Variation of the asymptotic diastolic pressure with different techniques in healthy humans

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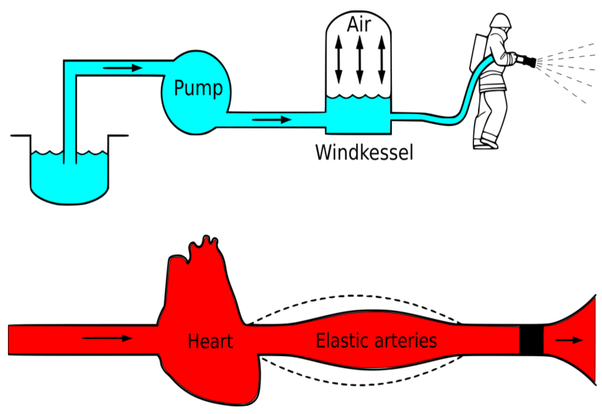
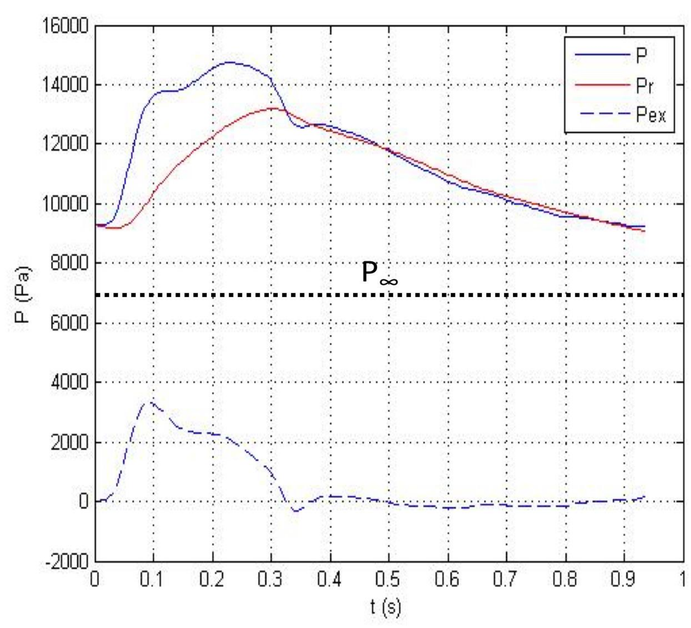
BACKGROUND

Incremental changes of arterial blood pressure can be affected by forward and backward waves, as well as by the compliance of the vessel. Therefore, to properly quantify the effects of forward- or backward- traveling waves on arterial pressure (and velocity), the component due only to the increase in arterial ''reservoir'' volume should first be excluded.



Analogy between the windkessel effect of a fire engine pump and the arterial reservoir[1].

Hybrid reservoir-wave models assume the measured pressure (P_m) consists of two additive components: reservoir (P_r) and excess pressure (P_{ex})[2-3]. Calculation of P_r requires fitting the diastolic decay of P_m for calculating the parameters P_∞ (asymptotical value) and b (time constant)[2]. However, there is no consensus over the value of these parameters[2-4-5] and some researchers keep P_∞ fixed. Although many investigators use free-fitting, different degrees of freedom (dof) - P_∞, b and the pressure at the dicrotic notch (P_n) - and fitting window lengths - diastole or the last 2/3 of diastole - could be used[2-3-6].



Hypothesis: Varying fitting method can significantly change P_∞ and b values, leading to different reservoir and excess pressure waveforms.

Aim: to examine the effect of varying fitting method (combining different dof and fitting windows) on P_∞ and b and calculate the peaks of P_r and P_{ex}.

METHODS

Subjects

505 healthy individuals (280 females)
age range: 35 to 55 years
randomly selected from the Asklepios cohort

Fitting Methods

- Calculation of reservoir and excess pressure waveforms[2]

Reservoir Component:

$$P_r = \frac{b}{a+b} P_\infty + e^{-(a+b)t}\left[\int_0^t aP(t')e^{(a+b)t'}dt' + P_0 - \frac{b}{a+b}P_\infty\right]$$

$$P_r = (P_n - P_\infty)e^{-b(t-t_n)} + P_\infty \text{ (in diastole; n: dicrotic notch)}$$

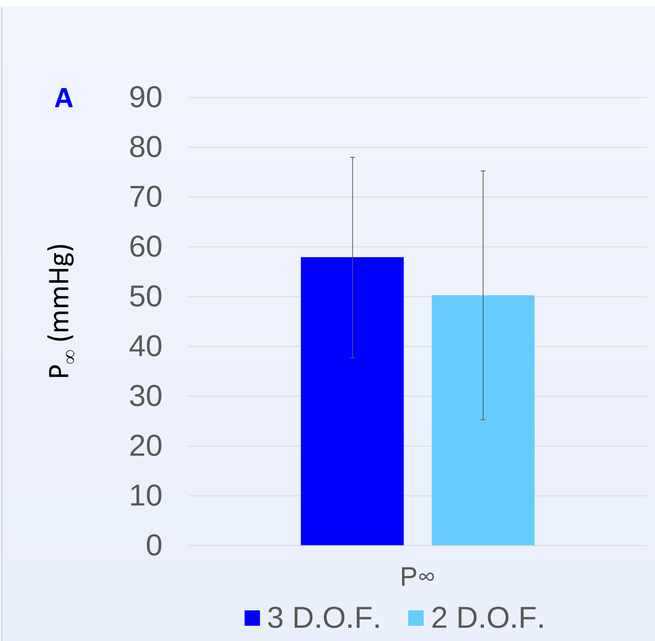
Wave component:

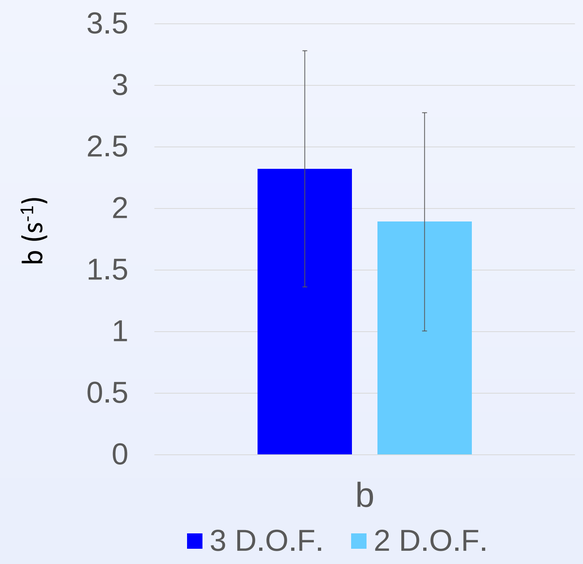
$$P_{ex} = P - P_r$$

- Fitting models

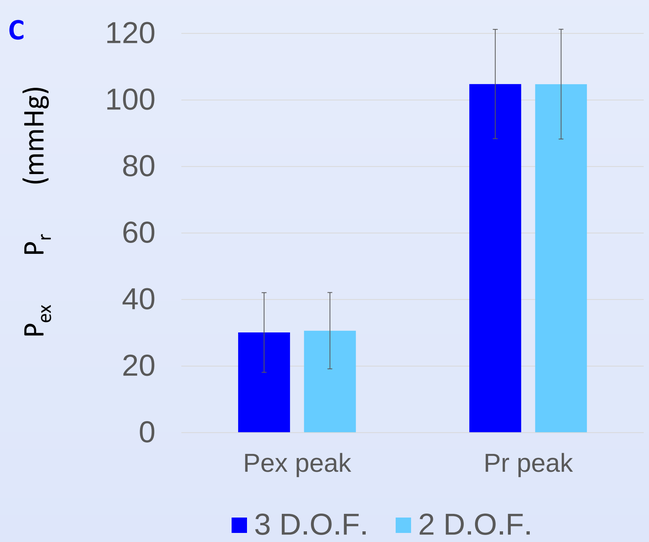
Based on the degrees of freedom:
3 dof: 3-parameter free fitting (P_n, b, P_∞)
2 dof: 2-parameter free fitting (P_n=*fixed*, b, P_∞)
Based on the length of the fitting window:
dias: fitting window equal to the diastole
2/3: fitting window equal to the last 2/3 of diastole

RESULTS

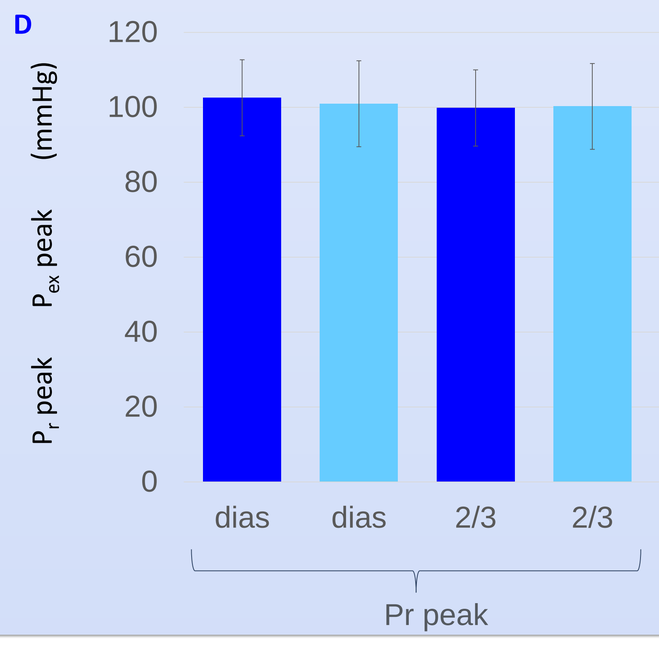




Having fixed the fitting window (dias), the mean value of P_∞ across all subjects changed significantly between 3 dof and 2 dof (58 vs. 50 mmHg; $p<0.01$; Figure A) as well as b (2.3 vs. 1.9 s^{-1}; $p<0.01$; Figure B). However, P_r- and P_{ex} peaks didn't significantly change, as shown in Figure C (P_r peak= 105 mmHg for 3 dof and 2 dof, respectively; $p>0.05$; P_{ex} peak= 30 mmHg and 31 mmHg for 3 dof and 2 dof, respectively; $p>0.05$).



In a smaller group (n=50, 26 females), the two types of fitting window (dias and 2/3) were compared (Table below). A significant increment was seen for P_∞ when the shorter (2/3 of diastole) window was used, for both 3 dof (+19.2%, $p<0.05$) and 2 dof (+55.3%, $p<0.001$). The same outcome was seen for b (+51.0%, $p<0.001$ for 3 dof, +88.1%, $p<0.001$ for 2 dof). However, P_r- and P_{ex} peaks didn't significantly change (Figure D): P_r peak showed a decrement of 2.6% ($p>0.1$) with 3 dof and a decrement of 0.7% ($p>0.05$) with 2 dof; while P_{ex} peak increased by 3.4% ($p>0.1$) with 3 dof and decreased by 2.6% ($p>0.1$) with 2 dof.



P_∞	3 dof	2 dof	b	3 dof	2 dof
dias	52 ± 22	38 ± 29	**dias**	1.96 ± 0.91	1.43 ± 0.99
2/3	62 ± 20	59 ± 25	**2/3**	2.96 ± 1.18	2.69 ± 1.21

DISCUSSION and CONCLUSIONS

The reservoir and excess pressure waveforms are related to clinical indices, like the arterial wave intensity. Thus the assessment of such indices in the clinical environment seems to be not affected by the fitting analysis. It is possible to draw the following conclusions:

- P_∞ and b values are method-dependent with a large variation between methods,
- P_∞ values in our study are higher than previously reported in literature,
- Variation in P_∞ and b values does not seem to affect P_r- and P_{ex} peaks,
- Given the variability in the combination of P_∞ and b in different subjects, the use of free-fitting is more appropriate.

Acknowledgements
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