

Commentary

Commentary on “In Vitro Modulation of Spontaneous Activity in Embryonic Cardiomyocytes Cultured on Poly (vinyl alcohol)/Bioglass Type 45S5 Electrospun Scaffolds” and Recent Advances

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The field of tissue engineering promotes the manufacturing of three dimensional tissue scaffolds that induce biocompatibility, adhesion, and cell culture by using natural, synthetic, or a blend of polymers, as well as active agents (growing factors to enhance cell proliferation, cell differentiation, nutrients, etc.). Electrospinning makes it feasible to approach fibrillar structure, adjust porosity, and high surface area-to-volume ratio to mimic the extracellular matrix of native tissues. Tissue scaffolds are generally used as supports destined to mimic the morphological structure, tune mechanical properties to the native tissue, and functionality in regeneration processes. Still, beyond this, they are expected to perform the physiological functions to which each tissue or organ is intended. In the case of cardiac tissue, it brings oxygen through the blood to each part of the body through the contraction of the cardiac muscle cells (cardiomyocytes). This contraction is neurologically stimulated to the voltage and calcium-dependent process denominated excitation-contraction coupling, which is mediated by several factors. In this sense, the composition of the scaffold becomes relevant.

To mimic the mechanical and surface properties of the cardiac tissue to be regenerated, hybrid organic/inorganic scaffolds has been developed using natural or synthetic polymers. polyvinyl alcohol (PVA) and polycaprolactone (PCL) have also been designed for the treatment of vascular emboli due to their biocompatibility and low protein absorption. Muscle contraction are a function of intracellular Ca²⁺ levels in cardiomyocytes, and a decrease of these ions reduces myocardial conductivity and the development of cardiovascular disease. Bioactive agents, such as bioglasses in the form of micro-or-nanoparticles mixed with ad hoc polymers enhance the mechanical properties of the scaffolds and stimulate angiogenesis in tissue engineering. The most successful was Bioglass 45S5 made by a sol-gel method. It contains (Ca²⁺) calcium ions among others. The Ca²⁺ ions in the cardiac tissue affect functions that enable blood circulations in the body.

Electrospun scaffolds made of conventional polymers lack of suitable mechanical and electrical properties. Therefore, synchronous beating rate of cardiomyocytes cultured on these materials has not been achieved. Recently, PVA mixed with nanoparticles of Bioglass 45S5, has been reported with promising results.

Remarks

The sol-gel technique used here to prepare the Bioglass 45S5 nanoparticles (diameter range: 5 nm - 20 nm), facilitating uniform distribution into the PVA fibers (diameter range: 130 nm - 340 nm). Chemical crosslinking of PVA fibers and bioglass concentration of 20% allowed the formations of strongly connected cardiomyocytes layer on the surface of the scaffolds, allowing synchronous and periodic contractile activity of the cells. Crosslinking also increased thermal stability of the scaffolds. Intracellular calcium fluctuations during contractile activity of cardiomyocytes was associated with the Ca²⁺ ions release from the bioglass nanoparticles.

Recent Advances

Ischemic heart disease, a major global health challenge, is exacerbated by oxidative stress and dysregulated calcium homeostasis. Embryonic chick cardiomyocytes were used in this study as a model to evaluate the biofunctionality of the scaffolds. In a previous work we demonstrated that procyanidin-enriched compounds derived from epicatechin (EC) decrease the frequency of chick embryonic cardiomyocytes, whereas collagen increases it, both components were combined in electrospun scaffolds of PCL. This study aimed to develop and characterize a bioactive scaffold by incorporating polymerized epicatechin (PEC) into PCL electrospun scaffolds to enhance antioxidant properties and evaluate potential PEC-Ca²⁺ interactions. PEC affects heart cell contractions and PCL, a biocompatible polymer, resist heart fatigue during regeneration of cardiomyocytes. The mechanical properties of scaffolds, such as their Young's modulus and tensile strength, are critical for their suitability in tissue engineering

applications, particularly in cardiovascular research. We developed a scaffold mixing PCL with cocoa-derived EC [1-5].

Remarks

PEC/PCL protects against oxidative stress and interacts with calcium, altering heart cell contractions and offering insights for future cardiac repair therapies. These scaffolds combine antioxidant activity with calciummodulating the capacity of cardiomyocyte contractibility, thus, positioning them as promising candidates for cardiovascular tissue engineering. Future efforts are focus on further optimizing the structural and mechanical properties of electrospun scaffolds to mimic better the native extracellular matrix of cardiac tissue.

References

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Citation:

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