Arteriograph

Validációs vizsgálatok és Cohort Study

Journal of Hypertension

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A new oscillometric method for assessment of arterial stiffness: comparison with tonometric and piezo-electronic methods

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Introduction Pulse wave velocity (PWV) and augmentation index (AIx) are parameters of arterial stiffness and wave reflection. PWV and AIx are strong indicators for cardiovascular risk and are used increasingly in clinical practice. Previous systems for assessment of PWV and AIx are investigator dependent and time consuming. The aim of this study was to validate the new oscillometric method (Arteriograph) for determining PWV and AIx by comparing it to two clinically validated, broadly accepted tonometric and piezo-electronic systems (SphygmoCor and Complior).

Design and method PWV and AIx were measured up to five times in 51 patients with the SphygmoCor, Complior and Arteriograph. In 35 patients, the measurements were repeated after 1 week in a second session using the same protocol.

Results The correlations of the PWV as assessed with the Arteriograph with the values obtained using the SphygmoCor ($r = 0.67$, $P < 0.001$) and the Complior ($r = 0.69$, $P < 0.001$) were highly significant. Variability and reproducibility for PWV were best for the Arteriograph, followed by Complior and SphygmoCor. AIx (SphygmoCor versus Arteriograph) were very closely correlated ($r = 0.92$, $P < 0.001$).

Perspectives The Arteriograph is a new, easy-to-use and time-effective method for assessing arterial stiffness and wave reflection. *J Hypertens* 26:523–528 © 2008 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Keywords: arterial stiffness, Arteriograph, augmentation index, Complior, oscillometry, pulse wave velocity, SphygmoCor, tonometry, validation

Abbreviations: PWV, Pulse Wave Velocity; AIx, Augmentation Index; NYHA, New York Heart Association; PP, Pulse Pressure; BHS, British Hypertension Society; AAMI, Association for the Advancement of Medical Instrumentation

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Invasive validation of a new oscillometric device (Arteriograph) for measuring augmentation index, central blood pressure and aortic pulse wave velocity

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Background The importance of measuring aortic pulse wave velocity (PWVao), aortic augmentation index (Aix) and central systolic blood pressure (SBPao) has been shown under different clinical conditions; however, information on these parameters is hard to obtain. The aim of this study was to evaluate the accuracy of a new, easily applicable oscillometric device (Arteriograph), determining these parameters simultaneously, against invasive measurements.

Methods Aortic Aix, SBPao and PWVao were measured invasively during cardiac catheterization in 16, 55 and 22 cases, respectively, and compared with the values measured by the Arteriograph.

Results We found strong correlation between the invasively measured aortic Aix and the oscillometrically measured brachial Aix on either beat-to-beat or mean value per patient basis ($r = 0.9$, $P < 0.001$; $r = 0.94$, $P < 0.001$), which allowed the noninvasive calculation of the aortic Aix without using generalized transfer function. Similarly strong correlation ($r = 0.95$, $P < 0.001$) was found between the invasively measured and the noninvasively calculated central SBPao; furthermore, the BHS assessment of the paired differences fulfilled the 'B' grading. The PWVao values measured invasively and by Arteriograph were 9.41 ± 1.8 m/s and 9.46 ± 1.8 m/s, respectively (mean ± SD); furthermore, the Pearson's correlation was 0.91 ($P < 0.001$). The limits of agreement were 11.4% for aortic Aix and 1.59 m/s for PWVao.

Conclusion Aix, SBPao and PWVao, measured oscillometrically, showed strong correlation with the invasively obtained values. The observed limits of agreement are encouragingly low for accepting the method for clinical use. Our results suggest that the PWVao values, measured by Arteriograph, are close to the true aortic PWV, determined invasively. *J Hypertens* 28:000–000 © 2010 Wolters Kluwer Health | Lippincott Williams & Wilkins.

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Keywords: arterial stiffness, Arteriograph, augmentation index, invasive measurement, oscillometric method, pulse wave velocity, validation

Abbreviations: Aix-ao, aortic augmentation index; Aix-br, brachial augmentation index; BP, blood pressure; CAS, coronary artery stenosis; c-f PWV, carotid–femoral pulse wave velocity; GTF, generalized transfer function; Jug-Sy, Jugulum-Symphisis; PWVao, aortic pulse wave velocity; RT, return time; SBPao, central systolic blood pressure

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Obtaining arterial stiffness indices from simple arm cuff measurements: the holy grail?

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determinants of PWV and AIx making use of any of these three devices. However, at least in the population of the study by Jatoi *et al.* [14], the limits of agreement when comparing the data provided by the three devices were quite wide. This indicates that these techniques for arterial stiffness assessment are not interchangeable. In Table 1, the main advantages and limitations of each of these three techniques are summarized. The results also indicate that the 'gold standard' in this field still needs to be identified, an issue that deserves to be addressed in a specific study.

Moreover, for a meaningful risk stratification, we need to have undisputable reference values for a patient to be classified as having elevated arterial stiffness. We also need to know which therapeutic interventions might be beneficial in patients with elevated arterial stiffness. Needless to say, the availability of a simple, affordable, and easy to apply technique will be of great help in this regard.

It has to be emphasized that this study raises a number of questions. First, it is still unknown what the minimal level of agreement between techniques, for them to be used interchangeably, might be. Second, it needs to be clarified whether we need data illustrating prediction of morbidity and mortality for each new technique, even when they are assessing a parameter, which has previously been shown to have an independent prognostic value. Finally, and most importantly, the biggest question is 'How and when should we use any measure of arterial stiffness in clinical decision-making?'. This question has yet to be addressed properly.

To our knowledge, the demonstration of a better risk stratification, leading to better care of patients by using arterial stiffness indices, has only been shown in a small group of patients with end-stage renal disease [17]. Similar studies are needed in more general populations.

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Table 1 Summary of main advantages and limitations of three different techniques for arterial stiffness evaluation

Device	Advantages	Limitations
Complior	• The delay in pulse transit time between two arteries sites is taken simultaneously using a 'foot to foot' waveform method • Numerous data on the prognostic value of cf-PWV so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Unable to allow PWA • Underestimation of elevated PWV by built-in algorithm
SphygmoCor	• PWA is available allowing assessment of augmentation index and central BP through a transfer function application • Numerous data on the prognostic value of the parameters so obtained are available	• Operator's skill dependency • Carotid tonometry is difficult • Necessity to undress and expose the groin • Possibility of technical errors in obese patients • Uncertainty and approximation in measurement of distance between the two arterial sites • Theoretical risk of carotid plaque rupture by probe (never reported) • Patients with atrial fibrillation cannot be evaluated • Debate regarding the validity of the generic transfer function used • Need of a precise BP calibration for PWA, currently not available • The PWV transit time delay is calculated using reference ECG signals obtained at different times, respectively, for carotid and femoral pulse waveforms sequentially recorded
Arteriograph	• The technique only needs access to the patient's upper arm (no need to undress) • It is based on an easy methodology (largely operator-independent method) • It is a time-saving method. This fast assessment of arterial stiffness parameters is particularly suitable to population studies • Higher reproducibility of parameters, as compared with the other two methods • Potentially adaptable to ambulatory arterial stiffness assessment	• Scarce data on its validation and on the prognostic value of parameters so obtained are available • Patients with atrial fibrillation or marked bradycardia cannot be evaluated

EDITORIAL COMMENT
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Arteriograph Cohort Study

Monday, June 17 09:00 - 11:00
ESH - LARGE ARTERIES - Parallel Oral Session

AORTIC STIFFNESS MEASURED BY A NOVEL OSCILLOMETRIC METHOD INDEPENDENTLY PREDICTS CARDIOVASCULAR MORBIDITY AND MORTALITY: A STUDY OF 4146 SUBJECTS

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Objective: Carotid-femoral pulse wave velocity (cfPWV) assessed by applanation tonometry evaluates aortic stiffness and predicts cardiovascular morbidity and mortality independently of classical CV risk factors. We studied the prognostic information provided by a novel and simpler oscillometric method, measuring aortic pulse wave velocity (PWVao) from a sole arm cuff.

Design and method: We studied 4,146 subjects (51% women) aged 35-75 years, who attended voluntary health screening in Hungary. Oscillometric PWVao (Arteriograph, TensioMed Ltd, Budapest, Hungary) measurement was performed in addition to a medical history, physical examination, and laboratory tests. All events (all cause mortality, non-fatal myocardial infarction, and non-fatal stroke according to ICD codes) were provided by the Hungarian National Health Insurance Fund, which performed an independent statistical analysis. Cox regression analyses were used to identify predictive factors for a composite endpoint, combining above events.

Results: Mean age was 53 years, brachial blood pressure 136/82 mm Hg, and total cholesterol 5.2 mM. There were 16% smokers, 48% patients on cardiovascular medications and 8% on antidiabetic drugs; 10% had a previous cardiovascular hospitalization. There were 241 events (100 deaths, 56 non-fatal myocardial infarctions, and 86 non-fatal strokes) during a mean follow-up of 5.5 years. In univariate analysis, a 1.0 m/s increase in PWVao was associated with HR 1.49 [1.34–1.65], $P<0.001$, for the composite endpoint. PWVao independently predicted the composite outcome in the final model of multivariate analysis (HR = 1.14 [1.01-1.30]) adjusted for pulse pressure, ejection duration, male gender, age, concomitant cardiovascular disease and treatment with thrombocyte inhibitors (all $P<0.05$); body mass index, smoking, heart rate, blood pressure, augmentation index, diabetes, and cardiovascular drug therapy were all accounted for.

Conclusions: Aortic pulse wave velocity assessed by a simple oscillometric method using an arm cuff only independently predicted all cause mortality and major CV events in a large cohort of subjects attending health screening. Using a simpler oscillometric cuff method for assessing aortic stiffness may facilitate risk assessment in routine clinical practice.