



## Artery Research

ISSN (Online): 1876-4401

ISSN (Print): 1872-9312

Journal Home Page: <https://www.atlantis-press.com/journals/artres>

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### **P2.12: INFLUENCE OF THE CENTRAL TO PERIPHERAL ARTERIAL STIFFNESS GRADIENT ON TIMING AND AMPLITUDE OF WAVE REFLECTIONS**

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**To cite this article:** S. Hickson, W. Nichols, I. Wilkinson, C. McEniery (2008) P2.12: INFLUENCE OF THE CENTRAL TO PERIPHERAL ARTERIAL STIFFNESS GRADIENT ON TIMING AND AMPLITUDE OF WAVE REFLECTIONS, Artery Research 2:3, 109–109, DOI: <https://doi.org/10.1016/j.artres.2008.08.378>

**To link to this article:** <https://doi.org/10.1016/j.artres.2008.08.378>

Published online: 21 December 2019

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.

doi:10.1016/j.artres.2008.08.376

## 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<sup>1</sup> 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 ( $Tr/2$ )<sup>2</sup>.

$PWV_e$  and  $PWV_m$  were  $7.8 \pm 1.0$  m/s and  $9.7 \pm 1.0$  m/s, respectively, in subjects with a positive stiffness gradient ( $PWV_m > PWV_e$ ) and  $10.8 \pm 2.1$  m/s and  $9.0 \pm 1.6$  m/s in subjects with a reverse stiffness gradient. Central pulse pressure and augmentation pressure were higher in subjects with a reverse stiffness gradient ( $38 \pm 18$  vs.  $48 \pm 9$  mmHg and  $12 \pm 6$  vs.  $14 \pm 5$  mmHg,  $P < 0.05$ ), as

was  $AI_a$  corrected for heart rate ( $23 \pm 8$  vs.  $27 \pm 6$ %,  $P < 0.05$ ) and reflection site distance ( $56 \pm 10$  vs.  $76 \pm 15$  cm,  $P < 0.01$ ). Time to reflection did not differ between groups ( $71.4 \pm 6.4$  vs.  $70.5 \pm 5.0$  ms).

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.

doi:10.1016/j.artres.2008.08.378

## 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  $\pm$  SD. The FF at the brachial artery was  $2.1 \pm 0.9$  % 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)
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\* 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.

doi:10.1016/j.artres.2008.08.379

## 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<sub>2</sub>) 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  $\mu$ g).