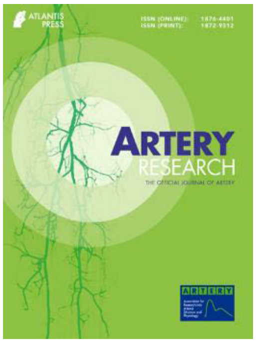

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P50: VALIDATION OF ULTRASOUND DETERMINATION OF LOCAL PULSE WAVE VELOCITY IN THE HUMAN ASCENDING AORTA AGAINST MRI MEASUREMENTS

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and geometric (diameter, ellipticity and curvature) parameters were investigated.

Results: Compared to HV, MFS presented larger aortic diameters only in the proximal AAo ($p < 0.001$) and DAo ($p = 0.028$). Increased ellipticity and a more distal location for the peak of aortic curvature were evident, even in the absence of dilation. Through most of the thoracic aorta, IRF was substantially lower in MFS, while SFRR was larger. Interestingly, non-dilated MFS had decreased IRF in the thoracic aorta compared to HV, although SFRR was not increased. Statistically-significant bivariate relations were found between arch IRF and arch ellipticity ($R = -0.34$) and proximal DAo peak curvature ($R = -0.35$). Local diameter was negatively correlated with local IRF ($R = -0.3$) and positively correlated to local SFRR ($R = 0.605$).

Conclusions: MFS presented altered ellipticity and curvature distribution, which are related to abnormal flow patterns even in the absence of dilation.

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COMPARISON BETWEEN INVASIVE AND NON-INVASIVE METHODS: TO EVALUATE AORTIC STIFFNESS BY PULSE WAVE VELOCITY

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Objective: To investigate if invasively measured aortic pulse wave velocity (PWV) is accurately estimated by non-invasive methods purporting to assess it.

Methods: One-hundred and two patients (30% female, age 65 ± 13 years) planned to undertake coronary angiography were evaluated with the following non-invasive devices: BPLab (Petr Telegin, Russia), Complior Analyse (Alam Medical, France), Mobil-O-Graph (IEM, Germany), pOpmètre (Axelife, France), PulsePen-ET, PulsePen-ETT (Diatecne, Italy) and SphygmoCor (AtCor, Australia). Aortic PWV was measured by aortic catheterization and simultaneous measurement of pressure waves above the aortic valve and at the aortic bifurcation (FS-Stiffcath, Flag Vascular, Italy).

Results: The devices evaluating carotid-femoral PWV showed a very strong agreement between each other ($r2 > 0.65$) and with invasive aortic PWV (mean difference ± SD with invasive PWV: -0.73 ± 2.83 m/s ($r2 = 0.41$) for Complior-Analyse; 0.20 ± 2.54 m/s ($r2 = 0.51$) for PulsePen-ETT; -0.04 ± 2.33 m/s ($r2 = 0.61$) for PulsePen-ET; -0.61 ± 2.57 m/s ($r2 = 0.49$) for SphygmoCor). The finger-toe PWV, evaluated by the pOpmètre, and the PWV measured by BPLab showed a weak relationship with invasive PWV (respectively r 2 =0.12, 0.05), with carotid-femoral PWV measurements (r 2 =0.11, 0.010) and with age (r 2 =0.10, 0.06). PWV estimated with Mobil-O-Graph through a proprietary algorithm showed a good agreement with invasive PWV (mean difference ± SD = -1.01 ± 2.54 m/s; $r2 = 0.51$) and appeared to be strictly dependent on age-squared and peripheral systolic blood pressure ($r2 > 0.99$).

Conclusions: Methods estimating carotid-femoral PWV should be considered the only non-invasive approach to reliably assess aortic stiffness. Aortic PWV values estimated by Mobil-O-Graph algorithm are also significantly related to invasive PWV, but do not offer any additional information on top of what provided by age and systolic blood pressure levels.

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QUANTIFYING WAVE REFLECTION IN CHILDREN: INVASIVE VS NON-INVASIVE CENTRAL AUGMENTATION INDEX AND REFLECTION MAGNITUDE AND THEIR ASSOCIATION WITH LEFT VENTRICULAR MASS

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Objective: The aims of this study in children were to 1) evaluate two brachial oscillometric devices for estimating central augmentation index (AIx) and reflection magnitude (RM), and 2) test whether AIx or RM are associated with left ventricular mass index (LVMI).

Methods: Intra-aortic (IA) AIx was calculated from high-fidelity pressure measured with a Verrata wire (Philips Volcano) in 60 children (9.2 ± 4.7 years) with unobstructed aorta undergoing clinically-indicated catheterisation. AIx was also obtained from SphygmoCor XCEL (SC, AtCor) and/or Mobil-o-Graph (MB, IEM) brachial oscillometric devices. RM(IA) was calculated via wave separation using a representative normalised flow waveform obtained from MRI in a separate group of normal adolescents, RM(SC) via the triangulation method, and RM(MB) provided by the proprietary software. LVMI was estimated via echocardiography.

Results: Invasive vs non-invasive AIx and RM are compared in the Table. AIx(IA) correlated weakly with AIx(SC) ($R = 0.27$, $P = 0.04$) but not AIx(MB) ($P = 0.4$). Neither RM(SC) nor RM(MB) correlated with RM(IA) ($P = 0.13$ and $P = 0.96$ respectively). RM(IA) was moderately correlated with AIx(IA) ($R = 0.69$, $P < 0.001$) and weakly correlated with AIx(SC) ($R = 0.36$, $P = 0.007$) but not AIx(MB) ($P = 0.7$). In a multivariable regression, height ($P < 0.001$) and RM (IA) ($P = 0.04$) were independently and positively associated with LVMI (adjusted $R^2 = 0.24$), whereas there were no associations of any AIx or non-invasively estimated RM with LVMI.

Conclusion: Central AIx and RM were poorly estimated by SC and MB in children. Unlike RM(IA), none of the non-invasive indices of wave reflection correlated with LVMI, likely due to inadequate estimation of the central pressure waveform shape in this age group.

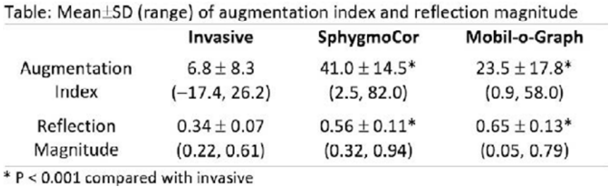

Table: Mean±SD (range) of augmentation index and reflection magnitude

	Invasive	SphygmoCor	Mobil-o-Graph
Augmentation Index	6.8 ± 8.3 (−17.4, 26.2)	41.0 ± 14.5* (2.5, 82.0)	23.5 ± 17.8* (0.9, 58.0)
Reflection Magnitude	0.34 ± 0.07 (0.22, 0.61)	0.56 ± 0.11* (0.32, 0.94)	0.65 ± 0.13* (0.05, 0.79)

* P < 0.001 compared with invasive

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VALIDATION OF ULTRASOUND DETERMINATION OF LOCAL PULSE WAVE VELOCITY IN THE HUMAN ASCENDING AORTA AGAINST MRI MEASUREMENTS

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Background: Pulse Wave Velocity (PWV) is a measure of arterial stiffness which predicts cardiovascular risk independently of blood pressure. Local PWV can be measured non-invasively in the ascending aorta of adults by means of Ultrasound (US), using successive recordings of Diameter (D) and the velocity (U) [1].

Aim: To test US measurements of local PWV in the ascending aorta of human adults against MRI measurements of local PWV.

Methods: PWV in the ascending aorta of 8 healthy volunteers (age 22—34 y, 3 females) was measured using a Siemens MAGNETOM Aera 1.5T MRI scanner as per standard protocols with cine and phase contrast imaging (sampling frequency 100 samples/cardiac cycle) and D and U were calculated using validated software [2]. US images were recorded using GE Vivid E95 scanner with a 1.5—4.5 MHz phased array transducer. PLAX was used for diameter recordings and A5CH for velocity. Measurements were recorded for 20 s during a breath-hold. D and U waveforms were extracted from each imaging modality to calculate PWV using the ln(D)U-loops technique [3].

Results: Average results are summarised in Table 1. The mean difference in PWV between MRI and US was 2.8 ± 0.3%.

Conclusions: PWV measured by US shows excellent agreement with MRI in the ascending aorta of adults. Given US availability, this technique offers an easy, affordable and non-invasive means of determining PWV and mechanical properties of the ascending aorta; thus, providing a tool for screening studies.

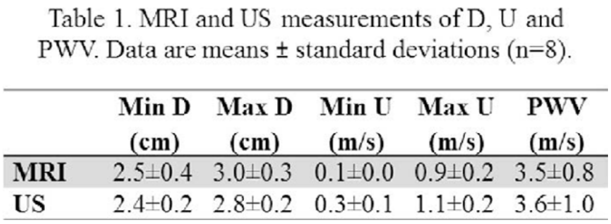

Table 1. MRI and US measurements of D, U and PWV. Data are means ± standard deviations (n=8).

	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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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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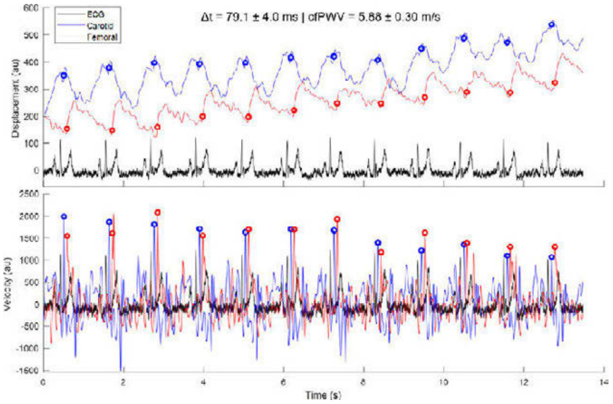
Objective: PWV measurement devices are technically demanding, expensive and prone to artefacts, thus limiting the measurement of arterial stiffness in primary care. The CARDIS consortium developed a non-contact device based on the detection of skin movements induced by arterial pulses through a laser 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.



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

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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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