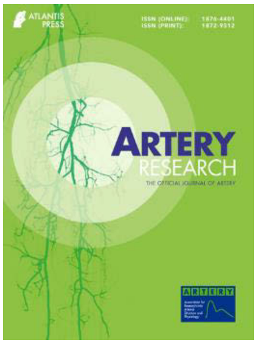

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P122: CALCULATING RESERVOIR PRESSURE WITH OR WITHOUT FLOW INFORMATION: SIMILARITY AND ALGORITHMIC SENSITIVITY AT RADIAL ARTERY

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hypertension, with investigators, however, not reaching a consensus on the relative importance of each wave component (1,2).

Objective: The aim of the current investigation was to examine the wave profile over time after developing an age-adapted, mathematical, one-dimensional model of the cardiovascular system.

Methods: Our state-of-the-art 1-D model (3,4) was extended to include turbulence and inertial effects of the flow exiting the left ventricle. Literature data on the age-associated changes in arterial stiffness, peripheral resistance and cardiac contractility were gathered and used as an input for the simulation.

Results: The predicted evolution of pressure and augmentation index with age followed accurately the curves obtained in a number of large-scale clinical studies. Analysis of the relative contribution of the forward and backward wave components showed that the forward wave becomes the major determinant of the increase in central and peripheral SBP and PP with advancing age.

Conclusions: The 1-D model of the ageing tree and heart captures faithfully and with great accuracy the central pressure evolution with ageing. The stiffening of the proximal aorta and the resulting augmentation of the forward pressure wave is the major contributor of the systolic pressure augmentation with age.

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P121

IDENTIFYING HAEMODYNAMIC DETERMINANTS OF PULSE PRESSURE: AN INTEGRATED NUMERICAL AND PHYSIOLOGICAL APPROACH

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Purpose: Hypertension, the single biggest killer worldwide[1], arises mainly as a result of an increase in central pulse pressure (PP)[2], yet haemodynamic basis of that increase is still disputed. We examined the ability of a simple "reduced" model comprising a proximal characteristic impedance linked to a Windkessel element to accurately predict PP from aortic blood flow and applied the model to examine PP dependence on cardiac and vascular properties.

Method: PP obtained from the model was compared with theoretical values obtained in silico and in vivo. Theoretical values were obtained using a distributed multi-segment model in a population of "virtual" subjects ($n = 3,095$) in which cardiovascular properties were varied over the pathophysiological range. In vivo measurements were in normotensive subject ($n = 13$) during modulation of physiology with vasoactive drugs with divergent actions on cardiac and cascular properties and in hypertensive subjects ($n = 156$).

Results: PP derived from the model agreed with theoretical values (mean difference SD, -0.09 ± 1.96 mmHg) and with measured values (-1.95 ± 3.74 and -1.18 ± 3.67 mmHg for normotensive and hypertensive subjects respectively). Parameters extracted from the model agreed closely with theoretical and measured physical properties. PP was seen to be determined mainly by total arterial compliance (inversely associated with arterial stiffness) and ventricular dynamics: the volume of blood ejected up to time of pulse pressure and the rate of ventricular ejection up to this point.

Conclusion: Increased flow and/or volume accounted for 20.1 mmHg (52%) of the 39.0 mmHg difference in pulse pressure between the upper and lower tertiles of the hypertensive subjects.

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P122

CALCULATING RESERVOIR PRESSURE WITH OR WITHOUT FLOW INFORMATION: SIMILARITY AND ALGORITHMIC SENSITIVITY AT RADIAL ARTERY

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Background: Reservoir pressure is typically estimated from the pressure waveform information only. Comparability with estimates made using pressure and flow depend on assumptions, e.g. a proportional relationship between excess pressure and flow [1]. In this study, we compared (i) results using flow and pressure versus pressure-only at the radial artery, and (ii) two different algorithms used in the literature for pressure- only analysis.

Methods: Reservoir pressure separations were performed on 95 hypertensive individuals where radial pressure and flow velocity waveform measurements were available [2]. Algorithm (F) used flow and pressure information [3]. Algorithms (P1) and (P2) refer to the two different pressure-only implementations as used in [4, 5], and [1, 6], respectively. Reservoir curves characterized by physiologically implausible parameters, i.e. a rate constant $b < 0$ or an asymptotic pressure $P_\infty < 0$, were discarded, leaving 63 subjects with valid reservoir pressure data.

Results: Estimated reservoir parameters are shown in Table 1. Algorithm (F) showed statistically significant differences in most of the parameters compared to (P1) and (P2), although, except time constant τ and asymptotic pressure P_∞, there was a strong correlation between methods. Significant differences were observed in reservoir pulse pressure and area estimates between (P1) and (P2) despite their, in general, high correlation.

Table 1. Quantification of reservoir pressures p_{res} obtained by methods (F), (P1) and (P2) at radial artery in the format of mean ± standard deviation based on 63 subjects whereby PP denotes the reservoir pulse pressure, A_p the area of reservoir pressure above diastolic blood pressure, τ the time constant describing the diastolic pressure decay, P_∞ the asymptotic blood pressure and $a,b = 1/\tau$ the rate constants. Peripheral (area) resistance and compliance, i.e. R and C, were estimated from the rate constants a and b for (P1) and (P2) using flow information. The correlation coefficient r was computed between relevant methods. The statistical significance of the differences between methods was based on a paired t-test with * indicating $p < 0.05$.

Radial artery	p_{res} (F)	p_{res} (P1)	p_{res} (P2)	r(F,P1)	r(F,P2)	r(P1,P2)
PP [mmHg]	41.5 ± 10.0	36.3 ± 7.2	35.7 ± 7.0	0.82*	0.82*	0.96*
A_p [mmHg s]	17.5 ± 4.3	15.6 ± 3.7	15.5 ± 3.7	0.94*	0.94*	1.00*
τ [S]	0.3 ± 0.1	0.6 ± 0.4	0.6 ± 0.3	0.36*	0.42*	0.88
P_∞ [mmHg]	65.7 ± 10.3	63.9 ± 15.2	64.8 ± 12.6	0.45	0.53	0.79
a [1/s]	–	8.1 ± 5.2	7.4 ± 2.7	–	–	0.93
b [1/s]	–	2.2 ± 1.1	2.1 ± 0.8	–	–	0.84
R [mmHg s/m]	419.0 ± 188.8	453.7 ± 348.2	436.7 ± 302.6	0.68	0.75	0.92
C [mm/mmHg]	0.8 ± 0.3	1.7 ± 1.0	1.7 ± 1.0	0.70*	0.70*	1.00

Conclusions: The discrepancies between (F) and (P1), (P2) raise concerns about the validity of the implicit assumptions in pressure-only reservoir pressure separation at the radial artery. Differences in (P1) and (P2) indicate some sensitivity of derived parameters to the algorithm employed.

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RESERVOIR PRESSURE IS INDEPENDENTLY ASSOCIATED WITH 11—12 YEAR OLD'S KIDNEY FUNCTION: POPULATION-DERIVED STUDY

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Introduction: Reservoir pressure (RP) and excess pressure (XSP) independently predict cardiovascular events in adults, but have never been investigated as markers of cardiovascular risk among children. This study aimed to determine the association of RP and XSP with end-organ makers of cardiovascular risk related to kidney function and large artery pre-atherosclerosis.
Methods: Participants were 1874 11—12 year-old children (50% male) from the Longitudinal Study of Australian Children's Child Health CheckPoint study. Brachial blood pressure was measured by cuff oscillometric device (SphygmoCor XCEL, AtCor, Sydney). The same device was used to derive reservoir pressure (RP) and excess pressure (XSP) from the brachial pressure waveform. Kidney function was determined from estimated glomerular filtration rate (eGFR, $n = 926$) and large artery pre-atherosclerosis was determined from carotid intima media thickness (cIMT, $n = 1131$) using ultrasound.
Results: The eGFR was significantly correlated with RP peak ($r = -0.109$, $p = 0.001$), RP integral ($r = -0.136$, $p < 0.001$), XSP peak ($r = 0.096$, $p = 0.004$) and XSP integral ($r = 0.102$, $p = 0.002$). The RP (whether expressed as peak or integral) was significantly associated with eGFR after adjusting for sex, waist-to-hip ratio, heart rate and brachial BP indices (RP peak $\beta = -0.079$, $p = 0.02$, partial $R^2 = 0.006$ and RP integral $\beta = -0.079$, $p = 0.02$, partial $R^2 = 0.007$). XSP was not independently associated with eGFR after adjusting for the above variables. Neither RP nor XSP were significantly associated with cIMT.
Conclusion: Independent of conventional risk factors, RP was significantly associated with kidney function among a large population of Australian children. The non-invasive method to derive RP using an oscillometric cuff device could provide useful clinical information in children.

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VALIDITY AND RELIABILITY OF PULSE WAVE ANALYSIS ESTIMATED BY A NOVEL WRIST-WORN TONOMETER

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Objective: To analyze the reliability and validity of Pulse Wave Analysis determined with the new wrist-worn tonometry.
Methods: Cross sectional study including 254 subjects. Aged 51.9 ± 13.4, being women 53%. Main measurements: Peripheral AIx (PAIx) and Central AIx (CAIx) by wrist-worn tonometry and Sphygmocor. Carotid femoral (cf) pulse wave velocity (PWV) by Sphygmocor, Cardio Anckle Vascular index (CAVI), anckle brachial index (ABI) and brachial anckle (ba) PWV by Vasera device. Carotid intima media thickness (IMT) by ultrasonography.
Results: Intra-class correlation coefficient (ICC) intraobserver for the PAIx was 0.886 (95% CI 0.803 to 0.934) and for the CAIx 0.943 (0.901 to 0.968) with a Bland Almant agreement limit of −0.75 (−23.8 to 21.8) and 0.08 (−15.7 to 15.9) respectively. ICC interobserver for PAIx was 0.952 (95% CI 0.915 to 0.972) and CAIx 0.893 (0.811 to 0.939) with an agreement limit of −0.45 (−13.7 to 12.8) and 0.43 (−17.7 to 1835) respectively. We found, compared with Sphygmocor, an ICC of 0.849 (0.798 to 0.887) for PAIx, and 0.783 (0.711 to 0.838) for CAIx. The agreement limit for PAIx was −1.03 (−22.73 to 20.67) and CAIx 2.14 (−20.50 to 24.79). We found positive correlation with PAIx, CAIx and CAIx HR75 by Aurora with age, CAVI, ABI, baPWV, cfPWV, IMT and cardiovascular risk and negative with glomerular filtration rate.
Conclusions: The wrist-worn tonometry shows an adequate reliability intra and interobserver, and interdevice when compared to Sphygmocor, and an adequate validity when compared with other measures that evaluate arterial stiffness, target organ damage and cardiovascular risk.

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USE OF VASCULAR ADAPTATION IN RESPONSE TO MECHANICAL LOADING FACILITATES PERSONALISATION OF A ONE-DIMENSIONAL PULSE WAVE PROPAGATION MODEL

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Background: Mathematical modelling of pressure and flow waveforms in blood vessels using pulse wave propagation (PWP) models could support clinical decision-making. For a personalised model outcome, measurements of all modelled vessel radii and wall thicknesses are required. In clinical practice, however, datasets are often incomplete. To overcome this problem, we hypothesised that the adaptive capacity of blood vessels in response to mechanical load can be utilised to fill in the gaps of incomplete patient-specific datasets.
Methods: We implemented homeostatic feedback loops in a validated PWP model [1] to allow adaptation of vessel geometry to maintain wall stress and wall shear stress. To evaluate our approach, we utilised complete