PARTIAL OR COMPLETE ENZYMATIC DIGESTION OF GLYCOSAMINOGLYCANS DOES NOT AFFECT PORCINE AORTIC WALL PROPERTIES MEASURED FROM BIAXIAL TESTING

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INTRODUCTION

Ruptured aortic aneurysms are life threatening pathologies with mortality rates exceeding 90%[1]. Current interventions for aortic aneurysm include monitoring yearly expansion rates and surgical treatment recommended with aneurysm diameter >5.5 cm²; these approaches are not considered adequate as many ruptures occur suddenly and below clinical guidelines for treatment. Understanding the contributions of each component of the arterial wall to its mechanical response will aid in enhancing models for *in-vivo* tissue responses, to help better predict arterial wall behaviour, especially of pathological tissue.

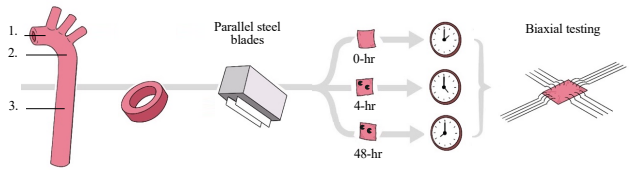
BACKGROUND INFORMATION

Soft tissues are fiber-reinforced composites, which display nonlinear, anisotropic mechanical response[3,4]. The structural influence and contribution of glycosaminoglycans (GAGs) is still unclear. GAGs are highly negatively charged long chains composed of unbranched repeating disaccharide units, found in the aortic extracellular matrix (ECM). These macromolecules are essential in influencing material viscoelasticity, serving to resist deformation and compression, ECM hydration, and providing residual stress in the unloaded state[5,6], although their low content in aortic tissue (2-5% by dry weight[7]).

HYPOTHESIS

GAG content in the porcine aorta does not affect tissue mechanical properties measured from biaxial testing.

MATERIALS & METHODS



$n = 8$ | 1. Asc. 2. Arc. 3. Tho. | 9x9 mm samples | Partial & complete enzymatic GAG-digestion | 9 loading & unloading protocols

The aorta was divided into 3 major regions: ascending (Asc.), arch (Arc.), and thoracic descending (Tho.)

Sample thickness was evaluated before and after 0-, 4-, and 48-hour incubation, prior to mechanical testing.

Strain (E) and stiffness (S) were computed from material models, Fung (F) and Guccione (G), and evaluated under arbitrary membrane tensions of 60 and 120 N/m (Fig. 1a).

STRAIN ENERGY FUNCTIONS

$$W = \frac{c_1}{2}[exp(Q_F \text{ or } Q_G) - 1]$$

$$Q_F = c_2E_{11}^2 + c_3E_{22}^2 + 2c_4E_{11}E_{22} + c_5E_{12}^2 + 2c_6E_{11}E_{12} + 2c_7E_{22}E_{12}$$

$$Q_G = c_2E_{11}^2 + c_3(E_{22}^2 + E_{33}^2) + 2c_4E_{12}^2$$

RESULTS

- 49.1 ±7.0% and 83.8 ±5.2% of GAGs were removed from the arterial tissue after 4- and 48-hours incubation.
- Tissue morphometry, thickness and area, remained unchanged following incubation (Table 1).
- Tissue thickness significantly decreased moving away from the heart, in all treatment groups (Table 1)
- Earlier transition to the stiffer portion of the stress-strain curve for treated samples in the circumferential direction (Fig. 1b, c, d)
- No statistical difference between S and E of untreated, partially digested and fully digested tissue, or in level of anisotropy (Fig. 2)

Table 1 – Average thickness of the Asc., Arc., and Tho. at varying incubation times

Location	Average Thickness [mm]		
	0 hours	4 hours	48 hours
ASC	2.11 ±0.22	2.21 ±0.24	1.86 ±0.23
ARC	1.81 ±0.29	1.71 ±0.18	1.81 ±0.18
THO	1.32 ±0.22	1.37 ±0.18	1.25 ±0.24

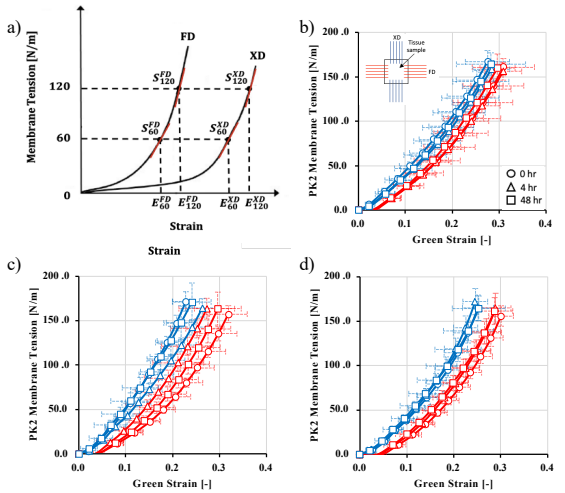


Figure 1 – (a) schematic stress-strain curve evaluated under membrane tensions of 60 and 120 N/m. Circumferential and longitudinal directions denoted by fiber (FD) and cross-fiber direction (XD), respectively; (b) Summary of average experimental equibiaxial results for the Asc.; (c) Arc; (d) Tho.

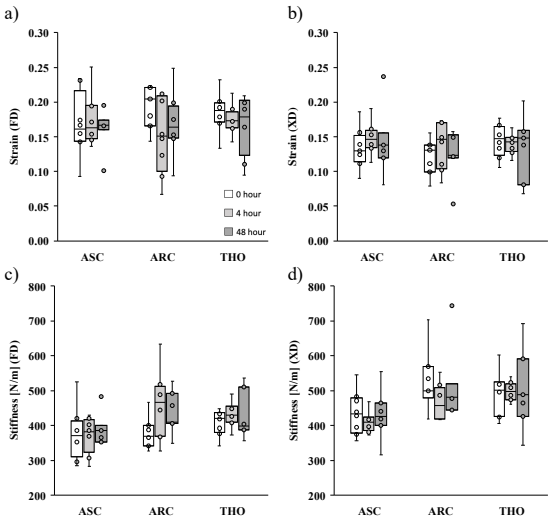


Figure 2 – Figures produced using the Fung model, comparing mechanical response at varying incubation times, under 60 N/m membrane tension a) circumferential strain (b) longitudinal strain (c) circumferential stiffness (d) longitudinal stiffness

DISCUSSION & CONCLUSION

The findings of the present study suggest that partial and complete enzymatic degradation of GAGs from porcine aortic tissue do not affect tissue mechanical properties, measured from biaxial testing, and do not influence morphometric parameters, including thickness and area. These findings will contribute to the fundamental understanding of aortic tissue mechanics and help determine the biomechanical relationship between individual arterial wall constituents and their response.

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