Kinetics: Bridging the Imaging-Bioengineering Gap in Biomedical Applications.

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Introduction

Imaging techniques and bioengineering approaches have made significant advances in the realm of biomedical applications. To completely appreciate and influence the intricacies of biological systems, however, it is necessary to bridge the gap between imaging and bioengineering. This integration is possible through the study and use of kinetics, which is concerned with understanding and quantifying the dynamic behaviour of biological systems.

Kinetics, as applied to biomedical applications, is the study of motion, change, and temporal patterns within biological systems. It includes a wide range of phenomena such as cell movement, fluid flow, biomolecule distribution, and the dynamics of physiological processes. Kinetics gives vital insights into the underlying mechanisms of numerous diseases, as well as prospects for developing innovative diagnostic and therapeutic strategies, by collecting and analysing these dynamic processes [1].

In the field of kinetics, the combination between imaging and bioengineering has the potential to revolutionise biomedical applications. Magnetic Resonance Imaging (MRI), Positron emission tomography (PET), and optical imaging are non-invasive techniques for visualising biological structures and functions. These imaging methods create massive volumes of data, allowing kinetic information to be extracted to characterise the dynamic behaviour of biological systems.

Bioengineering, on the other hand, provides tools and approaches for manipulating and controlling biological processes. Bioengineers can develop and optimise engineered systems that replicate or alter the dynamic behaviour of biological processes by integrating kinetic information collected from imaging. This multidisciplinary approach makes it easier to design sophisticated imaging technologies, tailored drug delivery systems, tissue engineering constructions, and personalised therapy techniques [2].

Cardiovascular disorders are the major cause of death throughout the world. Cardiomyocytes (CMs) are destroyed and replaced by fibrosis after an acute myocardial infarction (MI). The buildup of fibrillary cross-linked collagen deposition in the myocardium, as well as scar formation of the defect, can lead to significant ventricular remodelling and progressive heart failure, both of which can lead to cardiac death. The nonconductive fibrotic scar tissue in the infarct site may electrically uncouple viable CMs, resulting in a proarrhythmic environment. The absence of an electric link between the healthy myocardium and the insulated CMs in the scar may also contribute to asynchronous ventricular contraction, leading to gradual functional decompensation and mortality [3].

Tissue engineering is the process of implanting cells into a structural scaffolding in order to repair the architecture of damaged or diseased tissue. Understanding how cells collectively sense and react to the geometry of their local environment is required to effectively construct a scaffold. Understanding how normally soluble peptides and proteins aggregate to form amyloid fibrils is central to many areas of modern biomolecular science, from the development of functional biomaterials to the design of rational therapeutic strategies against increasingly prevalent medical conditions like Alzheimer's and Parkinson's disease. As a result, models that mechanistically describe how amyloid fibrils are produced from precursor peptides and proteins are desperately needed. Although early scar formation may prevent ventricular rupture, ventricular pressure may cause the scar to weaken and stretch, resulting in catastrophic ventricular dilatation and dysfunction. Novel approaches are thus needed to prevent ventricular thinning and dilatation, as well as to connect insulated contracting CMs and ensure their synchronised contraction, thereby preventing congestive heart failure [4].

The combination of contracting cardiac cells with a biomaterial scaffold as a cell delivery construct to replace cells lost as a result of an infarction and thus prevent ventricular dilation and restore heart function has piqued the interest of many researchers. This method of delivery offers the benefit of injecting a large number of heart cells, which can be grown in three dimensions to form a thick, functional bioengineered cardiac patch [5].

References

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