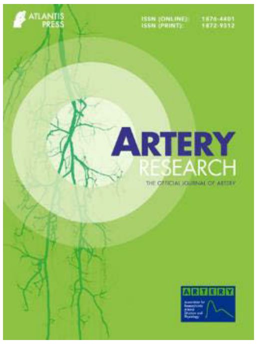

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P1.36: A PRELIMINARY STUDY FOR THE EVALUATION OF LARGE ARTERY STIFFNESS: A NON CONTACT APPROACH

M. De Melis, U. Morbiducci, L. Scalise, E.P. Tomasini, D. Delbeke, R. Baets, L.M. Van Bortel, P. Segers

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was assessed by the estabilished foot to foot method (Complior Artech, Paris); PWVba and CAVI were obtained by a commercially available system (Vasera Fukuda, Tokyo), recording simultaneously brachial and tibial sphygmogram, ECG and phonocardiogram (PGC). CAVI is derived from the stiffness index Beta, according to Bramwell-Hill formula.
Results: PWba was significantly correlated with PWVcf ($r = 0.785$, $p<0.001$); in Bland Altman analysis, all points but two were included into ± 2SD of mean difference (mean difference= 0.804 ± 2.17 m/s). CAVI, PWVba, PWVcf were directly correlated with age ($r = 0.778, 0.595, 0.687$; $p<0.001$) and pulse pressure ($r = 0.504, 0.300, 0.422$; $p<0.001$).
Conclusions: PWVba, an integrated index of aortic and femoro-tibial stiffness, shows good agreement with PWVcf. CAVI index seems to provide the best associations with age and pulse pressure.

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P1.33

COMPARISON BETWEEN ULTRASONIC MEASUREMENTS OF CAROTID WALL PROPERTIES AND NEW AUTOMATED METHOD BY ANALYSIS OF IMAGING

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Echotracking (ET) devices were developed to determine elastic properties of arterial wall material with high precision. The radiofrequency provides a higher precision than with B-mode image systems, limited by the spatial resolution of pixel. New approaches to analyse the B-mode imaging (IA) with offline semi-automated boundary tracking (AMSII) could enhance accuracy and limit variability of arterial measurements, but this method should be validated.
Objectives: To compare carotid parameters assessed with echotracking and applanation tonometry to IA process.
Methods: 10 healthy volunteers had successively common carotid artery measurements with ET and B-mode image analysis (standardized probe localization and orientation). Local carotid systolic and diastolic blood pressure (SBP, DBP), pulse pressure (PP) were measured with aplanation tonometry. Systolic and diastolic diameters (SD, DD), distension were assessed with both methods. Data were analyzed independently, blinded to the results of concurrent method. Coefficient of variation (CV) and Pearson's correlation coefficient between the methods were calculated. Wilcoxon's signed-rank test for matched pairs was used for significance.
Results: No significant differences were observed through results of the two assessment methods for local SBP, DBP, PP, Distension, DD and SD. All CV were inferior to 5%. Correlation coefficients between paired parameters were at least 0.90 for all the measurements.
Conclusion: Results from analysis of IA with AMS II seem to be in accordance with those from Artlab® echotracking (BM and FBM mode). Quality of image recording is an essential factor of concordance between the two methods and this implies further investigations in patients with cardiovascular diseases.

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P1.34

VALIDATION OF THE WORKING PRINCIPLE OF THE ARTERIOGRAPH, A NEW DEVICE TO MEASURE PULSE WAVE VELOCITY

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The Arteriograph, a device basically consisting of a brachial cuff, has recently been launched as a new tool to measure pulse wave velocity (PWV). Brachial blood pressure is measured during supra-systolic pressure inflation of the cuff, yielding pressure waveforms with pronounced first and secondary peaks. The second peak is ascribed to a reflection from the aortic bifurcation, and PWV is calculated as the ratio of 2 times the jugulum-symphysis distance (~ aortic root – bifurcation) and the time difference between the two peaks ($DT_{s1\text{-}s2}$). To test this working principle, we used a numerical model of the arterial tree to simulate pressure and flow in the normal configuration, and in a configuration with an occluded brachial artery (~supra-systolic over-inflation). A pronounced second peak in the pressure signal was found at the location of the cuff for the occluded configuration. Wave intensity analysis showed that this peak was caused by a forward compression wave, confirming the Arteriograph hypothesis. Simulations with 6 different stiffness values showed a linear correlation between $1/DT_{s1\text{-}s2}$ and PWV ($R^2=0.97$). It was, however, hard to locate the reflection site which, in combination with the transit time, reproduced the correct PWV. The distance to the aortic bifurcation was 45 cm, whereas the effective length of the simulated arterial tree was 27 ± 3 cm. The distance needed to reproduce PWV from $DT_{s1\text{-}s2}$ was 70 ± 6 cm. In conclusion, although the numerical model supports the basic working principle of the Arteriograph, measurement of actual PWV using the device might be more challenging.

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P1.35

A NEW NON-INVASIVE ANALYSIS FOR THE DETERMINATION OF LOCAL PULSE WAVE VELOCITY AND WAVE INTENSITY: APPLICATION TO THE CAROTID ARTERY

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Background: Local Pulse Wave Velocity (LPWV) and Wave Intensity (WI) are used to assess arterial stiffness and the arrival time of reflected waves; indices of clinical importance. We present a new non-invasive analysis which directly uses flow velocity (U) and arterial diameter (D) measurements for the determination of LPWV and WI.
Methods: From the water hammer equation it can be shown that $\mathrm{LPWV}=\frac{D}{2}\frac{dU_\pm}{dD_\pm}$where dU and dD are the changes in U and D, and ± indicates the forward and backward directions. The separation of WI can also be determined using $WI_\pm = \pm\frac{1}{4(D/2c)}(dD \pm \frac{D}{2c}\mathrm{dU})^2$, where c is LPWV. We studied 28 patients (58±15 years, 21 male) with good systolic function (EF>55%) and no valve disease. We measured U and D in the left carotid artery using Doppler ultrasound and a wall tracking system (Aloka, SSD-5500). ECG was also recorded and data were sampled at 1kHz.
Results: LPWV in patients > 50 years ($n=11$) were higher by 20% ($p < 0.05$) than in patients < 50 years. Reflected waves in patients > 50 years arrived earlier by 35% ($p < 0.05$) than in patients <50 years. Neither the size of reflected waves nor the forward compression and expansion wave differed significantly between the two age groups.
Conclusions: Results of the new technique are in agreement with other approaches for determining LPWV and WI. The new technique offers the possibility of studying arterial sites that are not accessible by applanation tonometery, and does not assume a linear relationship between arterial diameter and arterial pressure.

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P1.36

A PRELIMINARY STUDY FOR THE EVALUATION OF LARGE ARTERY STIFFNESS: A NON CONTACT APPROACH

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The evaluation of carotid-to-femoral pulse transit time (PTT) is required to estimate the carotid-femoral pulse wave velocity, a parameter considered as the gold standard for the quantification of large artery stiffness. In this study we propose a novel, non contact laser-based technique (laser class II ~ laser pen), named optical Vibrocardiography (VCG), for evaluating PTT from synchronous recorded vibrations of the skin at the carotid and femoral artery site. It has been demonstrated that these skin vibrations are directly related to the radial displacement of the underlying arteries, and are hence related to the passage of the pressure pulse. In this feasibility study, measurements were performed on 14 young male healthy subjects (25.3 ± 0.8) using 2 commercially available vibrometers (Polytec Gmbh, Waldbronn , Germany). The obtained PTT values (74.86 ± 8.63 ms) were compared with PTT evaluated on the same subjects by means of applanation tonometry applied simultaneously on the same locations (75.85 ± 8.61 ms). The two techniques were very well correlated ($r=0.89$, $P<0.001$, Spearman rho 0.88) and values were not statistically different ($p=0.377$). Our preliminary results demonstrate that laser-based non-contact measurement of pulse transit time is feasible in young healthy volunteers, and yields values that are equivalent to those measured using arterial applanation tonometry. Clinical application of this appealing non-invasive method can overcome practical and technical limitations inherent to currently used methods such as arterial applanation tonometry, ultrasound, plethysmography, requiring physical contact of the probe with the patient.

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P1.37

NON-INVASIVE QUANTITATIVE ASSESSMENT OF ATHEROSCLEROSIS WITH THE PULSE WAVE VELOCITY

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Arterial stiffness is a predictor of atherosclerosis. This study was conducted to develop a method of coronary atherosclerosis severity assessment by means of brachial-ankle pulse wave velocity (baPWV). MATERIALS AND METHODS. We measured baPWV in 126 males (age 56,2±8,9) who received coronary angiographic examination (CAG). baPWV was measured by Vasera VS-1000 (Fukuda Denshi). RESULTS The patients were categorized into 3 groups according to the number of major coronary arteries having stenosis, that is, 1 vessel disease (1VD) group, 2VD group and 3VD group. The baPWV value was significantly greater in 2VD (n = 46, baPWV= 13,82±2,40 m/sec, $p=0{,}049$) and 3VD groups (n = 44, baPWV =14,38±2,97 m/sec, $p=0{,}0028$) than that in 1VD group (n = 36, baPWV= 12,49±2,17 m/sec). No significant difference was observed between PWV value in 2VD and 3VD groups. To further investigate the relationship between baPWV values and CAG findings, we assessed the severity of stenosis (1 group - less than 75% stenosis, 2gr. - 75 to 99% stenosis, and 3gr. - complete occlusion, respectively). The baPWV value was significantly greater in 2 (n = 56, baPWV= 13,84±2,25 m/sec, $p=0{,}025$) and 3 groups (n = 45, baPWV= 14,16±3,32 m/sec, $p=0{,}007$) than that in 1 group (n = 25, baPWV= 12,23±1,42m/sec). No significant difference was observed between baPWV value in 2 and 3 groups. CONCLUSION. baPWV significantly increases with the number of affected vessels and severity of stenosis which indicates that it is a powerful diagnostic instrument for determining coronary artery atherosclerosis in males.

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P1.38

CONVERSION BETWEEN DEFINITIONS OF PULSE WAVE VELOCITY

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Background: Different methodologies for determination of carotid-femoral pulse wave velocity (PWV) exist. Distance (L) can be measured from carotid-femoral measurement sites (L_{direct}) or obtained by subtracting carotid-sternum from sternum-femoral distances ($L_{subtracted}$). Transit times are usually obtained either by detection of the maximal upstroke ($\Delta t_{maximal\ upstroke}$) or the foot ($\Delta t_{intersecting\ tangent}$) of the waveform at the measurement sites. This study investigates conversion factors between PWV methodologies.

Methods: 3043 subjects in which both distance measurements were available were divided into model and validation groups (1502/1541 subjects, respectively). In the model population the main determinants of the $ratio_{distance} = L_{subtracted}/L_{direct}$ were determined and a multivariate model was constructed. Estimated $ratio_{distance,est}$ was used to convert from PWV_{direct} to $PWV_{subtracted,est}$ in the validation population. $PWV_{subtracted,est}$ was compared to measured $PWV_{subtracted}$. Ninety three subjects in which both transit times were available were divided into model and validation groups (46/47 subjects, respectively). In the model population a model for estimation of $\Delta t_{maximal\ upstroke,est}$ from $\Delta t_{intersecting\ tangent}$ was constructed and used to estimate $\Delta t_{maximal\ upstroke,est}$ in the validation population. $\Delta t_{maximal\ upstroke,est}$ was compared to measured $\Delta t_{maximal\ upstroke}$. Data are presented as mean(stdev).

Results: The main determinants of $ratio_{distance}$ were age ($R^2=0.17$) and BMI ($R^2=0.15$) (combined: $R^2=0.27$, all $P<0.001$). $PWV_{subtracted,est}$ correlated well with $PWV_{subtracted}$ ($R=0.97$, $P<0.001$) with mean difference of 0.0007 (0.40) m/s. $\Delta t_{maximal\ upstroke,est}$ correlated well with $\Delta t_{maximal\ upstroke,est}$ ($R=0.82$, $P<0.001$) and mean difference of 0.58 (1.03) m/s.

Conclusions: Differences in absolute PWV values are important to compensate for in order to compare between studies. The models proposed allow for such conversion.

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P1.39

AORTIC PULSE WAVE VELOCITY: SHOULD THE CAROTID – FEMORAL DISTANCE BE MEASURED ON BODY SURFACE OR ESTIMATED FROM BODY HEIGHT?

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Objective: Aortic pulse wave velocity (PWV) can be biased by the measurement of carotid – femoral (c-f) distance on body surface. We wondered whether the estimation of distance according to body height could be used.

Methods: Three cohorts of altogether 598 subjects (mean age 58,9 years) were studied. PWV was measured by Sphygmocor device. The c-f distance was 1. measured by tape, 2. estimated: height was multiplied by 0,27 (= median ratio of measured c-f distance to body height).

Results: Difference in PWV calculated by the two methods (measured minus estimated) increased with PWV: it was -0.2 m/s for PWV 5 m/s and +1.8 m/s for PWV 15 m/s. In multiple regression analysis, this difference depended highly significantly ($p<0.0001$) on PWV, weight (positive associations) and height (negative association); there were weak positive associations ($p<0.05$) with male gender, high LDL level and presence of cardiovascular disease and no associations with age, smoking, hypertension or diabetes.

Conclusions: When PWV is estimated from body height, the highest PWV values show regression to the mean. Besides PWV, anthropometric parameters are major determinants of the differences between the two methods. Estimation of c-f distance from body height would simplify the procedure and bias due to obesity and body disproportion would probably be minimized. For future use of aortic PWV, the best method of the distance assessment should be studied in larger cohorts with known cardiovascular morbidity/mortality endpoints.

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P1.40

DETERMINATION OF PRESSURE INDEPENDENT ARTERIAL STIFFNESS BY CORRECTING PULSE WAVE VELOCITY FOR PRESSURE-AREA RELATIONSHIP

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Background: Intrinsic (pressure independent) arterial stiffness is becoming increasingly important as treatment target in hypertensive patients but is still difficult to assess non-invasively. We measured pulse wave velocity (PWV) and the pressure-area (p-A) relation to determine both apparent and intrinsic stiffness.

Method: Non-invasive PWV (nPWV) was measured by multiple-M-mode ultrasound in a phantom. The incisura of the diameter waveforms was used as time-reference point for calculating nPWV. A catheter was placed in the phantom to measure the pressure waveform simultaneously. Additionally, in hypertensive patients carrying a baroreceptor stimulator, finger-pressure and nPWV at the common carotid artery were measured simultanously. For both phantom and subject studies, intrinsic PWV (PWV_{int}) was derived employing the Bramwell-Hill equation with the incremental distensibility, dA/(A*dp), based on either a linear or exponential p-A relation.

Results: In the phantom setup, nPWV (12.3±0.8 m/s) increased with increasing pressure ($r=0.67$, $p<0.0001$). Because a linear p-A relation was observed, intrinsic PWV was calculated as $PWV_{int}^2 = A_{int}/A{*}nPWV^2$ and will be independent of pressure ($r=-0.001$). During baroreceptor stimulation MAP decreased from 138±22 to 109±1 mmHg and nPWV decreased from 10.5±1.5 to 6.6±1.3 m/s ($p=0.03$). In these patients the observed p-A relation was exponential and PWV_{int} was therefore calculated using $PWV_{int}^2 = p_{int}/p{*}nPWV^2$. PWV_{int} did not decrease upon stimulation ($p=0.23$).

Conclusion: Commonly apparent PWV is measured. Intrinsic stiffness can be calculated using nPWV and assuming a linear or exponential p-A relation. An