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### **P6.21: EFFECTS OF PHARMACOLOGICAL DRUGS ON THE AORTIC PRESSURE PULSE: UNDERSTANDING MECHANISMS THROUGH MODELLING**

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**Conclusion:** Ageing influences observed arterial stiffness values at given blood pressures through underlying changes in the properties and mechanical loading of arterial wall constituents.

#### P6.18 CAROTID-FEMORAL PULSE WAVE VELOCITY ESTIMATED BY AN ULTRASOUND SYSTEM

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To date, regional aortic stiffness can be evaluated by the reference tonometric technique via the pulse wave velocity (PWV) measured in two points: the carotid and the femoral arteries. Based on a similar intersecting tangent algorithm, we have developed a new method for the determination of carotid-femoral PWV using a high-resolution echo tracking ultrasound system. Herein, PWV can be computed from the measurement of the transit time between the foot of the carotid diameter waveform and the foot of the femoral diameter waveform. The study was carried out on 50 consecutive patients at rest (29 men, mean age  $30 \pm 18$  yrs) recruited on the occasion of a vascular screening for atherosclerosis. Carotid-femoral PWV was determined by a trained operator using a tonometric technique, (PWVpp, PulsePen, Italy), and an echotracking ultrasound system, (PWVus, e-tracking Alpha 10, Aloka, Japan). Relationship between PWVpp and PWVus was evaluated by linear regression. A Pearson's correlation coefficient of  $r=0.95$  was found between both variables (95% confidence interval 0.90-0.99;  $P<0.0001$ ;  $PWVus = 0.91 \cdot PWVpp + 0.44$ ). The Bland-Altman plot comparing PWVpp and PWVus showed a systematic offset of  $-0.07$  m.s<sup>-1</sup> with a limit of agreement from  $-1.33$  to  $1.19$  m.s<sup>-1</sup>. Our results show an excellent and significant correlation between both techniques which confirms that ultrasound system can provide a reliable estimate of the regional aortic stiffness like the tonometric technique does. Additional studies are now needed to show the simplicity of the measurement using ultrasound system while maintaining reliability even in overweight patients.

#### P6.19 PHYSIOLOGICAL CORRELATES OF AORTIC RESERVOIR AND EXCESS PRESSURE IN MAN

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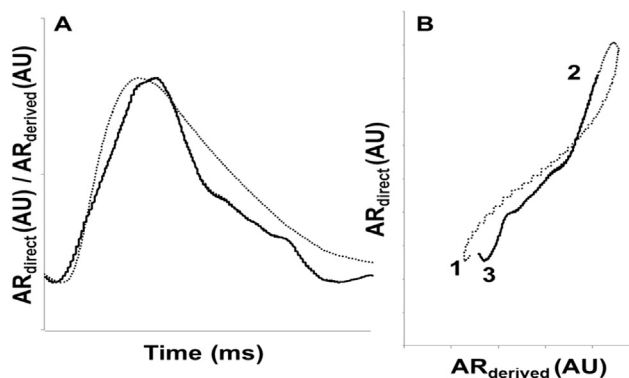
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**Background:** Central (aortic) blood pressure (BP) indices independently predict cardiovascular events and all-cause mortality, but the physiological mechanisms underlying aortic BP waveform morphology are subject to debate. The 'aortic reservoir' and 'excess pressure' are proposed as determinants of aortic BP, but this relationship has only been assessed using a mathematically-derived aortic reservoir-excess pressure model ( $AR_{derived}$  and  $XP_{derived}$ ). This study aimed to directly measure the aortic reservoir ( $AR_{direct}$ ; by cyclic change in aortic volume) and determine the relationship with  $AR_{derived}$  and aortic BP.

**Methods:** Ascending aortic BP and Doppler flow velocity were recorded via intra-arterial wire in 10 males (aged  $62 \pm 12$  years) during coronary artery bypass graft surgery. Simultaneous ascending aortic transesophageal echocardiography was used to measure  $AR_{direct}$ . Published mathematical formulae were used to determine  $AR_{derived}$  and  $XP_{derived}$ . A direct excess pressure ( $XP_{direct}$ ) was calculated by subtracting  $AR_{direct}$  from aortic BP.

**Results:** When normalised to the same scale (Figure A),  $AR_{direct}$  (solid line) was strongly and linearly related to  $AR_{derived}$  (broken line) during systole ( $r=0.980$ ,  $P<0.001$ , Figure B, point 1-2) and diastole ( $r=0.987$ ,  $P<0.001$  Figure B, point 2-3). The cyclic relationship between aortic BP and  $AR_{direct}$  was qualitatively and quantitatively ( $P>0.05$ ) similar to the cyclic relationship between aortic BP and  $AR_{derived}$ . Furthermore,  $XP_{direct}$  was linearly related to  $XP_{derived}$  during systole ( $r=0.909$ ,  $P<0.001$ ) and diastole ( $r=0.663$ ,  $P<0.001$ ).

**Conclusion:** Aortic reservoir and excess pressures are physiological phenomena highly related to mathematically-derived aortic reservoir, excess pressure and aortic BP.



#### P6.20 EFFECTS OF DIFFERENT MEASUREMENT TECHNIQUES ON CAROTID STIFFNESS EVALUATION

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In recent years, great attention has been placed on local carotid elasticity. Carotid pulse wave velocity (cPWV) can be considered a surrogate marker for carotid stiffness evaluation. Aim of this study was to compare four different techniques for carotid stiffness assessment.

Ten young healthy subjects ( $34.7 \pm 6.9$  years, 40% males, BMI  $21.6 \pm 2.2$  kg/m<sup>2</sup>) were enrolled. For each volunteer, four different carotid stiffness measurements were obtained: i) ultrasound carotid stiffness (CS) values were estimated from US diameter and tonometric pulse pressure measurements combined by Bramwell-Hill equation ii)  $cPWV_{loop}$  values were calculated from US simultaneous measurements of diameter and flow velocity using the lnD-V loop slope iii)  $cPWV_{MRI}$  values were obtained from velocity-encoded MRI images using QA method iv)  $cPWV_{Acc}$  values were achieved by means of a new accelerometric system which consists in two percutaneous accelerometers placed 2.4 cm apart on the subject's neck; PWV is calculated dividing the distance between the sensors for the time delay between the signals.

Table 1 shows the results of the comparisons between CS ( $5.39 \pm 0.76$  m/s),  $cPWV_{MRI}$  ( $5.81 \pm 0.77$  m/s),  $cPWV_{loop}$  ( $4.18 \pm 0.96$  m/s) and  $cPWV_{Acc}$  ( $5.12 \pm 1.25$  m/s) values. All the comparisons exhibit satisfying correlations. The only non-significant bias is shown by the comparison between CS values and  $cPWV_{Acc}$  ones while the comparison between CS measurements and  $cPWV_{loop}$  evaluations provides the lowest standard deviation of the difference.

In conclusion, this preliminary study suggests that attention should be placed when using different methods of carotid stiffness assessment, especially in case of comparison between values obtained with different methods.

Table 1

	Mean Difference $\pm$ SD of difference (m/s)	R <sup>2</sup>
CS vs $cPWV_{loop}$	$1.29 \pm 0.42$	0.81
CS vs $cPWV_{MRI}$	$-0.51 \pm 0.54$	0.55
CS vs $cPWV_{Acc}$	$0.27 \pm 0.75$	0.67
$cPWV_{loop}$ vs $cPWV_{MRI}$	$-1.77 \pm 0.56$	0.71
$cPWV_{loop}$ vs $cPWV_{Acc}$	$-1.16 \pm 0.57$	0.66
$cPWV_{MRI}$ vs $cPWV_{Acc}$	$-0.92 \pm 0.99$	0.39

#### P6.21 EFFECTS OF PHARMACOLOGICAL DRUGS ON THE AORTIC PRESSURE PULSE: UNDERSTANDING MECHANISMS THROUGH MODELLING

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Aortic pulse pressure and other pulsatile components of the aortic pressure pulse are important predictors of cardiovascular outcomes, however the

properties of the arterial tree that determine the aortic pulse are still poorly understood. We used numerical modelling to predict aortic pulse morphology and the characteristics of the arterial tree that determine pulse wave morphology when modulated by pharmacological agents with differential actions on the myocardium and arterial tree. Healthy volunteers aged 35 to 63 received cumulative doses of nitroglycerin (NTG, n=8), dobutamine (DB, n=10) and nor-epinephrine (NE, n=9). Aortic pressure was measured by carotid tonometry. Aortic dimensions, pulse wave velocity (PWV), blood velocity and flow were measured by echocardiography. These parameters were used to calculate the input data of a single-vessel, nonlinear one-dimensional model of pulse wave propagation in the human aorta coupled to a three-element Windkessel model of the downstream vasculature. The simulated pressure waveforms relative to the clinical data were reproduced with an averaged normalised root-mean-square-error < 10%, 7% and 6% for DB, NE and NTG groups respectively. By systematically and uniquely changing the parameters of the model by the amount measured clinically whilst keeping all other parameters at baseline conditions we identified the most significant determinant of the final pressure waveform to be total compliance and PWV for DB and peripheral vascular resistance for NTG and NE. Thus the majority of the change in aortic pulse morphology can be explained without invoking a change in the distributed characteristics of the arterial tree.

#### P6.22

##### A NOVEL DEVICE FOR MEASURING ARTERIAL STIFFNESS USING THE FINGER-TOE PULSE WAVE VELOCITY: VALIDATION STUDY OF THE POPMÈTRE®

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**Background:** Finger-toe pathway could represent a good alternative to assess the arterial stiffness conveniently. The aim of this study is to evaluate the accuracy of the pOpmètre which measures finger-toe pulse wave velocity (ft-PWV).

**Methods:** The pOpmètre® has 2 photodiodes sensors, positioned on the finger and on the toe, next to the pulp artery, and a cardiac activity electrode. Pulse waves were recorded continuously for 20 sec, and the difference (Dtf) between the toe pulse wave transit times (PWtt) and the finger PWtt was calculated relative to R-ECG. The travel distance was based on subject's height. Study 1 compared the ft-PWV to the carotid-femoral PWV (cf-PWV) obtained by the reference method SphygmoCor in 86 subjects (53±20 yrs) including 69 patients with various pathologies and 9 healthy normotensives. Study 2 compared the changes of ft-PWV and cf-PWV during a dynamic test in 10 healthy subjects.

**Results:** ft-PWV correlated significantly with cf-PWV ( $r^2 = 0.43$ ,  $p < 0.0001$ ). The better correlation was found in terms of transit time ( $r^2 = 0.6$ ,  $p < 0.0001$ ). The discrepancy between the transit times was related with age. The Dtf also correlated with the transit time at lower limbs. During dynamic changes induced by cold pressor test, both cf-PWV and ft-PWV gave similar patterns, with increase following by a decrease PWV during recovery.

**Conclusion:** pOpmètre® may be a promising device to assess arterial stiffness in routine clinical practice. Further studies are needed to adjust the bias and to validate the pOpmètre in larger populations.

#### P6.23

##### ARTERIAL STIFFNESS MEASUREMENT IN OBESE PATIENTS WITH A NEW DEVICE: POPMETRE®

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**Introduction:** Obesity is associated with increased cardiovascular morbidity and mortality. Arterial stiffness (AS) is an independent cardiovascular risk factor. The objective of this study was to evaluate the SA in obese patients.

**Patients and methods:** AS was measured in 212 participants divided into four groups: non-obese non-diabetic controls (n=114), non-diabetic subjects with obesity (n=37), obese and type 2 diabetic patients (n=34), non-obese type 2 diabetic subjects (n=27). AS was assessed by measuring the pulse wave velocity (PWV) using a new device: pOpmètre® (Axelife sas-France) at the right and the left side.

**Results:** PWV values were increased in obese subjects compared to controls (obese and diabetic patients:  $18.18 \pm 1.08$ , non-diabetic obese subjects:  $11.32 \pm 1.04$ , non-obese diabetic patients:  $15.58 \pm 1.21$  and controls:  $8.39 \pm 0.59$  m/s, mean±SEM,  $p < 0.001$ ). Similar results were observed in the left side ( $p = 0.0005$ ). This increase was more pronounced in obese and diabetic patients. After stratification on the presence of diabetes, we observed an increase of PWV in non-obese diabetic patients, compared to non-diabetic subjects ( $p = 0.001$  and  $0.0001$ ). Stratification on the presence of obesity shown no difference in non-diabetic obese subjects compared to non-obese subjects. Adjustment for sex, age, blood pressure and tobacco, confirmed the increase of PWV in obese and diabetic patients compared to controls (odds ratio: 1.31, 95% CI 1.15–1.51,  $p = 0.0002$ ) and increased PWV in non-diabetic obese subjects compared to controls (odds ratio: 1.25, 95% CI 1.09–1.46,  $p = 0.003$ ). We observed a positive correlation between age and PWV ( $r^2 = 0.24$  and  $0.25$ , for right and left limbs).

**Conclusion:** PWV is increased in obese patients, particularly in those with type 2 diabetes. PWV is positively correlated to ageing.

#### P6.24

##### CLINICAL FEASIBILITY OF THE NEW PULSE TIME INDEX OF NORM (PTIN) AND ITS CORRELATION TO LEFT VENTRICULAR MASS INDEX

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**Background:** Recently the pulse wave velocity (PWV) threshold of hypertensive target organ damage (TOD) was set at 10 m/s. New 24 – h monitors (e.g., BPLab-Vasotens) provide not only 1 PWV but several PWV measurements over a 24 – h period. The new Pulse Time Index of Norm (PTIN) can be calculated from these data. The PTIN is defined as the percentage of a 24 – h period during which the PWV does not exceed 10 m/s. The idea is to adopt the new PWV measurements for the definition of TOD and sharpen its level of detection. The aim of the present study is to test the new PTIN for clinical feasibility and its correlation to left ventricular mass index (LVMI).

**Methods:** Oscillometrically generated waveform files (n=510, measurements ranging from a single point to 72 hours), which were previously used for clinical research, were re-analysed using the new 2013 software version of the Vasotens technology program, which enables PTIN calculation.

**Results:** The cut-off point at 10 m/s in the ROC curve showed a sensitivity of 93.3% and a specificity of 81.5% for single measurements of PWV compared to SphygmoCor. The reference interval of PTIN was equal to 83.2% (lower limit). Reliability statistics showed Cronbach's alpha was 0.967 for day-to-day repeatability (i.e., excellent internal consistency of PTIN). Good correlation ( $r = -0.72$ ) between PTIN and LVMI was shown, and it was significantly above the blood pressure load ( $r = 0.41$ ).

**Conclusion:** Calculating PTIN from Vasotens technology is clinically feasible and seems to enhance the discriminatory power of detecting TOD.