C20. Investigation And Prediction Of Oxygen Transportation And Distribution In Aortic Valve Leaflets

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OBJECTIVES: This study investigated oxygen transport in the aortic valve leaflet with a view to elucidating the mechanisms of oxygen supply to tissue-engineered valves conditioned in a bioreactor.
METHODS: Synthetic rubber casting, micro-CT, MRI, and histology were employed to characterise the geometry and trilaminar structure of the aortic valve leaflet. A respiration chamber and a Clark-type oxygen probe were used to measure the oxygen consumption rate of valve interstitial cells (VICs). Indentation tests and finite element models were combined to derive the biphasic properties of the leaflet tissue. The leaflet geometry, trilaminar structure and biphasic properties, together with the oxygen consumption rate of VICs, were employed as inputs to the finite difference and finite element computational models developed to simulate oxygen diffusion and convection within the leaflet.
RESULTS: The oxygen consumption rate of VICs was found to be fairly constant for dissolved oxygen concentrations above 5%, whereas the cell metabolic activity was found to be highly responsive to the culture conditions (attached or in suspension). The predicted oxygen distribution within the leaflet suggested that convection due to tissue deformation can enhance oxygen transport by approximately 20-30% in the centre of the leaflet.
CONCLUSIONS: This study investigated oxygen diffusion, convection and consumption in the aortic leaflet utilizing computational and experimental methods. The results provided fundamental understanding of the oxygen metabolism in the cell/tissue level and how different transport mechanisms affected oxygen distribution within the tissue. The results underpinned the importance of tissue-deformation-induced convention in the oxygen supply of the valve leaflet tissue.