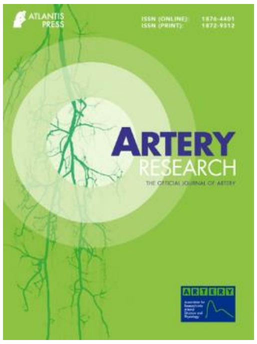

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P2.14: INFLUENCE OF CALIBRATION OF PERIPHERAL PRESSURE ON THE ESTIMATION OF CENTRAL SYSTOLIC BLOOD PRESSURE

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were 24-hour ambulatory blood pressures, AASI in addition to various metabolic and anthropometric indices of CV risk.

Results: Besides being takykardic TS women displayed relative systolic and diastolic hypertension with diminished circadian variation, while pulse pressures were similar. HRT in TS brought on a significant fall in diastolic pressures and borderline significant reduction in diurnal pulse variability. AASI was significantly elevated in TS prior to HRT when compared to controls (T_b vs. C: 0.36 (0.02) vs. 0.26 (0.03), P=0.01) and unaffected by HRT. Individual status, i.e. being TS or not, was the major explanatory variable to AASI followed by age, insulin sensitivity and the degree of diurnal pulse variability.

Conclusion: AASI was elevated in TS following HRT wash-out which possibly indicated a syndrome-associated elevated CV risk with no direct impact of HRT during 6 months.

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P2.11

WHEN DOES THE REFLECTED WAVE ARRIVE — SYSTOLE OR DIASTOLE? A SYSTEMATIC LITERATURE REVIEW

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Background: The arterial waveform in young adults is ascribed to the combination of a forward wave from the ventricle and a reflection arriving at the aortic root in diastole. With ageing, the reflected wave is proposed to arrive earlier, augmenting systolic pressure and increasing afterload. This view has been recently disputed[1] and it is suggested that pressure in diastole is attributable to an arterial 'reservoir'. We undertook a systematic review to ascertain whether reflected waves arrive in diastole.

Methods and Results: We searched the literature using PubMed and Cochrane. We identified 67 studies describing 139 cohorts totalling 13,957 subjects (mean age 53 years, range 4-91). The arrival time of waves was calculated from the time of the shoulder on the pressure waveform and the end of systole was estimated by the time of the dicrotic notch.

The arrival time of the reflected wave was 135.5 (95% CI 131.7-139.4) ms. In comparison, the end of systole occurred at 328.1 (314.0-342.2) ms. All reflection times were in the first two-thirds of systole. The peaks of the reflected pressure arrived at an average of 217.6 (207.8-227.4) ms, well within systole, across the age spectrum.

Conclusion: The mean time of arrival of the reflected wave is in systole even in the youngest subjects. These observations do not support the view that reflected waves typically arrive in diastole.

1. Wang JJ *et al*. Time-domain representation of ventricular-arterial coupling as a windkessel and wave system. *Am J Physiol Heart Circ Physiol* 2003;284(4):H1358-H1368.

doi:10.1016/j.artres.2008.08.377

P2.12

INFLUENCE OF THE CENTRAL TO PERIPHERAL ARTERIAL STIFFNESS GRADIENT ON TIMING AND AMPLITUDE OF WAVE REFLECTIONS

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In younger individuals peripheral muscular arteries are stiffer and pulse wave velocity (PWV_m) greater than central elastic artery stiffness and PWV_e ($PWV_m > PWV_e$). The marked increase in aortic stiffness with age, with little change in peripheral stiffness, results in a reversal of the arterial stiffness gradient ($PWV_e > PWV_m$). It has been hypothesized[1] that this may reduce wave reflection amplitude and augmentation index (AI_a) due to movement of the major reflection site further from the heart. To test this hypothesis we investigated whether a reverse stiffness gradient ($PWV_e > PWV_m$) is associated with a reduced AI_a and an increased reflection site distance.

Studies were performed in subjects aged>50 years who were free of medication. Following 10mins supine rest, blood pressure, pulse wave analysis and carotid-femoral (PWV_e) and femoral-dorsalis-pedis (PWV_m) PWVs were measured. Distance to the major reflection site was calculated from PWV_e and reflected wave travel time (Tr/2)[2].

PWV_e and PWV_m were 7.8±1.0m/s and 9.7±1.0m/s, respectively, in subjects with a positive stiffness gradient ($PWV_m > PWV_e$) and 10.8±2.1m/s and 9.0±1.6m/s in subjects with a reverse stiffness gradient. Central pulse pressure and augmentation pressure were higher in subjects with a reverse stiffness gradient (38 ±18vs.48±9mmHg and 12±6vs.14±5mmHg,P<0.05), as was AI_a corrected for heart rate (23±8vs.27±6%.P<0.05) and reflection site distance (56±10vs.76±15cm.P<0.01). Time to reflection did not differ between groups (71.4±6.4vs.70.5±5.0ms).

Reversal of the stiffness gradient ($PWV_e > PWV_m$) is associated with increased central pulse pressure, reflected wave amplitude and AI_a and a paradoxical increase in reflection site distance.

1.Mitchell GF et al. Hypertension. 2004;43:1239-45.

2.Murgo JP et al. Circulation. 1980;62:105-16.

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P2.13

THE FORM FACTOR (FF) OF PRESSURE WAVEFORMS IN A YOUNG POPULATION: DIFFERENCE BETWEEN MEN AND WOMEN

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Background: Bos et al stated that the well known one-third rule for the calculation of mean arterial pressure (MAP) from diastolic (DBP) and pulse pressure (PP) underestimates the MAP. We calculated the percentage (form factor, FF) of the PP to be added to the DBP to assess MAP at the brachial artery in a population sample of young adults and compared middle-aged adults.

Methods: Brachial artery tonometer measurements were performed in 95 healthy subjects (18 men, 77 women; age 19-35 yr). The pressure waveforms were calibrated using sphygmomanometer SBP and DBP. MAP was assessed as the numerical average of this pressure wave curve.

Results: The table shows the FF as mean percentage ± SD. The FF at the brachial artery was 2.1±0.9 % higher in women compared to men (p<0.02).

FF % (SD)	Men	Women	Total
Age 19-35 yrs	37.2 (3.1)	39.2 (3.4)	38.9 (3.4)

FF based on published data from the Asklepios study (age 35-55) *

Age 35-55 yrs	41.3 (3.0)	43.7 (3.1)	42.4 (3.3)

* D. Mahieu et al. Validity of the One-Third Rule to Calculate Mean Arterial Pressure. Artery Research 2007;1(2):71.

Conclusions: The present study confirms the findings from the Asklepios Study that the form FF to calculate MAP is higher in women than in men. This study also suggests that the FF is age dependent being lower in the age range of 19-35 compared to the range 35-55. Further research is needed to define the influence of age on the form factor to calculate MAP.

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P2.14

INFLUENCE OF CALIBRATION OF PERIPHERAL PRESSURE ON THE ESTIMATION OF CENTRAL SYSTOLIC BLOOD PRESSURE

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Objective: We compared the accuracy with which central systolic aortic pressure (cSBP) can be estimated from the late systolic shoulder of the digital artery pressure waveform (SBP_2) when the digital waveform is calibrated using a validated non-invasive oscillometric device and when it is calibrated using mean (MAP) and diastolic (DBP) central blood pressure measurement.

Design: Subjects (n=25) were studied at the time of cardiac catheterisation for diagnostic angiography and/or angioplasty. The study was approved by the local research ethics committee and all subjects gave written informed consent.

Methods: cSBP was measured with a Millar SPC-454D (Millar instruments Houston, Texas) catheter with the tip of the catheter in the proximal aortic root. Peripheral pressure waveforms were acquired from the digital artery using a Finometer (Finapres medical systems, Netherlands) and were calibrated from aortic mean and diastolic pressures and from systolic and diastolic pressures measured using an Omron 750IT (Omron Healthcare). Measurements of digital artery and aortic pressures were obtained at baseline and after nitroglycerin (NTG, sublingual spray 500 μg).

Results: The overall mean (±SD) difference between cSBP and SBP_2 calibrated using the Omron 750IT was 1.4±11.8 mmHg. When SBP_2 was calibrated from aortic MAP and DBP the difference between cSBP and SBP_2 was -1.1±5.6 mmHg.
Conclusion: These results suggest non-invasive calibration does not produce a major systematic error in estimation of cSBP from SBP_2 but does introduce greater variability when compared to invasive calibration.

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P2.15
A COMPARISON OF SHEAR STRESS ESTIMATES IN THE COMMON CAROTID ARTERY IN HYPERTENSIVES

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Shear stress (SS) is associated with the formation of localised atherosclerosis. Due to the complexities of flow accurate determination of shear stress is difficult. Whilst 2D methods of deriving SS are widely used, computational fluid dynamic (CFD) modelling allows modelling of flow within complex geometry of the carotid bifurcation (CB).
This study compared mean SS using ultrasound based Womersley's solution and MRI based CFD.
9 untreated hypertensive subjects [median age 42 (range 35-52) yrs] in a double-blind, placebo controlled, randomised, 3 way crossover trial using amlodipine or lisinopril underwent ultrasound examination of the right common carotid (CC) using a 7.5 MHz ultrasound transducer (L12-5 scanhead, HDI 5000, ATL, Bothell, Washington). Pulse wave Doppler was performed using a 1.5mm sample volume placed in the centre of CC 2cm proximal from the carotid bulb. Mean Womersley shear stress was calculated from these data using custom written software.
MRI of the CB was performed (Siemens Magnetom Sonata 1.5 T scanner) using a 2D TOF protocol and 3D PC sequence for flow measurements. These data were combined with custom refined CFD codes (CFX4.4 (AEA Technology, Didcot, Oxfordshire UK).
Mean difference was -0.242 Pa (SD 0.314; 95% limits of agreement -0.856, 0.373]; Lin's concordance correlation coefficient (rho_c 0.16; SE 0.13; p = 0.21); Pearson's r = 0.244; p = 0.219.
Overall the data indicate poor agreement between WSS measured by ultrasound/Womersley and MRI/CFD and underscore the limits of using 2D methods in the investigation of the relationship between SS and atherosclerosis in the CC.

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P2.16
PRESSURE PROFILE ANALYSIS AT HEMODIALYSIS NEEDLE: A NEW METHOD FOR EARLY DETECTION OF VASCULAR ACCESS STENOSES

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Hemodialysis vascular access stenosis remains a frequent complication. However; early detection is challenging and costly. The aim of this in-vitro study was to assess the value of a new detection method based on pressure profile analysis at the hemodialysis needle.
A silicon model of a radio-cephalic arteriovenous fistula was built (4mm artery connected by an end-to-side anastomosis with a 7mm vein). A water-glycerine mixture was used as blood mimicking fluid. Pressure profiles were measured at the arterial hemodialysis needle (4cm downstream the anastomosis) and in the feeding artery 20cm upstream the anastomosis. Stenoses (50% diameter reduction) were created 10cm upstream the anastomosis (proximal artery (PA)) and 3.5cm and 8cm downstream the arterial needle (distal vein (DV) and proximal vein (PV) respectively). The pulse pressure (maximum minus minimum) at the needle was divided by the pulse pressure at the feeding artery to obtain a dimensionless ratio, %PP. Experiments were conducted at different blood flow (500 to 1200 ml/min) and heart rates (60 to 90 beats/minute) to test this new index over a wide range of hemodynamic conditions.
In the control model (no stenosis), %PP was 20.26±4.55%. PA stenosis significantly decreased %PP to 7.69±2.08% ($P<0.001$), while presence of stenosis in the distal (36.20±2.12%) and proximal (32.38±2.17%) vein lead to significantly higher values of %PP ($P<0.001$).
This in vitro study shows that the analysis of the pressure profile at the dialysis needle is useful for early detection and localization of hemodialysis vascular access stenosis, independent of heart rate and flow level.

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P2.17
ASSESSMENT OF THE BRACHIAL ARTERY FLOW-MEDIATED DILATION WITHOUT ECG GATING

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The methods commonly used for non-invasive ultrasound assessment of endothelium-dependent Flow-Mediated Dilation (FMD) require an ECG signal in order to synchronize the measurement with the cardiac cycle. In this study we present a method for assessing FMD which does not require ECG gating. The approach is based on filtering of the diameter-time curve, which is obtained by means of a B-mode image processing system. Since diameter changes due to vasodilation/vasoconstriction mechanisms and diameter changes induced by the cardiac cycle happen at different frequencies (fractions of Hz for the former; more than 1 Hz for the latter), frequency filtering was used to separate the two components and obtain only the desired information.
The method was tested on 22 healthy volunteers without cardiovascular risk factors and the measurements obtained with the proposed approach were compared with those obtained with ECG gating. Diameter values computed with the new method were very similar to those obtained with ECG gating (3.90±0.75mm and 3.88±0.75mm respectively). %FMD values obtained with the two methods were compared with Bland Altman plot: the bias was negligible (0.02%) and the SD of the difference was 0.24%, a value which is largely acceptable for this measurement.
In conclusion, the new method showed a good agreement with ECG gated measurements. Moreover, since it is based on a larger number of measurements, it provided a higher precision. Further advantages were also found both in terms of reliability of the measure and simplification of the instrumentation.

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P2.18
NON INVASIVE MEASUREMENT OF ENDOTHELIAL DYSFUNCTION BY DIGITAL VOLUME PULSE ANALYSIS TECHNIQUE: APPLICATION & UTILITY IN CLINICAL PRACTICE

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Background: The assessment of endothelial function has been accepted as an independent surrogate marker of cardiovascular disease (CVD), having both positive prognostic and diagnostic implications. The Digital Volume Pulse (DVP) analysis technique is a non—invasive approach to derive endothelial function. However, the utility and clinical application of this analysis technique has not been established.
Methods: we determined the discriminatory performance of the DVP analysis technique in identifying the people with established risk indices compared to a healthy population (West Midlands of the UK). Endothelial dependent and independent vessel function (Δ RI) was calculated by analyzing the change in digital pulse wave forms obtained by DVP photoplethysmography technique(Micro Medicals)
Results: Of our cohort of (n=225) (60.1% male; mean age 53.7 (SE 1.5) years), 155 had established CVD risk factors and had significantly ($P<0.001$) impaired endothelial function (Δ RI% (SE) [Diabetes : 4.6%(0.3), Hypertension: 6.9(0.6), hypercholesteremia 6.4(0.6)] compared to healthy controls [10.5(0.5)]. On univariate analysis, endothelial function was strongly associated with glycaemic status (R:-0.38, P= <0.001) In multivariate analysis, after adjusting for age and other risk factors, glycaemic status independently predicted endothelial function (Beta: -2.32(95% CI:-4.36—0.03), P=0.04) In ROC analysis Δ RI was a better discriminator (AUC(SE): 0.7(0.06) compared to individual CVD risk factors such as mean blood pressure, wait hip ratio and total serum cholesterol level.
Conclusion: Measurement of endothelial function by DVP analysis technique provides a non- invasive method of measuring endothelial function in clinical practice for the discrimination of people with established risk factors and may aid more precise cardiovascular risk stratification.

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