THE EFFECT OF GLYCOSAMINOGLYCANS AND HYDRATION ON VISCOELASTIC PROPERTIES OF AORTIC VALVE

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INTRODUCTION

Glycosaminoglycans (GAG's), long chain sugar molecules that bind water due to their negative charge density, have been thought to be important in defining the viscoelastic properties of soft tissues such as skin [1]. Their importance in aortic valve mechanics however, has not been studied in detail. It has also been showed that cross-linked, commercially available bioprosthetic heart valves have less water content and less viscoelasticity. Therefore, the objective of this study was to determine the relative roles of hydration and GAG content on aortic valve cusp viscoelasticity.

METHODS

To extract the GAGs from porcine aortic valve leaflets, specimens were immersed in three consecutive baths of 0.1M NaOH at room temperature, followed by three consecutive solutions of distilled water. GAG extraction was verified by the protianase-K method (β elimination) [2]. Stress relaxation and failure tests were performed on circumferential specimens before and after GAG extraction. To vary the degree of hydration of GAG-depleted specimens, samples were subjected to deswelling media such as mineral and baby oil, and swelling media such as water, sodium dodecyl sulfate and phosphate-buffered saline solution. After equilibrium was attained, the samples were subjected to a mechanical stretch and hold protocol and their Quasi-Linear Viscoelastic (QLV) parameters ($\tau 1$, $\tau 2$, C) were obtained. Similar stress relaxation tests were performed on non-GAG depleted tissues, hydrated in swelling and deswelling media, and native tissue (control), tested immediately after harvesting.

RESULTS AND DISCUSSION

The native tissues equilibrated in deswelling media showed a significant decrease in the QLV parameter C relative to unswelled native control tissue (0.12 + 0.01 vs. 0.15 + 0.02). In contrast, samples equilibrated in swelling media showed an increase in C (0.21 + 0.03 vs. 0.15 + 0.02). Swelling and water content therefore, affect the QLV parameter C. GAGs extracted tissues had a lower C value whether equilibrated in swelling (0.11 + 0.04) or deswelling media (0.09 + 0.02) as compared to the native control tissue (0.15 + 0.02). GAG content therefore, also affects C in ways similar to water content. Regression analysis of the various samples in different media, with and without GAGs, showed an overall increase in the QLV parameter C with the swell ratio (Figure 1) and hence with water content. However, there was no significant difference in the slopes of the regression lines for tissues swelled with and without GAGs.

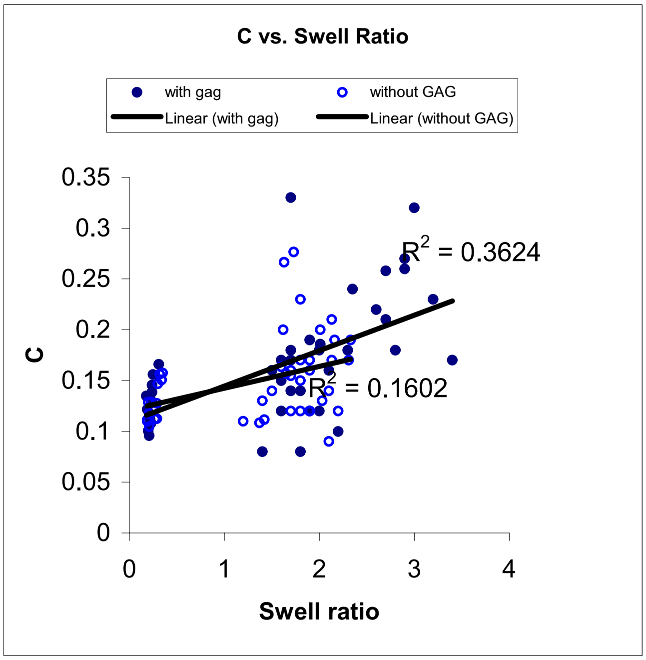

Figure 1: Comparison of QLV parameter C for tissue samples (swelled and deswelled in various media) with and without GAGs.

CONCLUSIONS

GAG depletion appears to affect the viscoelastic response of aortic valve tissue, although the major portion of this effect correlates with water content. Thus, it may be concluded that both GAGs and water content contribute to tissue viscoelasticity, with water being the major contributor.

REFERENCES

1. Fung, et al. *J of Biomechanics* ***9(10)**, 649-657*, 1976.
2. Grande AJ, et al. *J Biomed Mater Res* ***65A***, 251-259, 2003.