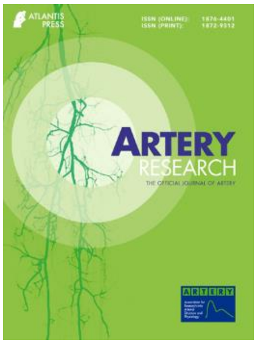

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15.5: ASSOCIATION OF A NEW SURROGATE OF TOTAL ARTERIAL COMPLIANCE WITH LEFT VENTRICULAR MASS: THE SAFAR STUDY

Theodore Papaioannou, Athanase Protogerou, Antonis Argyris, Evangelia Aissopou, Eftymia Nasothymiou, Christos Tountas, Petros Sfikakis, Nikolaos Stergiopulos, Dimitrios Tousoulis

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Additional studies are needed to confirm the statistical differences observed using this method and to predict the severity of carotid atherosclerosis.

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15.2
ESTIMATES OF ARTERIAL STIFFNESS AND CENTRAL BLOOD PRESSURE IN PATIENTS WITH TYPE 2 DIABETES: A COMPARISON OF SPHYGMOCOR AND ARTERIOGRAPH

Christoffer Krogager [1], Niklas B. Rossen [1], Klavs W. Hansen [2], Søren T. Knudsen [1], Christian D. Peters [1], Hans Erik Bøtker [1], Per L. Poulsen [1], Esben Laugesen [1]
[1]*Aarhus University Hospital, Aarhus, Denmark*
[2]*Regional Hospital Silkeborg, Denmark*

Background: The Arteriograph is a cuff-based oscillometric device for non-invasive assessment of central systolic blood pressure (cSBP), aortic augmentation index (Aix) and aortic pulse wave velocity (PWV). The reproducibility of Arteriograph measurements and the agreement with SphygmoCor measurements in diabetic patients has never been assessed.
Methods: We compared Arteriograph reproducibility and agreement with SphygmoCor with data from two study populations: Study 1 (n=17/mean age 64 years/diabetes duration 9 years) was conducted in a research laboratory and Study 2 (n=19/mean age 67 years/diabetes duration 9 years) in a catheter lab. SphygmoCor PWV data was only available in study 1.
Results: Reproducibility: Mean differences (Standard deviation of the difference (SDD)) between duplicate cSBP, Aix and PWV Arteriograph measurements were -0.6 $\pm$ 6.6 mmHg (cSBP), -1.1$\pm$3.3% (Aix) and 0.1$\pm$0.5 m/s (PWV) in study 1 and -0.01$\pm$4.3 mmHg (cSBP), 1.5$\pm$3.2% (Aix) and -0.2$\pm$0.6 m/s (PWV) in study 2, all differences non-significant.
Agreement: Mean differences between SphygmoCor and Arteriograph were -14$\pm$10 mmHg (cSBP), -8$\pm$7% (Aix) and 2.4$\pm$1.8 m/s (PWV), (p<0.001 for all) in Study 1 and -5$\pm$10 mmHg, p=0.04 (cSBP) and -10$\pm$8%, p=<0.001 (Aix) in Study 2. In study 1, a significant correlation was observed between the mean and the (SphygmoCor − Arteriograph) difference for cSBP, r=-0.75, p<0.001 and for Aix, r=-0.67, p<0.001.
Conclusion: In patients with type 2 diabetes, Arteriograph data were reproducible yet the device systematically overestimated cSBP, Aix and PWV compared with the SphygmoCor. Hence, the two devices cannot be used interchangeably in patients with type 2 diabetes.

15.3
ARTERIAL STIFFNESS RECORDINGS WITH POPMÈTRE® IN A GENERAL PRIMARY CARE POPULATION: THE IPC COHORT

Hasan Obeid [2], Frederique Thomas [1], Pierre Boutouyrie [2], Magid Hallab [3], Philippe Coucke [1], Nicolas Danchin [1], Bruno Pannier [1]
[1]*IPC Center, Paris, France*
[2]*Pharmacological Department, G.Pompidou Hospital, Paris, France*
[3]*Axelife SA, Nantes, France*

Objectives: Aortic stiffness, best approached by pulse wave velocity (PWV), is a determinant of health. Among the devices measuring PWV, gold standard are pulse transit time recordings. pOpmetre® (P®) measures pulse at finger and toe levels using oximetry clips and adequate algorithm in less than 5 minutes. It showed good agreement against reference techniques, but P® feasibility and relevance were never tested in a large general population.
Population and methods: From September 2015, 527 Normotensives (43.8$\pm$13.6 years) had a standard health check-up at the IPC Center (Paris, France) including finger to toe pulse wave velocity recording with pOpmetre®, performed by nurses after 10 minutes supine rest permitting ECG and blood pressure measurements (three values averaged). Data were compared to aortic PWV reference values (Eur Heart J, 2010 31, 2338-2350).
Results: Pre-specified factors for measurement failure were variation coefficient within one record> 30%, and PWV extreme outliers: 13 were excluded. BP and PWV were respectively: 121$\pm$10/73$\pm$7 mmHg 7.64$\pm$2.7 m/sec. 231 had optimal BP, 202 normal and 81 high normal BP. PWV increased with age classes from <30 to >70 years. The P® values fell exactly within the aortic reference ranges for age classes: 6.2$\pm$1.2, 7.1$\pm$2.1, 7.4$\pm$2.2, 8.2$\pm$2.8, 10.2$\pm$3.6, 9.6$\pm$2.6 m/sec.
Conclusion: The simple and quick measurement with pOpmetre® device can be performed by nurses during a tight time schedule. It provides values within aortic Reference value ranges in normal population. It is a promising substitute to reference techniques for assessing PWV during standard health check-up.

15.4
MEASURING ARTERIAL STIFFNESS WITH POPMÈTRE® IN CARDIAC REHABILITATION PROGRAM

Hasan Obeid [1], Bruno Pavy [2], Magid Hallab [3], Julie Darchis [2], Erick Merle [2]
[1]*Paris Descartes University, Paris, France*
[2]*Readaptation Cadiovasculaire, Centre Hospitalier Loire Vendee Ocean, Machecoul, France*
[3]*University Hospital of Nantes, Gerontology Department, Nantes, France*

Background and Objectives: Pulse Wave Velocity (PWV) is a good surrogate of the arterial aging. This is an independent biomarker of cardiovascular events (ESH-ESC Guidelines 2013). PWV seems to be reduced with regular exercise. The effect of cardiac rehabilitation (CR) is less known on this biomarker. The aim of this study was to evaluate the impact of a CR program on arterial stiffness measured by pulse wave velocity (PWV).
Patients and Methods: Data from 100 consecutive patients recruited in a French CR centre were analyzed after exclusion for High variability cv > 30 % and aberrant values PWV>30 m/s. The finger-toe PWV was measured with a new validated device (pOpmètre®-AxelifeSAS-France) at the beginning and the end of CR (mean duration =18.3$\pm$4 days). They were measured at the same time and under the same recommended conditions.
Results: Patients (Mean age 64$\pm$11 years, 84% males), were coronary artery disease (51%), valvular (38%), heart failure (3%) and other (8%). The classical cardio vascular risk factors were the following: 1- current smoking (n=3), 2- Diabetes (n=26), 3- high blood pressure (n=58), 4- high blood cholesterol (n=48), There were also obesity (n=15) coronary heredity (n=19) sedentary lifestyle (n=20). They took part in 155 physical training sessions (mean duration 120 min/day) The maximal workload (MWL) increased from 94.9$\pm$35 to 116$\pm$37 Watts and the 6min walking test (6MWT) from 430$\pm$113 to 505$\pm$106 m (p<0.0001). PWV decreased from 9.16$\pm$3.0 to 8.39$\pm$2.5 m/s (p<0.008). We found a positive correlation with age (r=0.38 p<0.0003) and inverse correlation with maximal workload (r=-0.34 p<0.001) and 6MWT (r=-0.22 p<0.003).
Conclusion: Maximal physical capacity and 6MWT correlated with PWV measured with pOpmètre, and a current CR program seems to improve the arterial stiffness in a cardiac population.

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15.5
ASSOCIATION OF A NEW SURROGATE OF TOTAL ARTERIAL COMPLIANCE WITH LEFT VENTRICULAR MASS: THE SAFAR STUDY

Theodore Papaioannou [4], Athanase Protogerou [2], Antonis Argyris [3], Evangelia Aissopou [3], Eftymia Nasothymiou [3], Christos Tountas [3], Petros Sfikakis [3], Nikolaos Stergiopulos [4], Dimitrios Tousoulis [1]
[1]*Biomedical Engineering Unit, 1st Department of Cardiology, "Hippokration" Hospital, Medical School, National and Kapodistrian University of Athens, Athens, Greece*
[2]*Cardiovascular Prevention & Research Unit, Department of Pathophysiology; Medical School, National and Kapodistrian University of Athens, Greece*
[3]*Hypertension Center and Cardiovascular Research Laboratory, 1st Department of Propaedeutic Medicine, "Laiko" Hospital, Medical School, National and Kapodistrian University of Athens, Greece*
[4]*Laboratory of Hemodynamics and Cardiovascular Technology, Institute of Bioengineering, École Polytechnique Fédérale de Lausanne, Switzerland*

We investigated the association of total arterial compliance (C_T) with left ventricular mass (LVM) and hypertrophy (LVH). The study hypothesis was that C_T may be better related with LVM compared to the gold-standard regional aortic stiffness.

Methods: Two hundred twenty six subjects with established hypertension (untreated or treated with antihypertensive drugs) or with suspected hypertension underwent blood pressure (BP) assessment, carotid-to-femoral pulse wave velocity (cf-PWV) and echocardiographic measurement of LVM. LVM index (LVMI) was calculated by the ratio of LVM to body surface area. C_T was estimated by a previously proposed and validated formula: $C_T = 36.7 / PWV^2$ [ml/mmHg], which is based on Bramwell-Hill equation.

Results: LVMI was significantly associated with age (r=0.207, p=0.002), systolic BP (r=0.248, p<0.001), diastolic BP (r=0.139, p=0.04), mean BP (r=0.212, p=0.002), pulse pressure (r=0.212, p=0.002), heart rate (r=-0.172, p=0.011), cf-PWV (r=0.268, p<0.001) and C_T (r=-0.317, p<0.001). The highest correlation was observed for C_T which was significantly stronger than the respective correlation of cf-PWV (p<0.001). Multivariate analysis showed that C_T was a stronger determinant, compared to cf-PWV, of LVMI and LVH.

Conclusion: Total (systemic) arterial compliance is better associated with left ventricular mass and hypertrophy than the cf-PWV. It remains to be further explored whether C_T has also a superior prognostic value beyond and above local or regional (segmental) estimates of pulse wave velocity.

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15.6

INFLUENCE OF THE PRESSURE MEASURING SITE FOR VELOCITY/PRESSURE LOOPS

Jona Joachim, Fabrice Vallée, Arthur Le Gall, Stéphanie Lenck, Alexandre Mebazaa, Étienne Gayat

St. Louis-Lariboisière-Fernand Widal University Hospitals, Department of Anaesthesiology & Intensive Care, Paris, France

Background: Velocity/pressure (Vel/P) loops are obtained by combining aortic blood velocity (measured by esophageal Doppler-ED-, CombiQ™, Deltex Medical, Chichester, UK) and arterial pressure signals. They represent a tool to estimate afterload of the heart and arterial stiffness with at least two remarkable angles: β and γ. Pressure is usually measured in the radial artery (PRad) rather than in the descending thoracic aorta (PAoDesc) where ED measures blood flow. Our aims were to assess the influence of the site of pressure recording on the values of β and γ and to develop a mathematical transfer function (TF) to estimate PAoDesc from PRad and then reconstruct Vel/PTFAoDesc loops.

Methods: After institutional review board approval (CE SRLF n#17611-356), 15 patients scheduled for elective endovascular neuroradiology were included. Pressures were recorded simultaneously in the radial artery and in the aorta. Vel/PRad and Vel/PAoDesc loops were constructed and compared. A transfer function was estimated using an autoregressive-exogenous (ARX)[1] model to obtain a simulated descending thoracic aorta pressure waveform (PTFAoDesc). The estimation was quantified by the normalized root mean squared error (NRMSE).Vel/PTFAoDesc loops were constructed and compared to Vel/PAoDesc loops.

Results: 153 loops were analysed. β and γ angles were systematically lower in the Vel/PRad compared to the Vel/PAoDesc loops (36 ° [34 ° − 40 °] vs. 43 ° [38 ° − 48 °] for β, 11 ° [3 ° -15 °] vs 25 ° [13 ° -30 °] for γ, p < 0.0001). The ARX model simulated PTFAoDesc with a NRMSE of 93% [77 − 96]. β and γ obtained with Vel/PAoDesc and Vel/PTFAoDesc were similar and strongly correlated $\rho = 0.96$, p < 0.0001) (Fig 1&2)

Conclusions: The location where the arterial pressure is monitored has a huge influence on the Vel/P loop parameters. Using a transfer function improves the estimation of the pressure waveform at the site of the Doppler signal.

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15.7

STUDY OF WAVE DYNAMICS OF AN EXTRA-AORTIC COUNTERPULSATION DEVICE IN A ONE-DIMENSIONAL COMPUTER MODEL OF THE ARTERIAL SYSTEM

Daime Campos Arias [1], Francisco Londono [1], Tania Rodriguez Moliner [2], Dimitrios Georgakopoulos [3], Nikos Stergiopulos [4], Patrick Segers [1]

[1]*Ghent University, Ghent, Belgium*

[2]*Instituto Superior Politecnico Jose Antonio Echeverria (Cujae), Havana, Cuba*

[3]*Sunshine Heart Inc, Eden Prairie, MN, USA*

[4]*Ecole Polytechnique Federale de Lausanne, Switzerland*

Background: The C-Pulse heart assist system (Sunshine Heart, Inc., Eden Prairie, Minnesota) is a novel extra-aortic counterpulsation device to unload the heart in heart failure patients. Its impact on overall hemodynamics, however, is not fully understood.

Methods: The function of the C-Pulse device was implemented in a previously published and validated one-dimensional model of the arterial tree (1).Central and peripheral pressure and flow waveforms with the C-Pulse disabled and activated were simulated for different settings. The results were studied using wave intensity analysis and compared with in-vivo data measured non-invasively in three heart failure patients and with invasive data measured in a pig.

Results: In all cases the activation of the C-Pulse showed a diastolic augmentation in the pressure and flow waveforms. The device activation initiates a forward compression wave, whereas a forward expansion wave is associated to the device relaxation, with waves exerting an action in the coronary and the carotid vascular beds. In settings with reduced arterial compliance, the same level of aortic compression demands higher values of external pressure, leading to stronger hemodynamic effects and enhanced perfusion. Computer simulations were in good qualitative agreement with in-vivo observations, but in-vivo effects of the device were stronger. We speculate that besides a direct hemodynamic effect, the C-Pulse action might also induce other adaptive (neuromodulated) mechanisms, not captured by the model.

Conclusions: The one-dimensional model may be used as an efficient tool for predicting the hemodynamic impact of the C-Pulse system in the entire arterial tree, complementing in-vivo observations.

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15.8

AN EXTENDED ONE-DIMENSIONAL ARTERIAL NETWORK MODEL FOR THE SIMULATION OF PRESSURE AND FLOW IN UPPER AND LOWER LIMB EXTREMITIES

Hasan Obeid [1], Patrick Segers [1], Nikos Stergiopulos [3], Pierre Boutouyrie [2], Stephane Laurent [2], Magid Hallab [4], Elie Mousseaux [2]

[1]*Ghent University, Ghent, Belgium*

[2]*Paris Descartes University, Paris, France*

[3]*Laboratory of Hemodynamics and Cardiovascular Technology, Swiss Federal Institute of Technology, Lausanne, Switzerland*

[4]*University Hospital Nantes, France*

Background: Arterial pulse wave velocity and pulse waveform analysis have become an established component of cardiovascular research. As validation and assessment of devices is not always trivial in an in vivo setting, arterial network computer models may be useful for that purpose. It is, however, mandatory that the model includes sufficient detail, especially when analysing peripheral waveforms.

Objectives: To extend the existing 1D arterial network model (103 segments) of Reymond et al. to a more detailed model (143 segments) including the foot and hand circulation (radial and tibial arteries). The arterial tree dimensions and properties were taken from the literature and completed with data from patient scans. The model solves the one-dimensional form of the Navier-Stokes equations over each arterial segment. A non-linear viscoelastic constitutive law for the arterial wall was considered.

Results: Comparison of simulations with and without detailed hand and foot circulation demonstrate important differences in waveform morphology in the distal beds. The completed model predicts pressure and flow waves in the hand and foot arteries which are in good qualitative agreement with the published in-vivo measurements. The agreement is especially good for