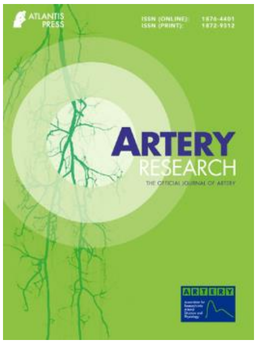

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P2.21: AORTIC AND CAROTID PWV ASSESSMENT: A MULTI-TECHNIQUE APPROACH

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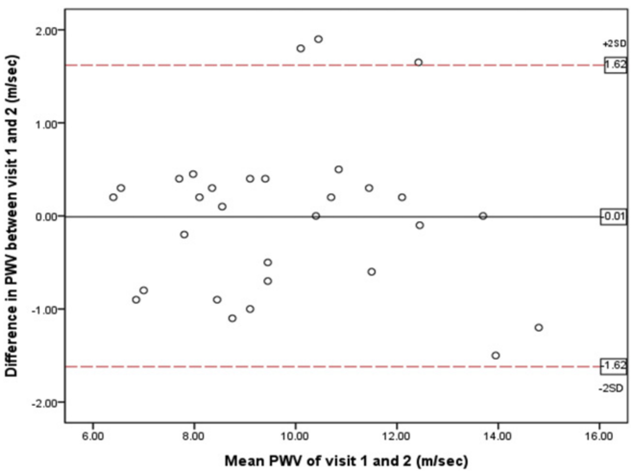

Figure 1 Bland and Altman plot showing between days difference in Pulse Wave Velocity (PWV) in patients with COPD.

P2.18

STUDY OF THE DETERMINANTS OF PWV MEASURED BY ARTERIOGRAPH AND SPHYGMOCOR AND THE DETERMINANTS OF DISCREPANCIES

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Introduction: Large artery stiffness is recognized as a strong, independent marker of cardiovascular risk, mainly through aortic pulse wave velocity (PWV). Arteriograph is a non-invasive oscillometric method, which estimates aortic PWV through brachial pressure wave analysis.
Aim: To compare the determinants of PWV measured with Arteriograph (Ar PWV) to carotid-femoral PWV (CF PWV) determinants and to study the determinants of discrepancies.
Methods: CF PWV was assessed by applanation tonometry (SphygmoCor®) and Ar PWV was assessed by Arteriograph. Multivariate analysis and stepwise regression was performed to study the determinants and Pearson's coefficient to study correlations.
Results: 90 subjects were included: 30 healthy subjects and 60 patients with essential hypertension. The correlation between Ar PWV and CF PWV is good ($r=0.77$; $p<0.001$). Determinants of CF PWV are arterial blood pressure and age as expected. Determinants of Ar PWV are unusual: jugulum-pubic symphysis distance, diabetes status and gender ($R^2=0.15$; 0.19 and 0.09 respectively). Concerning determinants of discrepancies of PWV we found again jugulum-pubic symphysis distance and gender ($R^2=0.08$; 0.14 respectively). And for determinants of discrepancies of the time delay (Δt): carotid stiffness parameters ($R^2=0.15$) and wave reflexions ($R^2=0.10$)
Conclusion: Arteriograph is well correlated with CF PWV but determinants of Ar PWV and CF PWV are different, Arteriograph seems to be sensitive to metabolic factors. Adjustments may have to be done in further studies.

P2.19

NON-INVASIVE ASSESSMENT OF CAROTID-FEMORAL PULSE WAVE VELOCITY. DOES THE MEASUREMENT SIDE MATTER?

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Recently an expert consensus group advised to measure carotid-femoral (cf) pulse wave velocity (PWV) on the right side of the body, using 80% of the distance between the carotid and femoral measurement site measured with a tape (80% rule). The present study investigated the real travelled cf path lengths at the left and right body side and compared the tape measure distance with the straight distance as obtained using an anthropometer.
Real travelled cf path lengths were measured with MRI in 98 healthy subjects (49 men, age 21-76 years). Path lengths from the aortic arch to the carotid (AA-CA) and femoral (AA-FA) sites were determined. The real travelled path length was calculated as (AA-FA)-(AA-CA). Straight distances between carotid and femoral sites were derived from the MRI images.
The real travelled cf path was slightly longer [11 mm (12), $p<0.001$] at the right side compared to the left. The proposed 80% rule overestimated real travelled cf path lengths with 0.5% at the right and 2.7% at the left side. Straight distance resembled more closely the real travelled distance (Right: 0.2 %, Left: 2.0 %), although not significantly different from tape measure ($p=0.085$).
The travelled cf path is slightly longer at the right than at the left body side. The present study supports the advice of the expert consensus group to preferentially measure cf-PWV at the right body side and suggests that the highest level of accuracy may be obtained using the straight distance, which supports the use of an anthropometer.

P2.20

NON-INVASIVE ESTIMATES OF CENTRAL SYSTOLIC BLOOD PRESSURE: COMPARISON OF THE CENTRON CBP301 AND SPHYGMOCOR DEVICES

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Background: Central systolic blood pressure (cSBP) may be more predictive of cardiovascular events than brachial BP. Therefore, non-invasive methods of determining central BP, which are suitable for routine clinical use, are required. The aim of this study was to compare estimates of cSBP provided by the Centron cBP301 with those obtained with the widely used SphygmoCor system.
Methods: In 60 subjects (30 females), age range 22-90 years, brachial BP was measured using the Centron device and then cSBP estimated using the Centron, and then SphygmoCor. In a subset of 16 subjects (8 females), measurements were repeated at rest and following the administration of glyceryl trinitrate (GTN).
Results: There was a strong correlation ($r=0.98$; $P<0.001$) between the estimates of cSBP obtained with each device. There was also good agreement between devices, with a mean difference ($\pm$SD) of 0.2 ± 3.5mmHg ($P=0.5$). Similarly, the devices were highly correlated and in good agreement following the administration of GTN, with the mean difference in cSBP ranging from 0.5 ± 3.9mmHg to 2.3 ± 3.7mmHg, across the measurement period.
Conclusion: The Centron cBP301 and SphygmoCor devices produce similar estimates of cSBP, both at rest and in response to a pharmacological challenge. The Centron device is potentially suitable for routine clinical monitoring of central BP.

P2.21

AORTIC AND CAROTID PWV ASSESSMENT: A MULTI-TECHNIQUE APPROACH

N. Di Lascio [1], D. De Marchi [2], E. Bianchini [1], V. Gemignani [1], R. M. Bruno [1], G. Giovannetti [1], V. Hartwig [1], F. Faita [1]
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Arterial stiffness plays an important role in the development of cardiovascular diseases and is increasingly used in clinical practice as a biomarker of disease's progression. Pulse wave velocity (PWV) is considered a state of the art surrogate marker for arterial stiffness assessment. Aim of this study was to compare regional and local (aortic and carotid) PWV values obtained with different techniques and to test feasibility of creating a dataset with these non-invasive PWV measurements.
Eight young healthy subjects (31.2 ± 7.9 years, 50% males, BMI 23.1 ± 3.3 kg/m^2) have been recruited. For each subject carotid-femoral PWV (cfPWV) measurements were obtained by applanation tonometry while carotid stiffness (CS) values were calculated from common carotid ultrasound images analysed by contour tracking techniques and Bramwell-Hill equation; carotid pressures measurements were estimated by local applanation tonometry. Two different sequences (at aortic and carotid level) of velocity-encoded MRI images were acquired for each subject: local aortic and carotid PWV (aPWV and cPWV respectively) values were calculated from these images using QA method.

Comparison between MRI aPWV (mean: 4.78±1.41 m/s) values and cfPWV (mean: 7.76±0.90 m/s) values showed a good correlation ($R^2=0.73$). MRI cPWV (mean 1.99±0.74 m/s) values were positively correlated ($R^2=0.90$) with CS (mean: 4.88±0.86 m/s) values and showed a lower correlation with cfPWV ones ($R^2=0.14$).
In conclusion, this preliminary study shows a multi-technique approach for regional and local PWV calculation aimed to realize a reference database that could be used when developing and validating new algorithms and techniques for PWV evaluation.

P2.22
ASSESSMENT OF CAROTID PULSE WAVE VELOCITY CHANGES OVER CARDIAC CYCLE: AN ACCELEROMETRIC APPROACH

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Great attention has been placed on the role of carotid elasticity in cardiovascular risk evaluation. Since carotid pulse wave velocity (cPWV) value changes over cardiac cycle, non-invasive cPWV measurements at different cardiac cycle moments could be helpful for a full characterization of vascular behaviour. Aim of this study is to test a new accelerometric system for cPWV assessment able to estimate three different cPWV values. Moreover, preliminary results regarding their comparison with ultrasound carotid stiffness (CS) evaluation are presented.
Twelve healthy subjects (33.4±7.2 years, 50% males, BMI 22.7±3.5 kg/m^2) have been recruited. CS values were obtained from ultrasound B-mode images analysed by contour tracking techniques together with tonometric local pulse pressure estimation and Bramwhell-Hill equation. A small device, with two percutaneous accelerometers (distance: 2.4 cm) placed on a soft bracket allowed to vibrate freely, was put on the neck of each subject. Temporal shifts between the two accelerometric signals were assessed on beat-to-beat temporal basis with correlation techniques. These temporal values allowed cPWV assessment for the whole cycle (allcPWV), diastolic (dcPWV) and dicrotic notch (dncPWV) phase.
Accelerometic allcPWV (3.81±0.70 m/s) values showed a good correlation with CS measurements (r=0.41) while dcPWV (3.26±0.97 m/s) and dncPWV (3.74±0.59 m/s) where less correlated with them (r=-0.17 and r=0.04 respectively). As we could expect dcPWV values were smaller than dncPWV ones.
In conclusion, the proposed system is easy-to-use and it could be useful for the evaluation of cPWV values characterizing the entire cardiac cycle, as well as diastolic and dicrotic notch phases.

P2.23
NONLINEAR ARTERIAL PROPERTIES: PRESSURE-INDEPENDENT CHARACTERIZATION

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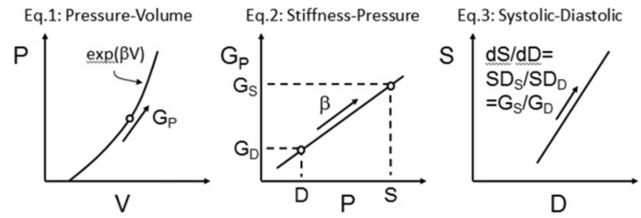
The pressure-volume relationship in real arteries is nonlinear. As a result, stiffness is pressure-dependent. Hereby, I propose a model-based pressure-independent and measurable characterization for such arteries. Literature shows that under normal conditions arterial pressure P, as measured in vitro or in vivo at the systolic pressure (S) and diastolic pressure (D), increases exponentially with the absolute or relative arterial volume V, lumen area or diameter (Eq.1&Figure). The *pressure-independent* exponent β ('stiffness constant') has diagnostic and prognostic significance. Defining arterial stiffness G_P by dP/dV, Eq.1 shows that G_P equals to βP plus a constant (Eq.2&Figure). Thus, β expresses the stiffness change per 1mmHg increase of pressure. Eq.2 predicts a linear relationship between repeatedly measured S and D, (Eq.3&Figure). Eq.2 shows that the change in S per 1mmHg increase in D ('dS/dD') is the mean relative increase in arterial stiffness during the systole G_S/G_D (Eq.3&Figure), i.e. 'stiffening', where dS/dD=1 for elastic arteries. The statistical estimate of dS/dD is given by SD_S/SD_D, where SD is the standard deviation (Figure). Using 24hABP data of 1,247 hypertensive patients (age 57±26 and 50% males) Eq.3 was confirmed with r=0.76±0.14 and dS/dD=1.4±0.3 with 90% of values in the range 1.0-2.0. Eq.2 was confirmed by Schillaci et al 2011 by measuring the diastolic pulse wave velocity (PWV_D) at different arm positions (since $G_D \sim PWV_D^2$), and Eq.3 was used to determine the systolic PWV or G_S. In conclusion, nonlinear arterial properties are strongly expressed during the cardiac cycle. Its modelling may be useful in interpreting stiffness measured by different methods.



P2.24
SEMI-INVASIVE CARDIAC OUTPUT MEASUREMENT BASED ON PULSE CONTOUR ANALYSIS: A REVIEW AND META-ANALYSIS

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Background: Different methods and several devices exist for measuring cardiac output by minimal invasive techniques, all based on arterial pulse contour analysis (FloTrac®/Vigileo®, Edwards Lifesciences; PiCCO®, Pulsion Medical Systems; LiDCO®/PulseCO®, LiDCO Ltd; PRAM/Mostcare, FIAB SpA; Modelflow®, Finapres Medical Systems). However, their measurement accuracy, especially during changing patient conditions, remains under discussion. The underlying CO measurement methods and their limitations will be presented in detail and the results of recent comparative studies between these devices and the "gold standard", pulmonary artery catheter thermodilution (PAC TD), will be discussed.
Methods: Prospective studies and available reviews on the comparison of the pulse contour approach with the established PAC TD technique were enclosed in our meta-analysis. As far as available, the relevant results (data for the range of cardiac output, bias, percentage error) and the software versions used were included.
Results: Studies comparing the available systems for CO measurement have been performed in a variety of clinical settings. For instance, out of 53 analysed studies of CO determination by arterial pulse contour analysis, the majority shows acceptable accuracy during stable hemodynamic conditions. However, the studies under varying hemodynamic situations (vasoactive drug administration, loss of fluids etc). demonstrate insufficient accuracy (with percentage errors exceeding the 30% limit as suggested by Critchley&Critchley).
Conclusions: Under stable hemodynamic conditions CO measurements based on intermittent bolus TD and arterial pulse contour analysis seem to yield comparable **Results:** Further improvement and validation studies are needed to prove the reliability of CO determination in unstable patients with the systems presently available.
Keywords: Cardiac output, arterial pulse contour, thermodilution, FloTrac™/Vigileo™, PiCCO®

P2.25
THE EFFECT OF MUSCULARITY AND HANDEDNESS ON RADIAL ARTERIAL PULSE WAVE VELOCITY IN HEALTHY VOLUNTEERS

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Introduction. Despite current interest in conduit artery stiffness, no in-vivo studies have reported its relationship to surrounding muscle and the possible effects of tethering. We investigated the effect of musculature and handedness on radial artery pulse wave velocity (raPWV) in each arm to test three hypotheses. Is there: 1) a difference in raPWV between the dominant and non-dominant arm? 2) an association between arm muscularity and raPWV? and 3) a difference in raPWV between left and right handers?
Methods: Handedness was assessed by questionnaire and examination of signatures in 54 healthy volunteers (18-40yr; 22 left-handed, male/female 12/10; 32 right-handed, male/female 17/15). Muscularity was defined by arm circumference measurements. raPWV was measured between the distal end of the brachial artery (8MHz Huntleigh Doppler) and the tip of the ring finger (Nelcor clip-on pulse-oximetry sensor). Data were sampled for 30s at 1kHz and analysed off-line.
Results: 1)There was no significant difference between dominant and non-dominant raPWV (paired t-test) and no sex differences in either arm. 2)