for estimating central BP in clinical practice.