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Evolution of Structure-Function Properties in Human Aortic and Pulmonary Valves

Daphne van Geemen1, Ana L.F. Soares1, Antoon J. van den Bogaerd2, Ad J.J.C. Bogers3,4, Anita Driessen-Mol5, Frank P.T. Baaijens1, and Carlijn V.C. Bouten1

1 Soft Tissue Biomechanics & Engineering, Department of Biomedical Engineering, Eindhoven University of Technology; 2 Heart Valve Bank, Department of Cardio-Thoracic Surgery, Erasmus University Medical Center, Rotterdam; 3 Department of Cardio-Thoracic Surgery, Erasmus University Medical Center, Rotterdam

Introduction

Although valvulogenesis and tissue morphogenesis of semilunar heart valves have been extensively studied (Fig 1), the evolution of structure-function properties with maturation largely unexplored in human valves. Therefore, the objective of this study is to quantify tissue mechanical properties, extracellular matrix (ECM) composition, architecture and maturation of human aortic and pulmonary valves in different age groups to study valve remodeling with time and to provide target values for future therapies like tissue engineering.

Methods

Up to now, 7 sets of structurally and mechanically unaffected human aortic and pulmonary valves, rejected for transplantation purposes, were obtained from Dutch donors, who gave permission for research. The valves were assigned into 3 groups (child [4 yr], adolescent [17–23 yr], and adult [40-55 yr]) to study valve maturation. ECM composition and organization were analyzed quantitatively from biochemical assays, and qualitatively by histology, immunofluorescence, and vital collagen staining. Mechanical properties were obtained from biaxial tensile tests and indentation tests to mechanically probe specific areas of the valve leaflets.

Results

This data set shows variations between aortic and pulmonary valves, but also within the valves. The aortic valve belly is thicker than the commissure (Fig 2a). The Elastic modulus increases with age, with notably more variation in the adult valves (Fig 2b). With respect to the ECM properties, a trend of age-related changes was observed (Fig 3 and 4), including a decreasing GAG content and increasing collagen content with age. These changes were more apparent for aortic valves than for pulmonary valves.

Conclusion

The ECM of the aortic valve remodels with age with a decreasing GAG content and increasing collagen content. In addition to this remodeling, an inter-subject variation in valve properties was observed within age groups. The latter variation is also observed in tissue engineered heart valves prepared in our group using cells from different donors [3]. The obtained results might be used to identify target properties for tissue engineered heart valves and to optimize these protocols.

References