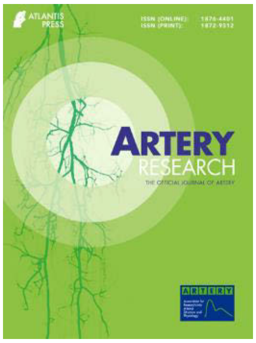

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P52: ESTIMATING CENTRAL BLOOD PRESSURE FROM MRI DATA USING REDUCED-ORDER COMPUTATIONAL MODELS

Jorge Mariscal Harana, Peter H. Charlton, Samuel Vennin, Arna van Engelen, Torben Schneider, Mateusz Florkow, Hubrecht de Bliek, Bram Ruijsink, Israel Valverde, Marietta Charakida, Kuberan Pushparajah, Spencer Sherwin, Rene Botnar, Jordi Alastruey

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Table 1. MRI and US measurements of D, U and PWV. Data are means ± standard deviations (n=8).

	Min D (cm)	Max D (cm)	Min U (m/s)	Max U (m/s)	PWV (m/s)
MRI	2.5±0.4	3.0±0.3	0.1±0.0	0.9±0.2	3.5±0.8
US	2.4±0.2	2.8±0.2	0.3±0.1	1.1±0.2	3.6±1.0

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P51

NON-CONTACT MEASUREMENT OF LOCAL CAROTID AND CAROTID-FEMORAL PULSE WAVE VELOCITY BY LASER DOPPLER VIBROMETRY: VALIDATION OF A NEW DEVICE AGAINST REFERENCE TECHNIQUES IN HYPERTENSIVE PATIENTS

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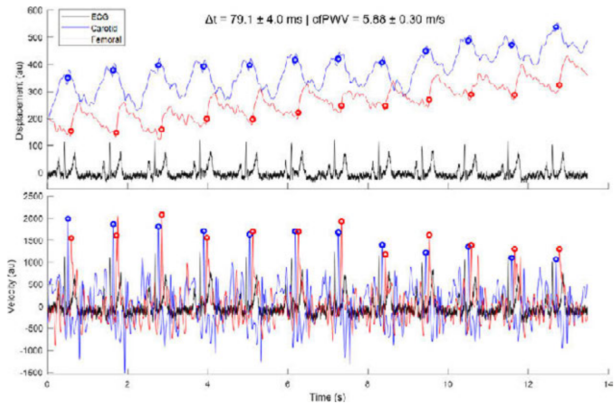
Objective: PWV measurement devices are technically demanding, expensive and prone to artefacts, thus limiting the measurement of arterial stiffness in primary care. The CARDIS consortium developed a non-contact device based on the detection of skin movements induced by arterial pulses through a laser Doppler vibrometer (CARDIS-LDV). Our objective is to validate CARDIS-LDV against reference techniques.

Methods: This study sponsored by INSERM will include 100 essential hypertensives, males and females, grade I—III, aged 18—80. The CARDIS-LDV comprises two rows of 6 laser beams spaced 5 mm (2.5 cm wide). These rows are either situated 2.5 cm apart for local PWV measurement or can be split in two for carotid to femoral measurement. To calculate PWV, the time delay between the two rows is assessed by analyzing the corresponding skin displacement signals. Aortic stiffness is measured by the Sphygmocor® technique and carotid stiffness by echotracking ArtLab®

Results: Measurements by CARDIS-LDV are easy and fast to perform. A simple palpation of pulse is enough to position the device and obtain good signals thanks to the 6-beam array. Figure 1 shows an example of a carotid-femoral recording on a healthy volunteer (age 28). PWV is 5.88 ± 0.30 m/s using the maximum of 1st derivative method, compared with 5.96 ± 0.40 m/s with tonometry. Data on larger sample size will be presented at the meeting.

Conclusion: CARDIS-LDV is a promising technique to assess arterial stiffness; we expect to demonstrate its good agreement with reference techniques and that it improves the screening of cardiovascular risk in large populations.



P52

ESTIMATING CENTRAL BLOOD PRESSURE FROM MRI DATA USING REDUCED-ORDER COMPUTATIONAL MODELS

Jorge Mariscal Harana [1,2], Peter H. Charlton [2], Samuel Vennin [2], Arna van Engelen [3], Torben Schneider [4], Mateusz Florkow [2,4], Hubrecht de Bliek [5], Bram Ruijsink [2], Israel Valverde [2], Marietta Charakida [2], Kuberan Pushparajah [2], Spencer Sherwin [1], Rene Botnar [2], Jordi Alastruey [2]

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Purpose: Central Blood Pressure (CBP) is a better cardiovascular risk indicator than brachial pressure [1]. However, gold standard CBP measurements require an invasive catheter. We propose an approach to estimate CBP non-invasively from Magnetic Resonance Imaging (MRI) data coupled with a non-invasive brachial pressure measurement, using reduced-order (0-D/1-D) computational models. Our objectives were: identifying optimum model parameter estimation methods and comparing the performance of 0-D/1-D models for estimating CBP.

Methods: Populations of virtual (simulated) healthy subjects were generated based on [2]. Pressure and flow waveforms from these populations were used to develop and test Methods: for estimating model parameters. Two common clinical scenarios were considered: when a brachial pressure waveform is available; and when only systolic and diastolic blood pressures are available. Optimal parameter estimation Methods: were identified for each scenario and used with two 0-D Windkessel models and a 1-D aortic model. Results were compared with invasive CBP in a post-coarctation repair population ($n = 10$).

Results: Model parameters were best estimated by: fitting an exponential to the pressure waveform to estimate compliance and outflow pressure; using the least-squares method to estimate pulse wave velocity from flow data; assuming characteristic impedance was 5% of arterial resistance; and estimating end-systolic time from the second derivative of the pressure waveform. Average pulse and systolic CBP errors were <5 mmHg and <2 mmHg, respectively.

Conclusions: We have demonstrated the feasibility of estimating CBP from MRI and brachial pressure. Different reduced-order models provided similar performance, although the 1-D model reproduced pressure waveform morphology more accurately.

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P53

ZERO FLOW PRESSURE (PINFINITY) IS LARGER THAN MEAN CIRCULATORY FILLING PRESSURE. A SYSTEMATIC REVIEW AND META-ANALYSIS

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Background: Zero flow pressure (P∞), the steady-state pressure following cardiac arrest or cessation of flow is often assumed to equal mean circulatory filling pressure (MCFP). [1] However, this assumes complete equilibration of circulatory pressures, which may not occur if there is a 'critical closing pressure' or 'Waterfall' in the circulation. We undertook a systematic review and meta-analysis to obtain robust estimates of P∞ and compared this with MCFP measured in the same studies.
Methods: A literature search was performed using PubMed and was limited to full articles in English using the search terms "mean circulatory filling pressure" OR "critical closing" OR "zero-flow". Only data relating to measurements of pressure following cardiac arrest or cessation of blood flow were included. Other exclusions were: individual case-reports, pregnancy, non-adult animals, not mammalian, or any non-human models of disease. Meta-analysis was performed using a random effects model in Stata 15.1. Data are mean (95% confidence intervals).
Results: A total of 1082 unique publications were identified; 1062 were excluded during screening. The remaining 20 studies with P∞ data were used to perform a meta-analysis. These included data from dog, rat, pig and human; 8 of these articles also provided data on MCFP. From this analysis P∞ = 26.5(23.4, 29.5) mmHg (n = 20) and the difference between P∞ and MCFP was 15.1(12.0, 18.3) mmHg (n = 8).
Conclusions: P∞ and MCFP differ substantially, indicating non-equilibration of pressures in the circulation following cessation of flow at least in the short-term (seconds to minutes).

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A MACHINE LEARNING SYSTEM FOR CAROTID PLAQUE VULNERABILITY ASSESSMENT BASED ON ULTRASOUND IMAGES

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Purpose/Background/Objectives: Carotid plaque vulnerability assessment is essential for the identification of high-risk patients. A specific mouse model for the study of carotid atherosclerosis has been recently developed. Aim of this study was to develop a predictive mathematical model for carotid plaque vulnerability assessment based on the post processing of micro-Ultrasound (μUS) images only.
Methods: 17 ApoE-/- male mice (16 weeks) were employed. After three weeks of high-fat diet, a tapered cast, designed to induce the formation of an unstable plaque upstream from the cast and a stable one downstream from it, was surgically placed around the right common carotid. μUS examination was repeated before the surgical procedure and after three months from it. Color-Doppler, B-mode and Pulsed-wave Doppler images were acquired to assess morphological, functional and hemodynamic parameters. In particular, texture analysis was applied on both the atherosclerotic lesions post-processing B-mode images. Peak velocity (Vp), Relative Turbolence Intensity (rTI) and velocity range (rangevel) were assessed from PW-Doppler images. Relative Distension (relD) and Pulse Wave Velocity (PWV) were evaluated for both the regions. All the μUS indexes underwent a feature reduction process and were used to train different machine learning approaches.
Results: The downstream region presented higher PWV values than the upstream one; furthermore, it was characterized by higher values of rTI and rangevel. The weighted kNN classifier supplied the best providing 92.6% accuracy, 91% sensitivity and 94% specificity.
Conclusions: The mathematical predictive model could represent a valid approach to be translated in the clinical field and easily employed in clinical practice.

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EFFECTS OF CAROTID PRESSURE WAVEFORM OBTAINED IN DIFFERENT WAYS ON THE RESULTS OF WAVE SEPARATION, WAVE INTENSITY AND RESERVOIR PRESSURE ANALYSIS

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Purpose/Background/Objectives: Recently great attention has been placed on innovative cardiovascular biomarkers obtained from wave separation (WS), wave intensity analysis (WIA) and the reservoir-wave (RW) concept. Pressure waveforms needed to implement these techniques can be obtained in different ways. Aim of this study was to evaluate differences in WS, WIA and RW parameters obtained deriving pressure curves in different ways.
Methods: Twenty-two individuals (49 ± 17 years, 59% males) were examined. Common carotid blood flow waveforms were obtained from Pulsed-Wave Doppler images. Carotid pressure waveforms were obtained in four different ways: 1) standard method, i.e., with applanation tonometry; 2) linear scaling from ultrasound (US)-derived diameter curve; 3) exponential scaling from US-derived diameter curve; 4) linear scaling from an accelerometric-derived diameter signal. In each case, reflection magnitude (RM) and reflection index (RI) were obtained from WS. The amplitude of the first positive peak (W1), of the second positive peak (W2) and of the negative one (Wb) were calculated from WIA; the maximum of the reservoir (maxPr) and the excess (maxPex) pressure were achieved from RW.
Results: According to the intra-class coefficient values, the agreement between the standard method and all the others was excellent in case of RM, RI, maxPrand maxPex(0.82—0.97), while reached only a fair/good level in case of W1, W2and Wb(0.44—0.82).
Conclusions: The use of alternative carotid pressure waveforms does not influence the cardiovascular parameters obtained by WS and RW, while those derived by WIA are affected by the carotid pressure curve employed.

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CENTRAL PULSE PRESSURE IS ASSOCIATED WITH RETINAL ARTERIOLAR WALL THICKNESS AND WALL CROSS SECTIONAL AREA AS EVALUATED BY ADAPTIVE OPTICS

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Introduction: In 1991 Baumbach et al demonstrated taht pulse pressure (PP) but not mean arterial pressure (MAP) was correlated with pial arterioles wall cross-sectional area (WCSA)in rats. Adaptive optics (AO) allows a near-