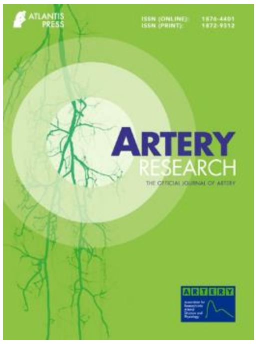


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# P2.08: CENTRAL-TO-PERIPHERAL BLOOD PRESSURE AMPLIFICATION: INVASIVE VALIDATION OF TWO DEVICES (SPHYGMOCOR AND OMRON HEM9000AI)

G. Pucci, F. Battista, S. Notaristefano, C. Cavallini, E. Mannarino, G. Schillaci

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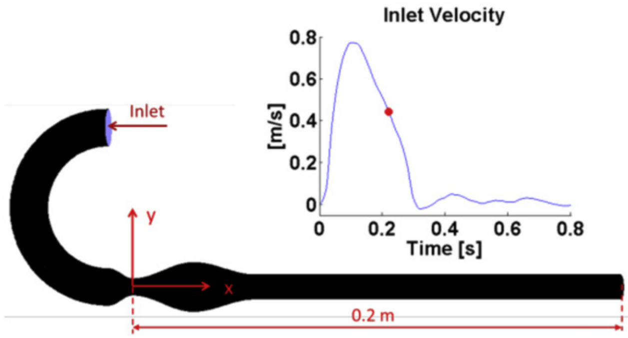


**Figure 1** Geometry with flow direction and inlet pulse profile.

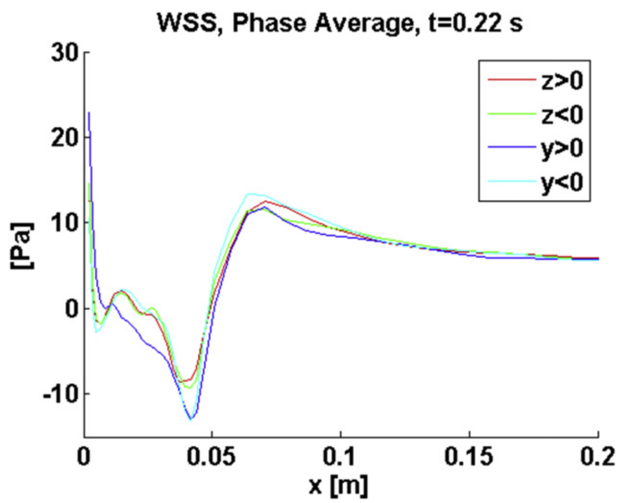


**Figure 2** Phase averaged axial WSS along four lines between the throat (x=0) and the exit (x=0.2 m).

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[1] Kleinstreuer, C. and Lei, M. and Archie, J.P. Jr., "Flow input waveform effects on the temporal and spatial wall shear stress gradients in a femoral graft-artery connector", J Biomech Eng., Vol. 118, No 4, 506-510, 1996.

### P2.06
### RETINAL PULSE WAVE VELOCITY ASSESSMENT FOR IN-VIVO ESTIMATION OF MICROCIRCULATORY ARTERIAL STIFFNESS IN MEDICALLY VALIDATED HEALTHY VOLUNTEERS

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A novel clinical methodology is proposed, which characterizes in-vivo arterial stiffness in the central microcirculation. Pulse wave propagation in retinal arteries is assessed and a parameter "retinal pulse-wave velocity" (rPWV) is calculated. We demonstrated previously that both aging with not excluded cardiovascular risk factors and mild arterial hypertension are associated with elevated rPWV. Whether rPWV increases with age in a cohort of medically validated healthy subjects is investigated. 71 healthy 41.0±12.1 (range: 20 — 66) years old volunteers were examined. The following cardiovascular risk factors were excluded: overweight, increased blood pressure, cholesterol level and blood glucose. Time dependent alterations of vessel diameter were assessed by the Dynamic Vessel Analyzer in a segment of a retinal artery. The data was filtered and evaluated by methods of mathematical signal analysis in order to obtain rPWV value. rPWV amounted to 370±100 (range: 180 — 620) units/second in the whole group (units correspond to μm in the Gullstrand's eye model). In the cohort rPWV increased with age (Pearson's correlation: r=0.41, p<0.005) to 21 units/second per a decade. rPWV showed weak correlations with vessel diameter: r=-0.27, p<0.05 and mean arterial pressure: r=0.22, p<0.05. Thus healthy aging with excluded mentioned cardiovascular risk factors is associated with a flat increase of rPWV and hence with age-related elevation of retinal arterial stiffness. This rPWV alteration and absolute rPWV values in medically validated volunteers allow to distinguish this cohort well from young hypertensives (1620±1310 units/second) or aged subjects with not excluded cardiovascular risk (1200±520 units/second) reported in our previous studies.

### P2.07
### CENTRAL HEMODYNAMIC ESTIMATES BY ULTRASOUND-DERIVED CAROTID DISTENSION WAVEFORMS: COMPARISON WITH APPLANATION TONOMETRY

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**Background:** new commercially available radiofrequency (RF) based ultrasound (US) allows accurate depiction of common carotid (CCA) distension waveforms, whereas carotid applanation tonometry represents a validated technique for pressure waveform description. From both distension and pressure waveforms local carotid pressure and some hemodynamic indices, such as Left Ventricular Ejection Time (LVET), are obtained. Aim of this study was to validate estimates of local CCA pressure and LVET by ultrasound distension waveforms against applanation tonometry.
**Methods:** in 112 subjects (66 males; mean age 56.2±9.9; 16 non diabetic non hypertensive, NL; 34 hypertensives, HT; 62 diabetics, DM), right CCA distension waveforms were obtained by RF-based wall tracking of the near and far wall (MyLab70, Esaote). Afterwards, CCA pressure waveforms were recorded by applanation tonometry (Pulsepen, Diatecne). Local systolic, diastolic and pulse pressure were derived calibrating both waveforms for brachial pressure (Omron) as previously described (Van Bortel LM et al, J Hypertens 2001). LVET was also evaluated with both systems.
**Results:** brachial SBP and PP were 137.0±17.1 and 57.4±13.9 mmHg, significantly higher (p<0.001) than those recorded by tonometry or US. Brachial DBP was 79.6 ± 8.9 mmHg. US-derived SBP, DBP and PP were slightly but significantly higher than tonometric values, while LVET was lower (see Table).

| Method | SBP (mmHg) | DBP (mmHg) | PP (mmHg) | LVET (ms) |
|---|---|---|---|---|
| Tonometry | 121.3±15.8 | 77.9±9.2 | 43.5±13.1 | 317±27 |
| Ultrasound | 126.6±16.6** | 79.6±8.7** | 46.9±13.8** | 297±25** |

**: p<0.01 for US vs Tonometry.

However, corresponding measures obtained with the two techniques were well correlated (r values from 0.754 and 0.896, p< 0.001). In Bland-Altman analysis, the outliers were between 4 and 6 for each parameter.
**Conclusions:** RF-US allows accurate estimate of central BP and LVET.

### P2.08
### CENTRAL-TO-PERIPHERAL BLOOD PRESSURE AMPLIFICATION: INVASIVE VALIDATION OF TWO DEVICES (SPHYGMOCOR AND OMRON HEM9000AI)

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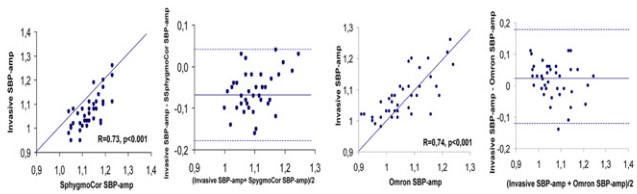
**Introduction:** central-to-peripheral systolic blood pressure (SBP) and pulse pressure (PP) amplification (SBP-amp, PP-amp) are independent predictors of cardiovascular events beyond brachial BP. The non-invasive estimation of central BP is limited by the differences between invasive brachial BP and cuff-based BP measurements. SBP-amp and PP-amp, given their independence from BP, are less influenced by brachial BP input errors.

**Objective:** to compare SBP-amp and PP-amp given by Omron HEM9000AI and SphygmoCor devices with invasive SBP-amp and PP-amp.

**Methods:** during coronary angiogram, invasive BP was measured in ascending aorta and in the brachial artery after pulling back a 6F fluid-filled catheter in 40 patients (66±12 years, 88% males). Simultaneously, radial waveform was acquired by the two devices contralaterally, and brachial BP was measured oscillometrically. Radial waveform was calibrated to brachial SBP/DBP. Radial-to-aortic transfer function (SphygmoCor) or the second systolic peak (HEM9000AI) were used for central BP estimation. Amplification was calculated as brachial BP/central BP.

**Results:** invasive aortic and brachial BP were 139/71±18/10 mmHg and 146/68±18/10 mmHg. Both devices underestimated central SBP (HEM9000AI -6±11 mmHg, SphygmoCor -18±9, both $p<0.001$). Invasive SBP-amp was 1.05±0.07 while invasive PP-amp was 1.18±0.19. HEM9000AI provided reasonable estimates of SBP-amp and PP-amp (ΔSBP-amp -0.01±0.08, ΔPP-amp -0.06±0.21, both p=n.s.), while SphygmoCor overestimated both SBP-amp and PP-amp (Δ vs invasive 0.08±0.07 and 0.15±0.16, both $p<0.001$, Figure).

**Conclusions:** SBP-amp and PP-amp non-invasively estimated by HEM9000AI was in line with invasive SBP-amp and PP-amp, while SphygmoCor overestimated SBP-amp and PP-amp. Systematic measurement errors or other variables may be responsible for the difference between the two devices.




## P2.09

### DIASTOLIC 'WAVE' BELIES ITS UNDERLYING MECHANICS

K. D. Reesink [1], J. E. Davies [1], C. M. Park [1], K. H. Parker [1], A. W. Khir [2], A. D. Hughes [1]
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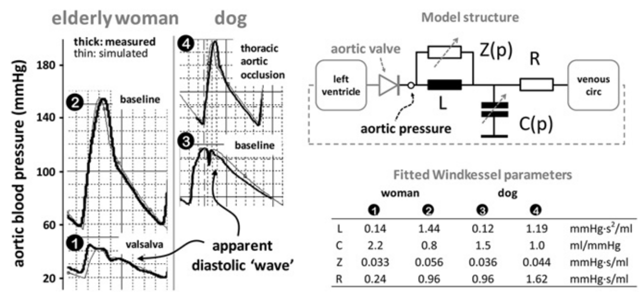
Aortic blood pressure waveforms in young normotensive subjects exhibit a wave-like amplitude increase in diastole (Figure). Current views contend that this signals a reflected wave which summates with the incident arterial pulse wave, producing the dicrotic pulse waveform. With arterial stiffness (thus pulse wave velocity) increasing with age, the reflected wave will arrive earlier, augmenting systolic pressure while the diastolic 'wave' disappears. This paradigm assumes ventricular-arterial interaction is a linear time-invariant system, which is questionable because arterial compliance is pressure-dependent and the system contains a valve. We studied the diastolic 'wave' in a non-linear time-varying model and based on pressure recordings in an elderly woman and a dog, both showing the presence of a diastolic 'wave' at lower pressure but none at higher pressure (Fig.). Our analyses show that at lower pressures total inertia maintains ventricular outflow whilst pressure declines *before* valve closure and that *upon* valve closure a diastolic 'wave' is induced by conversion of kinetic into potential energy by vascular inertia (L). At higher pressures the associated lower arterial compliance (C) caused the diastolic peak to occur earlier in time. However, to fully simulate the high pressure data, L had to be 10 times the value at lower pressure (Table). Our findings suggest that in young normotensive subjects interplay between inertia and compliance reduces systolic pressure and induces the diastolic 'wave', while in old hypertensive subjects these effects are absent. We conclude that the mechanics underlying the diastolic 'wave' may not comply with the wave reflection paradigm.




## P2.10

### COMPARISON OF THE VICORDER AND SPHYGMOCOR DEVICES IN ROUTINE, COMMUNITY-BASED BLOOD PRESSURE ASSESSMENT

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Estimates of central blood pressure (BP) using the Vicorder have recently been validated in the catheter- and clinical-laboratory settings. The aim of the present study was to compare estimates of central BP obtained with the Vicorder and SphygmoCor, in a routine, community-based screening setting. Paired Vicorder and SphygmoCor measurements of central BP were available in 1032 individuals, age range 20-93 years. Brachial cuff BP was assessed using the Vicorder and central pressure derived from brachial cuff BP waveforms recorded with the same device. Brachial cuff pressure was also measured using an Omron 705CP and radial pressure waveforms recorded using the SphygmoCor. Both approaches used the respective brachial systolic and diastolic BP for peripheral waveform calibration, and the order in which Vicorder and SphygmoCor measurements were made was random.

Brachial cuff BP measured with the Vicorder and Omron devices were highly correlated ($r=0.80$, $P<0.001$, SBP; $r=0.74$, $P<0.001$, DBP) and in reasonable agreement, with a mean difference (±SD) between devices of 4±11 mmHg for SBP ($P<0.001$) and 5±7 mmHg for DBP ($P<0.001$). Similarly, estimates of cSBP were highly correlated ($r=0.82$, $P<0.001$) and in reasonable agreement (mean difference of 2±10 mmHg, $P<0.001$). In younger individuals, Vicorder-derived cSBP tended to underestimate SphygmoCor-derived values (Figure).

When used in routine practice, the Vicorder and SphygmoCor produce similar estimates of central systolic BP, although a greater disparity tended to be present in younger individuals. The ease of a cuff-based system for estimating central pressure is likely to be better suited to community-based screening programmes.

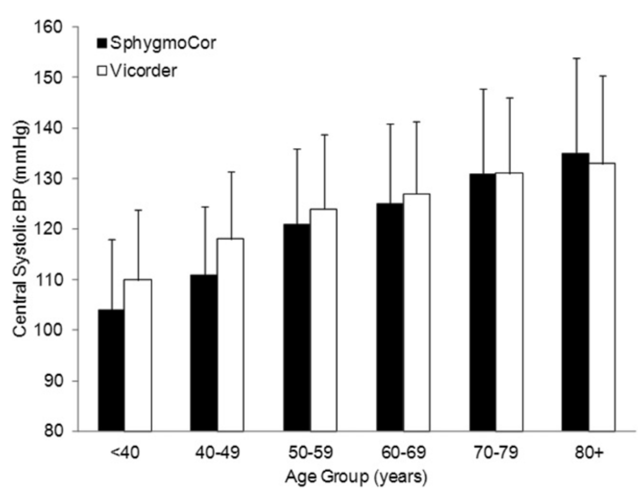


**Figure** Estimates of central systolic BP obtained with the Vicorder and SphygmoCor devices across the age range.