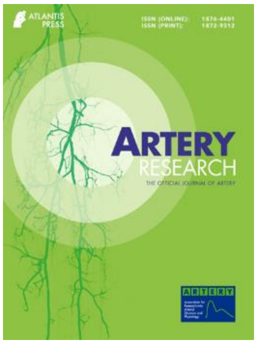

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P135: PRECISION CALIBRATION OF PERIPHERAL PRESSURE WAVEFORMS USING INTRA-ARTERIAL BLOOD PRESSURE REVEALS THE NEED FOR IMPROVED WAYS TO ACCURATELY ESTIMATE AORTIC BLOOD PRESSURE

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(VC) in patients with end- stage renal disease (ESRD) and its associations with clinical parameters of arterial stiffness.
Methods: In 68 adults with ESRD on maintenance hemodialysis for >3 months (45.6% males, median age 58.3 (interquartile range (IQR) 54.6; 61.6) years, dialysis duration 62.7 (47.8; 77) months, echocardiography and applanation tonometry was performed.
Results: Calcification of the aortic, mitral and both valves was revealed in 46 (67.6%), 34 (50%) and 33 (48.5%) of patients. 20 (29%) patients had no signs of VC. Patients with vs without AVC were older (65.1 ± 9.5 vs $41.4 \pm 11{,}9$ years, $p < 0.001$), had higher dialysis duration (51 (8; 252) vs 21 (10; 38) months, $p < 0.01$), lower peripheral diastolic blood pressure (DBP) (76 ± 17 vs 84 ± 12 mmHg, $p < 0.05$), central DBP (75 ± 15 vs 82 ± 11 mmHg, $p < 0.05$), reflected wave transit time (RWTT) (131 ± 17 vs 137 ± 15 ms, $p < 0.05$). Patients with vs without MVC were older (67.8 ± 8.2 vs $47.9 \pm 13{,}5$ years, $p < 0.001$), had higher dialysis duration (51 (34; 111) vs 36 (14; 57) months, $p < 0.01$), carotid-femoral pulse wave velocity (10.1 ± 2.7 vs 8.9 ± 3.5 m/s, $p < 0.05$), lower peripheral DBP (73 ± 17 vs 84 ± 14 mmHg, $p < 0.01$), central DBP (72 ± 13 vs 83 ± 13 mmHg, $p < 0.001$), higher central pulse pressure (52 ± 13 vs 45 ± 16 mmHg, $p < 0.05$), lower RWTT (133 (120; 130) vs 135 (132; 142) ms, $p < 0.05$).
Conclusion: High prevalence of VC (71%) was revealed in patients with ESRD on maintenance hemodialysis. Patients with vs without VC were older, had higher duration of dialysis and more pronounced arterial stiffness.

P113
DIASTOLIC AMBULATORY BLOOD PRESSURE PARAMETERS ARE ASSOCIATED WITH VALVE CALCIFICATION IN PATIENTS WITH END-STAGE RENAL DISEASE ON MAINTENANCE HEMODIALYSIS

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Objective: Valve calcification (VC) is common in patients on hemodialysis and increases the risk of cardiovascular morbidity and mortality. The aim if the study was to evaluate the association between VC and 44-hour ambulatory blood pressure (ABP) variables.
Materials and methods: In 68 patients with end-stage renal disease (ESRD) on maintenance hemodialysis (45.6% males, median age 58.3 (interquartile range (IQR) 54.6; 61.6) years, dialysis duration 62.7 (47.8; 77) months, arterial hypertension 94%, heart failure 28%, diabetes mellitus 21%, glomerulonephritis 35%, pyelonephritis 25%, multicystic dysplastic kidney 13%) echocardiography and 44-hour ABP monitoring was performed. Mann-Whitney test was considered significant if $p < 0.05$.
Results: Calcification of the aortic (AVC), mitral (MVC) and both valves was revealed in 46 (67.6%), 34 (50%) and 33 (48.5%) of patients. 20 (29%) patients had no signs of VC. Patients with vs without AVC had lower daytime diastolic BP (DBP) (79 ± 13 vs 89 ± 12 mmHg, $p < 0.01$), nighttime DBP (75 ± 13 vs 83 ± 13 mmHg, $p < 0.05$), day one DBP (77 ± 13 vs 89 ± 15 mmHg, $p < 0.01$), day two DBP (79 ± 14 vs 88 ± 10 mmHg, $p < 0.01$), 44-hour DBP (78 ± 13 vs 88 ± 12 mmHg, $p < 0.01$).
Patients with vs without MVC had lower daytime DBP (78 ± 15 vs 86 ± 11 mmHg, $p < 0.01$), nighttime DBP (74 ± 14 vs 81 ± 12 mmHg, $p < 0.05$), 44-hour DBP (77 ± 15 vs 85 ± 11 mmHg, $p < 0.01$), higher daytime DBP variability (10 ± 3 vs 9 ± 3 mmHg, $p < 0.01$).
Conclusion: High prevalence of valve calcification (71%) was revealed in patients with ESRD on hemodialysis. Patients with VC were older, had higher duration of dialysis, lower values of ambulatory DBP.

P114
ARTERIAL STIFFNESS IS ASSOCIATED WITH AMBULATORY BLOOD PRESSURE PARAMETERS IN PATIENTS ON MAINTENANCE HEMODIALISYS

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Introduction: Arterial stiffness is a principal pathogenetic mechanism of aortic systolic blood pressure (SBP) augmentation, left ventricular hypertrophy and sudden cardiac death. The aim of the study was to evaluate the association between parameters of pulse wave and 44-hour ambulatory blood pressure (ABP) variables in patients with end- stage renal disease.
Methods: In 68 patients with ESRD on maintenance hemodialysis (45.6% males, median age 58.3(interquartile range (IQR) 54.6; 61.6) years, dialysis duration 62.7(47.8; 77) months applanation tonometry and 44-hour ABP monitoring was performed.
Results: Carotid-femoral pulse wave velocity (PWV) < 10 vs PWV $\geq$ 10m/s was revealed in 52(76.5%) of patients respectively. Patients with PWV ≥ 10 vs < 10 m/s had higher dialysis duration (median 60; IQR 36; 84) vs 28; IQR 11; 50.5) months, $p < 0.05$), peripheral SBP ($148.1 \pm 24{,}8$ vs $140.7 \pm 23{,}6$ mmHg, $p < 0.05$); diastolic blood pressure (DBP) ($85.7 \pm 15{,}2$ vs $83.3 \pm 12{,}7$ mmHg, $p < 0.05$); 48-hour heart rate (HR) ($74.7 \pm 13{,}0$ vs $72 \pm 8{,}7$ bpm, $p < 0.05$), mean day one HR ($78.7 \pm 7{,}5$ vs $72.5 \pm 9{,}7$ bpm, $p < 0.05$), 48- hour DBP variability (DBPV) (78 ± 13 vs 88 ± 12 mmHg, $p < 0.01$), day two SBP variability ($13.5 \pm 4{,}4$ vs $13.1 \pm 4{,}1$) mmHg, $p < 0.05$), mean day two BD variability ($12 \pm 3{,}9$ vs median 11; $11.8 \pm 3{,}6$) mmHg, $p < 0.05$).
Patients with PWV ≥ 10 vs $<$10 m/s had lower daytime DBPV (median 8.5; IQR 7; 9) vs IQR 10 (8; 11) mmHg, $p < 0.05$), day one DBPV (median 8; IQR 8; 9) vs 9 IQR 8; 10 mmHg, $p < 0.01$).
Conclusions: Patients with PWV $\geq$ 10 m/s had higher duration of dialysis, higher values of ambulatory DBP and higher — of HR. These findings may have implications in gaining further insights into the mechanism of arterial stiffness.

P115
ALBUMIN-TO-CREATININE RATIO IS ASSOCIATED WITH TARGET ORGAN DAMAGE IN HYPERTENSION

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Purpose/Background/Objectives: Hypertension is associated with higher cardiovascular risk as well as several markers of subclinical target organ damage (TOD). Albumin to creatinine ratio (ACR) in urine has been recognised as an independent risk factor for cardiovascular events. We hypothesised that there is a relationship between ACR and markers of TOD in never-treated hypertensives.
Methods: We enrolled 924 consecutive essential hypertensives (mean age 53 ± 12 years, 486 males) without known cardiovascular disease (CVD). Markers of subclinical TOD [left ventricular mass index (LVMI), pulse wave velocity (PWV), ankle-brachial index (ABI) and estimated glomerular filtration rate (eGFR)] were evaluated in all patients. LVMI was assessed echocardiographically using the Devereux formula. Carotid-femoral PWV was estimated with the Complior device. eGFR was calculated by the Cockcroft-Gault formula. ABI was calculated by dividing the highest ankle systolic blood pressure by the highest brachial systolic blood pressure.
Results: ACR exhibited significant association with LVMI ($r = 0.277$, $p < 0.001$), PWV ($r = 0.277$, $p < 0.001$) ABI ($r = -0.078$, $p = 0.018$) and eGFR ($r = -0.100$, $p = 0.002$). In further analysis, ACR was associated with TOD as suggested by the 2013 European Guidelines for Hypertension [left ventricular hypertrophy (LVMI > 115 g/m^2 in men and >95 g/m^2 in women), increased PWV (PWV $>$ 10m/s), decreased ABI (ABI < 0.9) and decreased renal function (eGFR $<$ 60ml/min)]. Specifically, ACR exhibited a significant association with the number of TOD and this association was independent of age and gender ($p < 0.05$).
Conclusions: Our findings support the close relationship between ACR and TOD in hypertension, as well as, the predictive ability of ACR for TOD.

Poster Session II — Models and Methodologies II P135
PRECISION CALIBRATION OF PERIPHERAL PRESSURE WAVEFORMS USING INTRA-ARTERIAL BLOOD PRESSURE REVEALS THE NEED FOR IMPROVED WAYS TO ACCURATELY ESTIMATE AORTIC BLOOD PRESSURE

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Background: Estimating aortic blood pressure (BP) non-invasively requires peripheral waveform calibration using cuff systolic (SBP) and diastolic

(DBP). Accuracy of estimated aortic BP has never been determined when peripheral waveforms are precision calibrated using peripheral intra-arterial SBP/DBP. This is relevant to understanding the best methods to estimate aortic BP accurately and was the aim of this study. We also determined how other calibrations influence estimated aortic BP accuracy.
Methods: Ascending aortic, brachial and radial artery intra-arterial BP was measured among 104 patients (61.8 ± 10 years, 66% male) undergoing coronary angiography. Intra- arterial aortic SBP was compared with estimated aortic SBP by generalised transfer function (SphygmoCor) using: (1) intra-arterial brachial pressure waveforms calibrated with intra-arterial brachial SBP/DBP; (2) intra-arterial radial pressure waveforms calibrated with intra-arterial brachial SBP/DBP and (3) radial SBP/DBP and; (4) intra-arterial aortic mean arterial pressure (MAP)/DBP.
Results: All intra-arterial SBP/DBP peripheral waveform calibrations significantly underestimated intra-arterial aortic SBP ((1) -4.5 ± 7.0 mmHg; (2) -8.8 ± 8.0 mmHg and (3) -5.4 ± 7.6 mmHg; $p < 0.0001$ all). Conversely, intra-arterial aortic MAP/DBP calibration (4) accurately estimated aortic SBP (0.03 ± 4.6 mmHg, $p = 0.95$). Underestimation of intra-arterial aortic SBP was related to lower aortic-to-brachial SBP amplification ($r > 0.25$, $p < 0.009$ all calibrations).
Conclusion: Even when using accurate (intra-arterial) SBP/DBP for precision peripheral waveform calibration, aortic SBP was significantly underestimated. Intra-arterial aortic MAP/DBP was the most accurate calibration, but is not feasible for non-invasive use. These findings highlight the need for improved ways to accurately estimate aortic SBP.

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ALTERED ADVENTITIAL COLLAGEN FIBRIL MECHANICS AND MORPHOLOGY WITH HIGH PULSE WAVE VELOCITY

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Background: Arterial stiffening, occurring as part of the natural aging process of the artery, is well- established as a powerful predictor of cardiovascular disease. However, little is known about how localised changes in the extracellular matrix and mechanical properties of arterial tissue contribute to gross stiffening in the vasculature, particularly in the adventitia. The mechanical properties of the adventitia are attributed to the collagen fibrils which exhibit high tensile strength when an axial load is placed on the vessel.
Objective: To determine the relationship between the adventitial collagen fibril properties and carotid-femoral pulse wave velocity (PWV).
Methods: 16 patients were split into high PWV ($13.6 \pm 1.1 ms^{-1}$) and low ($8.5 \pm 0.3 ms^{-1}$) PWV groups (t-test, $P < 0.001$). Internal mammary arteries (IMAs) which were collected during coronary artery bypass grafting (CABG) were used to nano-scale characterisation of the tissue with atomic force microscopy (AFM). AFM was used to determine nanomechanical properties and collagen fibril morphology.
Results: Abundant, highly oriented collagen fibrils were observed in the adventitial layer in both groups. The adventitia had high elastic modulus values in the high PWV group (Low PWV = 2298.64 ± 75.38MPa; High PWV = 2734.63 ± 95.52MPa, $P < 0.001$). The collagen fibril diameters were found to be higher in patients with high PWV (Low PWV = 117.23 ± 22.19nm, High PWV = 119.18 ± 21.96nm, $P < 0.001$).
Conclusion: Nanomechanical properties and collagen fibril morphology in arterial tissue associated with carotid-femoral PWV. Nano-scale changes in the IMA are therefore indicative of systematic changes in arterial stiffness in the vasculature.

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NUMERICAL ASSESSMENT AND COMPARISON OF PULSE WAVE VELOCITY METHODS PRESUMING TO MEASURE AORTIC STIFFNESS

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Recently several methods have been proposed as tools to measure aortic pulse wave velocity (aPWV). The carotid-femoral pulse wave velocity (cf-PWV), the current clinical gold standard method for the noninvasive assessment of aPWV, uses the carotid–femoral pulse transit time (cf-PTT) to derive cf-PWV. The heart-ankle PWV (ha-PWV), brachial-ankle PWV (ba-PWV) and finger-toe (ft-PWV) are also methods presuming to approximate aPWV based on time delays between physiological signals at two locations (~heart-ankle PTT, ha-PTT; ~brachial-ankle PTT, ba-PTT; ~finger-toe PTT, ft-PTT). To test the validity of these methods, we used a 1D arterial network model (143 segments) including the foot and hand circulation.
The arterial tree dimensions and properties were taken from the literature and completed with CT-scans data. We calculated PTT's with all the methods above.
The calculated PTT's were compared with the aortic PTT (aPTT), considered as the absolute reference method in this study. The correlation between methods and aPTT was good and significant, cf-PTT ($R^2 = 0.97$; $P < 0.001$; mean difference 5 ± 2 ms), ha- PTT ($R^2 = 0.96$; $P < 0.001$; 150 ± 23 ms), ba-PTT ($R^2 = 0.96$; $P < 0.001$; 70 ± 13 ms) and ft-PTT ($R^2 = 0.95$; $P < 0.001$; 14 ± 10 ms). Consequently, good correlation was also observed for the PWV values derived with the tested methods, but absolute values differed because of different path lengths used. In conclusion, our computer model based analyses demonstrate that for PWV methods based on peripheral signals, PTT's closely correlate with the aPTT, supporting the use of these methods in clinical practice.

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CAN PULSE WAVE VELOCITY BE MEASURED IN THE FETAL ASCENDING AORTA?

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Background: Routine ultrasound exams are conducted to assess fetus development. Heart defects and cardiac function are the main areas investigated in an ultrasound assessment. However, prenatal assessment of the fetal arterial stiffness is yet to be established in the ascending aorta.
Aim: To investigate whether pulse wave velocity (PWV) can be determined in the fetus ascending aorta using ultrasound examination.
Methods: 35 fetuses (19 normal, 16 growth restricted) were included in the study. High quality recordings were achieved in 6 normal and 8 fetuses diagnosed with fetal growth restriction (FGR). Images of the diameter and blood velocity in the ascending aorta were recorded (Voluson, GE and Samsung) with a curvilinear probe 2–8MHz/1–7MHz. The diameter and velocity waveforms were extracted from DICOM images, offline, using in-house developed codes in Matlab. The extraction was based on thresholding of the grey-scale images. Local PWV was determined using the ln(D) U-loop method [1].
Results: PWV in the fetal ascending aorta increased with gestational age in both normal ($r^2 = 0.77$) and FGR ($r^2 = 0.55$) fetuses. Mean PWV in the fetal ascending aorta per gestational week was 0.045m/s in normal and 0.066m/s in FGR fetuses, with a percentage difference of 32%.

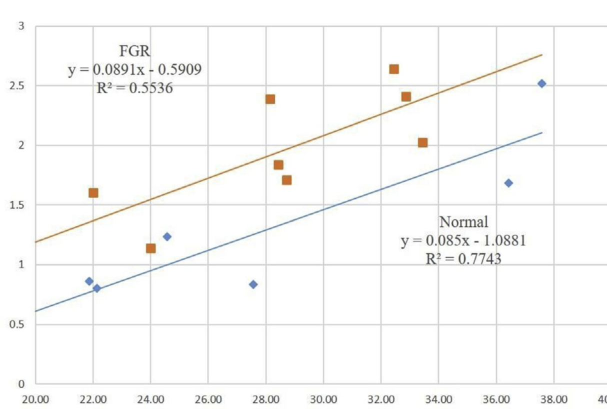

Figure 1. PWV vs gestational age in weeks for normal (blue diamond ♦) and FGR (red squares ■) fetuses and the trendlines with equations describing them and their r^2 values. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)