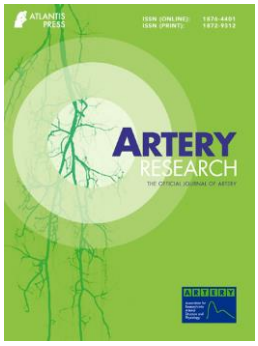

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P6.08: CHARACTERIZATIONS OF THE ARTERIAL SYSTEM COMPARED

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PWV was assessed in all patients first by a fast PC cine sequence of magnetic resonance imaging (MRI) between the ascending aorta and the descending thoracic aorta under the diaphragm and second by Pulsepen and Complior II between right carotid and femoral sites.
Results: Aortic MRI PWV value was 8.00 ± 2.66 m.s-1. Complior II PWV values were significantly lower than those obtained with Pulsepen, respectively 7.88 ± 1.38 m.s-1 vs 9.01 ± 1.64 m.s-1, $p < 0.0001$. There was a good correlation between Pulsepen PWV and aortic MRI PWV ($p = 0.005$, $r = 0.47$) and between Complior II PWV and aortic MRI PWV ($p = 0.01$, $r = 0.43$).
Conclusion: This is the first study to show the reliability of PWV assessment by transcutaneous devices in comparison to MRI PWV measurements in obese patients.

P6.05
MRI AORTIC THORACIC ELASTIC PROPERTIES ASSESSMENT COMPARED TO ARTERIAL STIFFNESS ASSESSMENT BY TRANSCUTANEOUS DEVICES

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Background: Aortic elasticity properties (aortic distensibility, compliance, elastic modulus, and stiffness index) can be evaluated by cross-sectional thoracic aorta areas measurements at 2 times of the cardiac cycle (peak systolic and end-diastolic phases) with PC-cine MRI series. Pulse wave velocity (PWV) measurement between carotid and femoral sites is considered as the gold standard measurement of aortic stiffness and elastic properties of aorta. Obesity is a difficult feature to assess aortic elasticity properties because of methodological problems due to the use of transcutaneous devices.
The aim of this study was to assess aortic elasticity properties with PC MRI and to compare the results with PWV assessed by two transcutaneous devices (Pulse pen and Complior II) in 32 consecutive patients presenting an isolated abdominal obesity defined by a waist circumference >102 cm in men and >88 cm in women ($27 < BMI < 35$).
Results: Aortic cross-sectional compliance assessed with MRI was inversely correlated with: Pulse Pen PWV ($p = 0.01$, $r = -0.44$), with the same trend for Complior PWV ($p = 0.07$, $r = -0.32$). Positive relationship was found between the above 2 PWV measurements and aortic stiffness index computed by MRI. Relationship was stronger for PWV assessed by MRI ($p = 0.02$, $r = 0.41$) and Pulse Pen ($p = 0.03$, $r = 0.38$). The relationship between aortic stiffness index and Complior PWV did not reach statistical significance ($p = 0.12$, $r = 0.28$).
Conclusion: In clinical difficult situation like obesity, aortic elasticity can be measured by PC MRI with a good correlation with peripheral PWV assessments.

P6.06
CAN WE LEARN ANYMORE ABOUT ARTERIAL FUNCTION FROM THE VALSALVA MANOEUVRE? WAVE INTENSITY ANALYSIS CAN INFORM US ABOUT RESERVOIR FUNCTION

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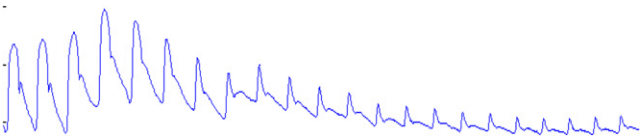
Background: The Valsalva manoeuvre (VM) is a physiological manoeuvre capable of generating profound changes in venous return. Although its physiology has been extensively described, the predominant focus has been on dynamic effects on cardiac preload with subsequent impact on cardiac output. However, analysis of the dramatic changes seen in arterial pressure and flow during this manoeuvre offers valuable insight into arterial function.
Methods: In 11 patients (9male, mean age 64 years), invasive measurement of pressure & Doppler flow velocity were made in the proximal aorta using sensor-tipped intra-arterial wires. Whilst recording, patients performed a controlled VM by blowing into a syringe. Calculation of pressure, aortic reservoir function and wave intensity were performed offline.
Results: Peak systolic blood pressure fell on average by 24% during sustained VM (157 ± 43mmHg to 122 ± 48mmHg, $p < 0.0001$). The peak reservoir pressure fell by an average of 65% (55 ± 17mmHg to 20 ± 13mmHg, $p < 0.0001$). The aortic pressure waveform during sustained VM assumes that morphology typically seen peripherally (Figure).



Conclusion: Prolonged VM is able to dramatically reduce both measured pressure and reservoir pressure in the proximal aorta and appears to produce a loss of this normal 'cushioning' effect. Is this simply a consequence of decreased stroke volume or are there other mechanisms involved?

Pressure waveform recorded invasively in proximal aorta during sustained Valsalva manoeuvre.

P6.07
METHODOLOGICAL ASPECT OF BRACHIAL FLOW MEDIATED DILATION: IMPROVEMENT OF REPRODUCIBILITY

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Brachial artery flow-mediated dilation (FMD) is the most widely used technique for assessing endothelial function in humans. FMD is reduced in the presence of cardiovascular risk factors and diseases and it is an independent predictor of events. However, its major limitation is the relatively low reproducibility. One of the main challenge is to maintain a stable scan plane during examinations, especially when the forearm cuff is inflated/deflated. The aim of this study was to evaluate the FMD reproducibility when resting diameter is calculated as the mean value measured from 8th to 9th minute after reactive hyperemia, when the vasodilation is concluded (BAS_POST), and to compare the results with those obtained with a standard assessment of resting diameter over 1 minute before cuff inflation (BAS_PRE). Thirty healthy subjects (age 25-45 years) underwent two FMD examinations 30 minutes apart. FMD to 5 minutes forearm ischemia was assessed by one trained operator using a clamp to hold the ultrasound probe in the same position and calculated as maximum percentage increase in diameter with respect to BAS_PRE and BAS_POST, by a real-time automatic edge-detection system (FMD Studio, Institute of Clinical Physiology, Pisa, Italy). FMD% variability was assessed as intra-session coefficients of variation (CV). Diameter was $3.56 + 0.66$ mm in BAS_PRE and $3.57 + 0.66$ mm in the BAS_POST. FMD% was $7.4 + 3.8$% with BAS_PRE and $7.1 + 3.7$% with BAS_POST. CV of FMD% was $15.61 + 10.9$% in BAS PRE and $9.22 + 5.93$% with BAS_POST calculation. These results suggest that FMD% calculated with BAS_POST can ensure a more reproducible measure of conduit artery endothelial function.

P6.08
CHARACTERIZATIONS OF THE ARTERIAL SYSTEM COMPARED

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Systolic pressure, P_s, and pulse pressure, PP, are determined by heart and arterial system. We here compare systemic arterial system characterizations alone, and mention their use and limitations (aspects).
1. *Peripheral resistance*, R_p. Required: Mean Pressure and Cardiac Output; Characterization: partial. Aspects: derivation simple; linear.
2. *Arterial Input Impedance*, Z_{in}. Required: Pressure, $P(t)$, and flow, $F(t)$; Characterization: complete and comprehensive. Interpretation: R_p, Total Arterial compliance, C, Characteristic impedance, Z_c. Aspects: Derivation difficult, data noisy; linearity.
3. Wave Transmission
   a. Aortic Pulse Wave velocity, c, (Foot-foot wave speed). Required: two (uncalibrated) $P(t)$, (flows or diameters); Characterization: (Total) Arterial compliance. Aspects: Derivation simple, Aorta a uniform tube. Carotid-Femoral: not entire aorta; i.e., not total arterial compliance.
   b. Waveform Analysis. Required: $P(t)$, $F(t) + Z_c$. Characterization: Amount and timing of reflections. Interpretation: diffuse (peripheral) and distinct reflections. Tube (aorta) with reflection site at end, no phase shift. Phase shift and c, change with age and effects may cancel. Aspects: Only timing and ratio $P_{backward}/P_{forward}$ give arterial characterization. Small error Z_c real.

4. Lumped Models

a. Two-element, Frank's, Windkessel. Required: *P(t)* and CO. Many ways to derive *C* (e.g. RC-time). Interpretation: R_p, and *C*, see 2. Aspects: No Z_c.

b. Three-element Windkessel. Required: *P(t)* and *F(t)*. Computer fits. Interpretation: Model description of 2, R_p, *C*, and Z_c. Aspects: Mean $P = CO(R_p + R_c)$ not only R_p.

5. *Wave Intensity Analysis*. Not a characterization of the arterial system alone. Reflections as 3b above.

CONCLUSION: only 2 and 4b characterize the whole arterial system.

P6.09

ULTRASONOGRAPHIC MEASUREMENT OF ARTERIAL WALL AND INTRAPLAQUE STRAIN IN THE CAROTID BULB AND COMMON CAROTID ARTERY

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Background: Transient ischemic attacks and stroke are commonly caused by vulnerable plaques in the carotid bulb. Noninvasive ultrasound imaging techniques, revealing spatial inhomogeneities in strain distribution, could possibly improve the timely diagnosis of plaque at risk of rupturing.

Methods: In 20 subjects with cerebrovascular ischemia, radiofrequency ultrasound data, covering 20 by 24 mm, of the carotid bulb and distal common carotid artery (CCA) were twice and bilaterally recorded during 6 cardiac cycles to assess 2D wall strain rate distribution at radial and lateral increments of 0.45 mm and 1.8 mm, respectively at peak distension rate.

Results: Reproducible strain rates were obtained for distal CCA and carotid bulbs free of plaques (unilateral intrasubject variation of 1.1 ± 0.6%/s and 1.2 ± 0.7 %/s, respectively). Strain rate was generally higher in the distal CCA (7.5 ± 3.9%/s) than in carotid bulb (3.4 ± 2.5%/s). Strain inhomogeneity was significantly associated to plaque area ($p < 0.001$) and was lower in distal CCA (1.2 ± 0.6) than in carotid bulb (1.6 ± 1.0).

Discussion: High resolution strain distribution in carotid segments reveals inhomogeneities in mechanical characteristics of the artery wall, and of the carotid artery plaques. Strain in the distal CCA is different in magnitude and inhomogeneity from the strain in the carotid bulb. Therefore, the proposed method for noninvasive identification of wall composition using ultrasonography might be a powerful tool to assess the plaque burden in an arterial segment particularly prone to plaque formation.

P6.10

A COMPARISON BETWEEN THE VICORDER AND SPHYGMOCOR DEVICES FOR THE NON-INVASIVE ASSESSMENT OF CENTRAL BLOOD PRESSURE

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Background: There is increasing evidence that central (aortic) blood pressure (BP) may be a more important determinant of cardiovascular risk than brachial BP. Most of actual devices to assess central BP non-invasively are partially operator-dependent, or rely on the detection of the late systolic shoulder as an estimation of central systolic BP (cSBP). The Vicorder is a new cuff-based, operator-independent device which obtains brachial BP waveforms using a volume displacement method and derives aortic waveforms using a previously published brachial-to-aortic mathematical transfer function[1].

Aim: to compare central BP measurements using the Vicorder and SphygmoCor devices.

Methods: 27 subjects (38 ± 11 years, 44% males) without cardiovascular diseases were studied after 10 minutes of supine rest. Brachial BP was assessed using the Vicorder. Brachial pressure waveforms calibrated to brachial systolic and diastolic pressure were recorded using the Vicorder and radial pressure waveforms calibrated to brachial mean and diastolic pressure were recorded using the SphygmoCor. The corresponding cSBP measurements were compared between devices (vcSBP versus sphygcSBP).

Results: The average ($\pm$SD) brachial BP was $113 \pm 12/63 \pm 8$ mmHg. There was good agreement between vcSBP (106 ± 12mmHg) and sphygcSBP (105 ± 15mmHg; $P = 0.56$). Similar results were observed for central pulse pressure (cPP), with a mean difference of 1.6 mmHg ($P = 0.18$). Conclusions: the values of cSBP and cPP provided by the Vicorder and SphygmoCor devices show good agreement when radial artery waveforms are calibrated to brachial mean and diastolic pressure. Further comparative data are required in a larger sample size, and with invasive BP measurements.

1. O'Rourke M. Cardiovascular Research.1970;4;291-300.

P6.11

RELATIONSHIPS BETWEEN ENDOTHELIAL FUNCTION, ARTERIAL ELASTICITY AND BAROREFLEX SENSITIVITY

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Endothelium derived nitric oxide (NO) increases conduit artery distensibility, through relaxation of vascular smooth muscle. Barosensory wall distensibility influences the mechanical component of baroreflex sensitivity (BRS) by modifying the baroreceptor stimulus. NO bioavailability may also affect the neural component of BRS, by influencing afferent sensitivity, central neural processing or neuroeffector mechanisms.

We aimed to study the relationships between the above variables in young healthy volunteers ($n = 28$, male:female 10:18; age 16.5 ± 1.4 years).

To this end we measured brachial artery endothelial function by brachial flow mediated dilatation normalized with peak mean shear rates (nFMD) and carotid artery biomechanical parameters and blood pressure by ultrasonographic wall-tracking and tonometry. From these variables elastic parameters were calculated. BRS was measured by the spontaneous sequence method (Seq+).

The mean values (mean $\pm$ SD) were 5.41 ± 1.49 [10^{-3}/mmHg] and 4.79 ± 1.14 for carotid artery distensibility coefficient and stiffness index β, respectively, 2.59 ± 1.00 for nFMD and 25 ± 16 [ms/mmHg] for Seq+. Using correlation and linear regression analysis, we found that elastic parameters were not related, but BRS was significantly related to nFMD ($r = 0.486$, $p < 0.05$). However, the correlation was limited only to males ($r = 0.681$ $p < 0.05$ vs. $r = 0.368$ $p = 0.133$, females).

Our results suggest that the positive correlation between endothelial function and BRS can not be explained by the mechanical vessel wall properties. This association may be due to neural mechanisms transmitted by NO. The gender differences and the relationship between endothelial function and the neural component of the BRS need further studies.

P6.12

BRACHIAL ARTERY REACTIVITY IS DIRECTLY PROPORTIONAL TO BASAL BRACHIAL ARTERY TONE: POSSIBLE CONFOUNDER IN MEASURING ENDOTHELIAL FUNCTION

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Brachial artery reactivity following compression is used as a surrogate marker of endothelial function. Brachial diameter increases exceeding 10% indicate normal endothelial function. We investigated if basal brachial artery tone influenced brachial artery reactivity.

One hundred never smoking, healthy, normotensive, normolipidaemic subjects (41 + 9 yrs, 71F, 29 M) underwent brachial artery assessments. Basal, Reactive (endothelial dependant diameter change following 4 minutes of cuff compression) and Post GTN (endothelial independent dilatation) diameters were recorded.

Tone was calculated as the percent difference in Post GTN and Basal brachial diameters.

Basal diameter 3.6 + 0.05 mm, Reactive diameter 4.0 + 0.06 mm, Post GTN Diameter 4.4 + 0.1 mm

There was a significant correlation between Brachial artery reactivity and basal brachial artery tone (All $r = 0.60$, $p < 0.0001$, Women $r = 0.57$, $p < 0.0001$, Men $r = 0.68$, $p < 0.0001$).

These data indicate that basal brachial tone has a strong association with the degree of brachial artery reactivity in men and women and consideration should be given to the influence of tone on percent reactivity when measuring endothelial function by this methodology.

A Reactivity/Tone ratio should be considered once new cut-off points are determined.