

Development of a Decellularized Extracellular Matrix from Porcine Aorta for Heart Valve Applications in the Ross Procedure

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Cardiovascular diseases are the leading cause of adult mortality worldwide, according to the WHO [1]. An important surgical approach for treating diseased aortic valves is the Ross procedure, in which the affected aortic valve is replaced with an autograft from the patient's own pulmonary valve. The main concern about this procedure is linked to wall dilatation, which can lead to valve leakage and reoperation. Dilatation occurs due to the fivefold increase in blood pressure when transitioning from pulmonary to aortic conditions. Current solutions rely on permanent and stiff synthetic materials to provide structural support, however, these lack biological functionality. Our approach aims to incorporate a decellularized extracellular matrix (dECM) in a semi-permanent textile wrapped around the autograft promoting benign biological adaptation. The decellularization process by removing cellular components, reduces the risk of inflammatory responses and immune rejection. Moreover, essential ECM components that regulate cellular behavior are maintained, which is crucial for effective decellularization outcomes [2].

This study is focused in the development and optimization of an efficient decellularization protocol for obtaining dECM from porcine aorta with mild effects on ECM components preservation. Decellularization of the porcine aortic tissue was performed using a detergent and enzymatic-based protocol combined with supercritical CO₂ (scCO₂). Additional steps of sonication, agitation, washing and freeze-thaw were performed to enhance decellularization efficiency.

Graphic A shows a significant decrease in the DNA content after optimized decellularization processing, indicating the removal of approximately 85% of the DNA from the native tissue, and suggest an effective reduction of potential immunogenic components. Further characterization of ECM components (i.e. glycosaminoglycans, total collagen and elastin) is required to evaluate its preservation and the biological potential of the dECM when integrated in the Ross procedure.

To do so, aorta dECM powder will be combined with polycaprolactone and elastin and processed through electrospinning used to create a tubular device to enhance bio-mechano-compatibility, further improving current external supports for the Ross procedure and enhancing its general clinical outcomes. Since this support is biodegradable, it allows the new valve to take over the required strength. The dECM specifically offers essential biochemical cues to promote tissue integration and enable long-term functional repair after the Ross procedure.



(A) DNA concentration per milligram of dry weight for non-treated and treated samples; (B) Native porcine aortic tissue; (C) Treated porcine aorta squares; (D) Aorta dECM Powder.

References:

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