# Investigation of the Heterogeneous Mechanical Properties of the Intact and GAG-depleted Thoracic Aortic Tree using Indentation

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## I. Introduction

To assess the risk of lethal aortic complications such as those caused by aneurysms and dissections [1], current clinical evaluation tools are essentially based on anatomical dimensions. As such, they ignore the heterogeneity of the aorta, which may play an important role, and they have inherent limitations that negatively impact the quality of patient care. Recent efforts have focused on deciphering the influence of the aortic composition and its mechanical functions. The extracellular matrix (ECM) of the aorta is of prime interest, as a mixture of elastin, collagen and glycosaminoglycans (GAG) [2]. The purpose of this study was to evaluate the regional mechanical properties of the aorta along its tree using indentation, and most importantly, to evaluate the effect of GAG on the tissue's mechanical response.

## II. Methods

Five porcine thoracic aortas were acquired from a local abattoir and cleaned from surrounding fatty tissue. Three aortic strip samples were extracted from each of the ascending region (AS), aortic arch (AR), and descending thoracic region (TH). One sample was tested under fresh conditions, the second sample served as a control, and the third sample underwent enzymatic GAG depletion. A 100mM ammonium acetate buffer, pH 7.0, was used for control and GAG-depleted samples. GAG depletion was ensured using 15U/mL hyaluronidase, 0.075U/mL chondroitinase ABC, 0.75U/mL heparinase for 48 hours at 37°C.

Uniaxial compressive properties were evaluated using a commercially available mechanical tester: Mach-1 Biomomentum (Biomentum Inc., Laval, QC, Canada). Indentation mechanical testing was performed using a 150-gf load cell along with a 1-mm diameter indenter. The sample was placed in a sample chamber filled with phosphate buffered saline at room temperature and was strained to 20% of its thickness from the intimal layer, after 40 preconditioning cycles. Five positions were tested in each sample.

The efficiency of GAG removal treatment was evaluated using a dimethylmethylene blue spectrophotometric assay. Significance was accepted at $p<0.05$ and results are presented as mean±standard error of the mean.

## III. Results and Conclusion

We first confirmed that the treatments did not alter the tissue response by comparing the properties of fresh and control samples, as no significant difference was found. The stress at 10% indentation (from intima) was significantly higher in AS where it was 16.7±3.1 kPa, 17.3±1.6 kPa and 21.5±0.6 kPa in the fresh, control, and GAG-depleted samples, compared to AR where values were 10.0±3.1 kPa ($p=0.002$), 9.3±2.8 kPa ($p<0.001$) and 10.6±3.4 kPa ($p<0.001$), and TH where values were 10.5±0.7 kPa ($p=0.020$), 10.8±2.8 kPa ($p<0.001$) and 10.2±1.7 kPa ($p<0.001$), in fresh, control and GAG-depleted samples respectively. These findings confirm that the aorta is biomechanically heterogeneous along its tree, and more specifically, reveal that AS exhibited higher compressive stiffness compared to AR and TH. In addition, GAG-depleted samples in AS exhibited a significantly stiffer response compared to the fresh and control samples. However, this was not the case in AR or TH. These findings suggest that the compressive stiffness of the aorta is influenced by the presence of GAG, and that more work is needed to decipher the mechanism of interaction between GAG and other ECM constituents.

## Acknowledgements

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## References

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