Pulsatile Load-Dependent Strain Rate Modulates Aortic Tissue Viscoelasticity *ex vivo*

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INTRODUCTION

Central aortic tissue is continuously exposed to cyclic pulsatile stretching. Previous data indicated that increased pulsatile load reduced both arterial rigidity and vascular smooth muscle cell (VSMC) contractility, suggesting a potential causal relationship between VSMC function and pulsatile load-controlled tissue stiffness. In the present study, the effect of pulsatile load on arterial physiology was further investigated.

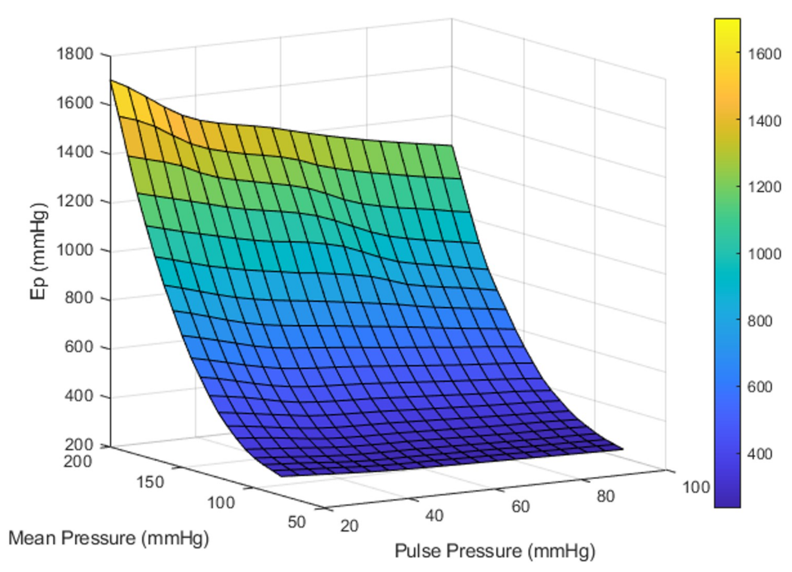

Figure 1. Pulse pressure modulates the pressure-stiffness relationship. (Neutel et al., 2021)

METHODS

Aortic segments from C57BL/6J (n=4) mice were mounted in the ROTSAC, and subjected to high frequency cyclic stretch. Diastolic and systolic diameter as well as the Peterson modulus (E_p), as a measure of aortic stiffness, were determined. The viscous (E_η) and elastic modulus (E_E) were extracted from pressure- diameter tracings by eliminating loop hysteresis.

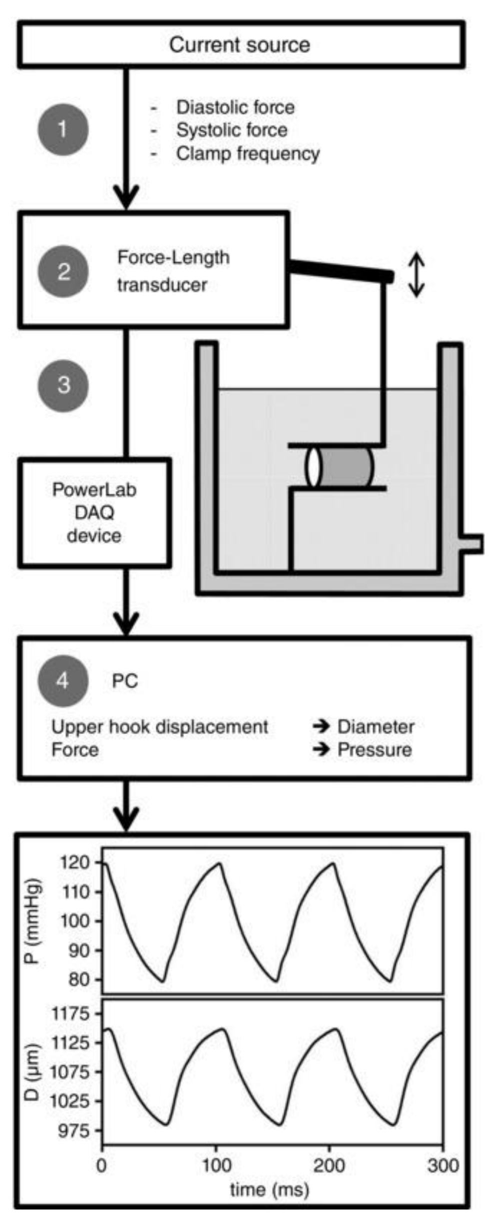

Figure 2. Rodent Oscillatory Tension Set-up for measuring Arterial Compliance (ROTSAC). (Leloup et al, 2016)

RESULTS

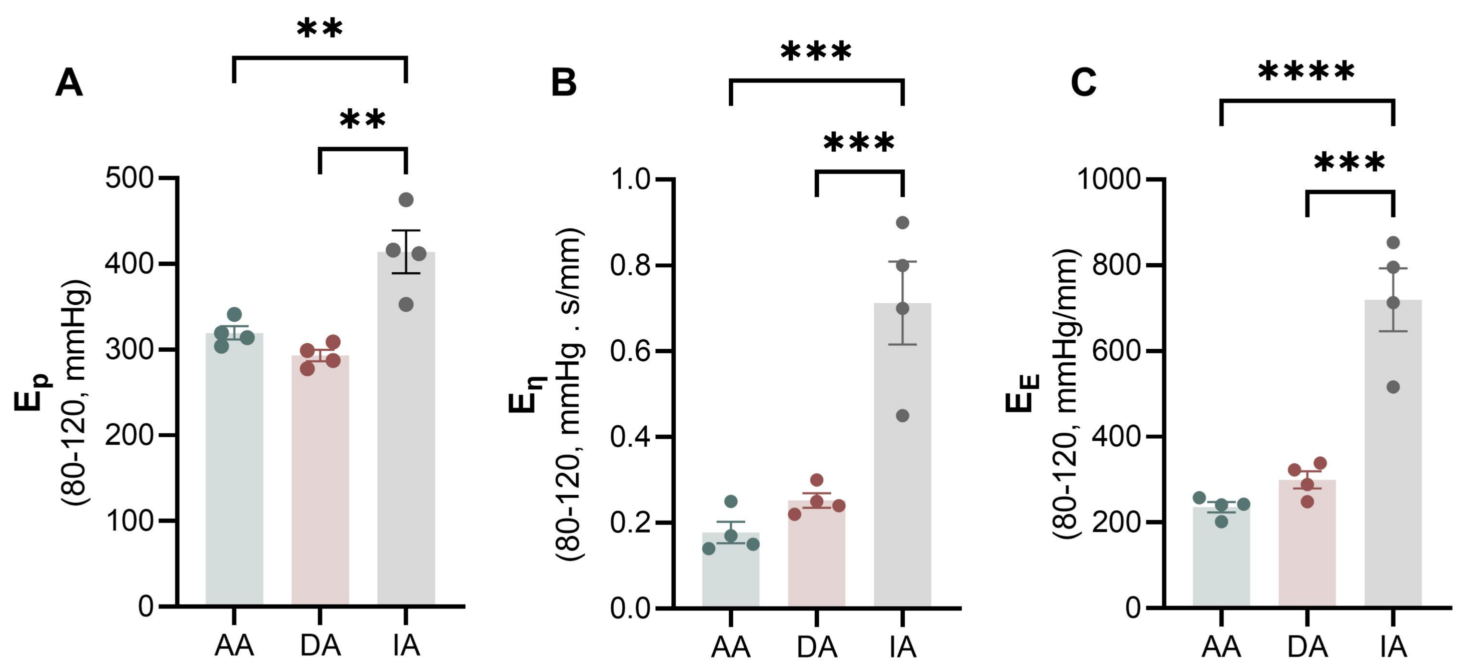

Figure 3. Viscoelastic properties along the aortic tree. (A) The IA has a significantly higher E_p than both the AA (p<.01) and DA (p<.01). (B, C) Additionally, the IA has both a significantly higher E_η and E_E than the AA (p<.001; p<.0001) and the DA (p<.001; p<.001). There was no difference in viscoelastic parameters between the AA and the DA. Data is expressed as mean ± SEM, n=4, One-way ANOVA with Holm-Sidak post hoc test for multiple comparisons. **p<.01, ***p<.001, ****p<.0001. **E_p** = Peterson's Elastic Modulus, **E_η** = Viscous Modulus, **E_E** = Elastic Modulus, **AA** = Ascending Aorta, **DA** = Thoracic Descending Aorta, **IA** = Abdominal Infrarenal Aorta

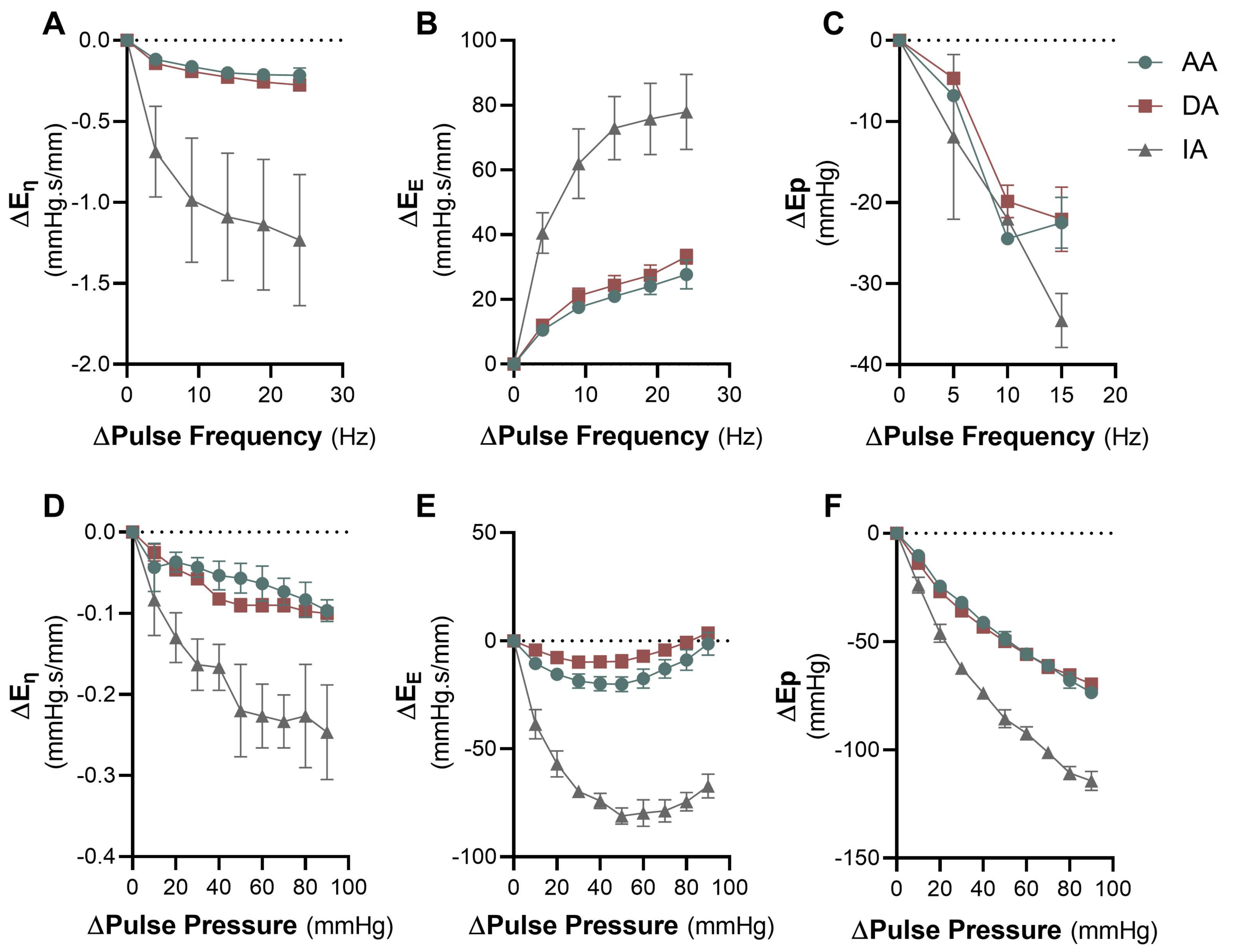

Figure 4. Pulse pressure and pulse frequency modulate blood vessel viscoelasticity. (C) Increasing pulse frequency (from 10 Hz to 25 Hz) decreased E_p in all vascular tissues. (A, B) Increasing pulse frequency (from 1 Hz to 25 Hz) decreased E_η, but increased E_E. (C) Increasing pulse frequency (from 10 Hz to 25 Hz) decreased Ep in all vascular tissues. Increasing pulse pressure (10 mmHg to 100 mmHg) decreased (D) E_η and (F) Ep. (E) A biphasic response of the E_E was observed when increasing pulse pressure. Data is expressed as mean ± SEM, n=4. **E_p** = Peterson's Elastic Modulus, **E_η** = Viscous Modulus, **E_E** = Elastic Modulus, **AA** = Ascending Aorta, **DA** = Thoracic Descending Aorta, **IA** = Abdominal Infrarenal Aorta.

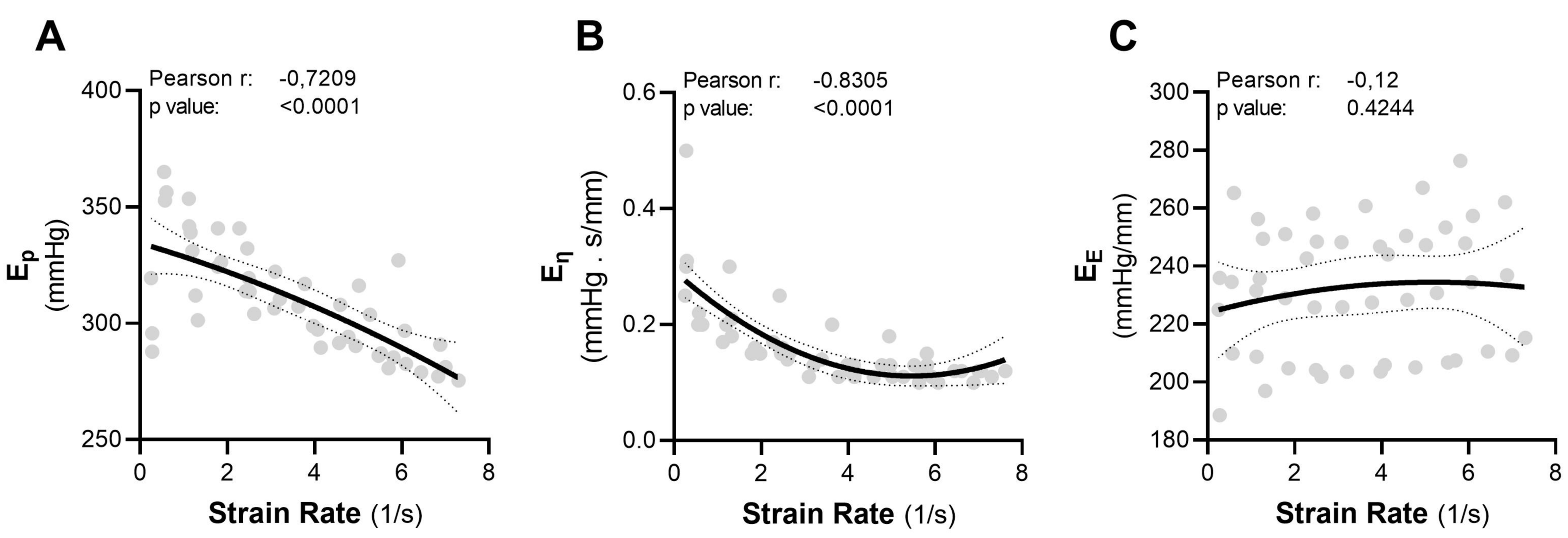

Figure 5. Strain rate is inversly correlated with the stiffness and the viscous properties of the ascending aorta. (A) An increase in strain rate is significantly (p<.0001) inversly correlated with the E_p. (B) Increased strain rate is significantly (p<.0001) inversly correlated with E_η. (C) There was no correlation between strain rate and E_E in this dataset. **E_p** = Peterson's Elastic Modulus, **E_η** = Viscous Modulus, **E_E** = Elastic Modulus

CONCLUSION

There are significant differences in viscoelastic properties between segments from distinct anatomical regions along the aortic tree, especially when comparing thoracic and abdominal aortic tissue. Pulsatile load (either via pulse frequency or via pulse pressure) modulates the viscoelastic properties of the arterial wall due to, in part, strain rate-dependent effects.

NEXT STEPS

Whereas increased strain rate causes strain softening in aortic tissue *ex vivo*, its mechanism is not yet fully known. Studying which viscous and/or elastic component(s) are affected by strain rate could reveal new physiological mechanisms. Additionally, the cellular responses to these mechanical stimuli could be investigated to identify the involved vascular mechano-transduction pathways.

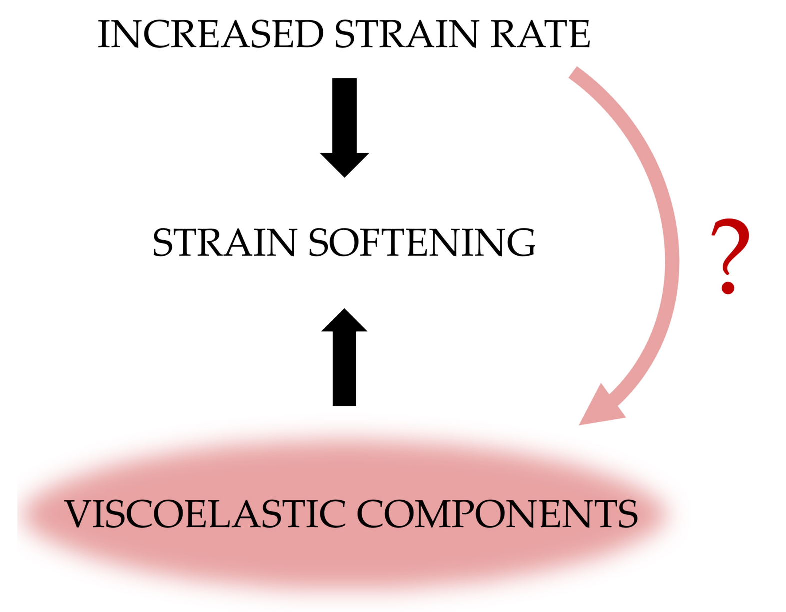

Figure 6. Increased strain rate induces (strain) softening of vasular tissue. How strain rate affects the viscoelastic components of the arterial wall, responsible for this effect, is not fully known. Identifying which viscoelastic components are affected, could reveal strain-rate dependent vascular mechanotransductive pathways.

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