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Viscoelastic behaviour of Bovine Myocardiam and valvular tissue: Applications in Bio prosthetic heart valve with enhanced properties

MD Anwarul HASAN*, Alap Ali Zahid, Raza ur Rehman Syed, Noorunnisa Khanam, Hani A. Alhadrami

Qatar University
* ahasan@qu.edu.qa

Cardiovascular diseases are among the major causes of morbity and mortality. Particularly, the prevalence of heart valve disease(damaged heart valve leaflet) is one of the most common ailment. In elderly people, every year 30,000 patients are treated with heart valve replacement surgeries in the developed countries. Mechanical and bioprosthetic heart valves are commonly used in heart valve surgeries. While mechanical valves require the patient to be on blood thinning agent, rest of the life, bioprosthetic valves have only limited life span. Adequate knowledge of the biomechanics of nano-microscale structure and the viscoelastic properties of the native (bovine) heart valves can pave the ways for enhancing the strength of bio-prosthetic heart valves. In present work, we measured the viscoelastic and structural properties of the native bovine myocardiam and valvular tissue of heart valve. These heart valves were taken from bovine hearts and cryopreserved as necessary. The rheological and viscoelastic properties of heart valves were investigated by fixing in formaldehyde and phosphate buffer solutions (PBS). The samples were then tested in SEM (Scanning Electron Microscope) to investigate the microstructure of valve leaflets. Using Dynamic Shear Rheometer, the critical parameters such as modulus of elasticity, storage modulus, loss modulus, complex modulus, complex viscosity and the oscillatory shear properties were thoroughly investigated. Results show that the rheological properties vary with different chemical fixation effects. Chemical fixations like formaldehyde fixation were improving the rheological properties of heart

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valves. However, there is no significant influence of different time periods of fixations on mechanical properties. The complex modulus as well as the compression and storage moduli of the sample fixed with formaldehyde showed the satisfactory values after the fixation. It was indicating the mechanical strength has improved in terms of its structure, as much as solid/rigid as before the fixation. Also, the viscosity of fresh valve was higher, showing that the aldehyde fixation alters the mechanical property of the heart valve. Through the creep tests, it was investigated that the fixation of the heart valves did affect the viscoelasticity and mechanical properties of the heart valves. The valves become stiffer when they were fixed with formaldehyde. The reactions were less by a whole order of magnitude. However, by fixing the sample in formaldehyde we observed that the aortic valve had much more strength than the fresh sample. Another proof of how the aldehyde fixation drastically affected the stiffness of the valve was in the fact that the extension of the aldehyde-fixed valve under a stress of 5 kPa was less than that of the fresh valve at 0.5 kPa. These outcomes provide significant insights into the correlations between the microstructure and mechanics of the heart valves and their macro scale behaviors under various conditions. These results were modeled using Computer Aided Engineered software. The software can help scientists in evaluating the performance of tissue engineered heart valves with natural heart valves.