Independent Modifications to Backward and Forward Pressure Waves Lead to Non-Physiological Aortic Flow

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Background: Arterial wave reflections are important contributors to LV afterload. So as to demonstrate the role of increased forward wave amplitude and morphology in late systolic pressure augmentation, a recent study [1] modified backward waves independently of forward waves to form simulated aortic pressure waveforms, without regard for the underlying flow necessary to meet those altered conditions.

Methods: Simultaneous aortic pressure and flow waveforms were measured in an anesthetized open-chest dog under i.v. infusion of methoxamine. Pressure and flow waves were decomposed into backward and forward waves using standard methods**.** As done in the recent study, the backward waves were shifted in time to simulate earlier arrival of reflected waves. The forward and backward waves were then recombined to generate simulated aortic pressure waveforms. Unlike the recent study, we also recombined forward and backward flow waves to assess the flow that is necessary for the proposed backward wave modification.

Results: Arbitrarily modifying backward waves independently of forward waves resulted in markedly non-physiologic flow waveforms with positive flow in diastole (Figure, panel D, dashed line), despite simulated pressure waveforms that appear physiological (Figure, panel B, dashed line).

Conclusions: Modification of the backward pressure wave requires the same modification of the backward flow wave in order to satisfy the hemodynamic definition of aortic characteristic impedance. When backward waves are modified independently of the forward wave, basic hemodynamic principles are violated and non-physiological aortic flows are produced. Previous findings using this method cannot be used to support the importance of the forward wave. Our findings illustrate the key influence of wave reflections on any given combination of forward wave and flow waveforms. Changes in reflections for any given forward wave will necessarily change flow. Similarly, changes in reflections in the presence of any given flow wave will necessarily change the forward wave.

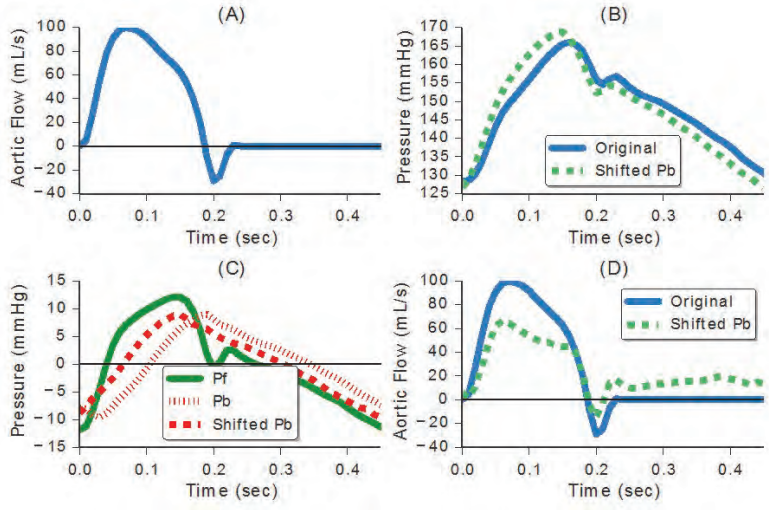

Figure. Simultaneously measured aortic flow (panel A) and pressure (panel B). Pressure waveform decomposed into forward (Pf) and backward (Pb) waves (panel C). Pb is shifted in time to simulate earlier arrival of reflections (panel C, dashed line). Despite a simulated pressure waveform that appears physiological (panel B, dashed line), the corresponding flow waveform is non-physiological (panel D, dashed line).

References

[1] Torjesen, Alyssa A., Na Wang, Martin G. Larson, Naomi M. Hamburg, Joseph A. Vita, Daniel Levy, Emelia J. Benjamin, Ramachandran S. Vasan, and Gary F. Mitchell. "Forward and backward wave morphology and central pressure augmentation in men and women in the Framingham Heart Study." *Hypertension* 64, no. 2 (2014): 259-265.