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Cardiovascular diseases (CVD) are the leading cause of death in the industrialised world [1] and now have risen to a similar position for developing countries. Myocardial infarction is the main cause of death in patients with CVD, although damage to heart muscle can also occur from infection, drugs, alcohol, chemotherapeutic agents or because of congenital conditions. While much progress has been made in preventing acute deaths from myocardial infarction, in the patients who survive the initial acute event there is a common progression to heart failure. This condition has a prognosis that is poorer than many cancers and even transplantation does not fully restore life expectancy.

The adult heart cannot adequately repair the damaged tissue, as mature contracting cardiomyocytes have severely limited ability to divide [2], and the stem/progenitor population within the adult heart apparently do not provide the scale of replacement needed after substantial damage [3]. Thus the result of myocardial infarction is the formation of scar tissue with different contractile, mechanical and electrical properties to that of normal myocardium, and a heart which is unable to deliver sufficient blood to meet the body’s metabolic requirements [4].

Both materials and cells of various kinds have been developed in an attempt to reverse this decline, with varying degrees of success. Myocardial tissue engineering (MTE) represents the combination of these strategies to solve problems of delivery, retention and support of introduced cells, as well as to harness additional therapeutic properties of the materials themselves. This book contains 11 chapters written by leading experts in MTE, giving a complete analysis of the field and presenting the latest advances from the research and applications points of view. The chapters cover all relevant aspects of MTE strategies, including cell sources, specific TE techniques and biomaterials used.

Many different cell types have been suggested for cell therapy in the framework of MTE, including, skeletal myoblasts, fetal cardiomyocytes, embryonic or induced pluripotent stem cell-derived cardiomyocytes, and resident adult stem/progenitor cells, all having advantages and disadvantages. Cell replacement therapy approaches are being proposed as convenient alternatives for regeneration or repair of the damaged myocardium and strategies are discussed in this book.
The book covers also a complete range of biomaterials, examining different aspects of their application in MTE, such as biocompatibility with cardiac cells, mechanical capability and compatibility with the mechanical properties of the native myocardium as well as degradation behaviour in vivo and in vitro. Although a great deal of research is being carried out in the field, this book also addresses many questions that still remain unanswered and highlights those areas in which further research efforts are required. Some of the chapters give also an insight into clinical trials and possible novel cell sources for cell therapy in MTE.

A commonly proposed method of introducing new cells into the damaged myocardium is by injection in suspension into either the circulating blood or directly into the myocardium or around the infarct. Cell delivery by direct injection can be inefficient with substantial cell loss, while intracoronary infusion may be contraindicated because of the larger size of pre-differentiated cardiomyocytes. This situation has prompted search for alternative delivery techniques for the cells whereby biomaterials play a key role in the success of several myocardial tissue regeneration strategies. In this context engineered three-dimensional scaffolds, in the form of mesh, patch or foam, cultured with relevant cells, provide a basic structure to be implanted into the infarcted region of the heart. The approach involves stitching an engineered cardiac construct, made from cardiomyocytes seeded into a suitable scaffold or matrix, directly onto the infarct region. This process ensures delivery of cells directly to the desired site, i.e. damaged myocardium. The use of structural biomaterial patches which will act not only as delivery vector for cells but also as mechanical support to the injured myocardium is being investigated worldwide and several examples of the research being carried out are presented in different chapters of this book. The expectation is that while supporting the ventricle, the wall stress will be reduced and potential scar expansion and further deterioration will be prevented. Either differentiated cardiomyocytes or cardiomyocyte progenitors could be grown in thin layer on the biomaterial patch, which would then be attached with cells in contact with the infarct area [5]. A linked hypothesis is that the residual vascularisation of the infarct region, coupled with the high resistance of embryonic cells to hypoxia, should preserve the cells until their own vascular networks are established. A number of engineered biomaterial patches are being proposed and investigated, indicating that a great variety of synthetic and natural polymers, and their combinations, is being investigated for applications in MTE approaches, as also discussed in dedicated chapters of this book.

As a summary, the book includes an introductory chapter to the field of MTE (Tissue Engineering for Cardiac Regeneration, Gaetani et al.), and two chapters describing new strategies in MTE (Inherently Bio-Active Scaffolds: Intelligent Constructs to Model the Stem Cell Niche, Di Nardo et al., Strategies for Myocardial Tissue Engineering: The Beat Goes On, Akhayari et al.). Next, a group of chapters focus on cell-based approaches (Creating Unique Cell Microenvironments for the Engineering of a Functional Cardiac Patch, Dvir et al., Intramyocardial Stem Cell Transplantation Without Tissue Engineered Constructs: The Current Clinical Situation, Donnodorf et al., Tissue Engineered Myocardium,
Zimmerman). The application of injectable biomaterials for MTE is described in Injectable Materials for Myocardial Tissue Engineering (Singelyn et al.) while Tissue Engineering Approaches for Myocardial Bandage: Focus on Hydrogel Constructs (Giraud et al.) presents the application of hydrogel constructs in MTE. Two chapters focus on advanced polymeric biomaterials for MTE: Engineering of Multifunctional Scaffolds for Myocardial Repair Through Nanofunctionalization and Microfabrication of Novel Polymeric Biomaterials, (Rossellini et al.), focusing on new strategies for nanofunctionalisation and microfabrication of MTE constructs, and Electrospun Nanocomposites and Stem Cells in Cardiac Tissue Engineering, (Genovese et al.), describing electrospinning based scaffolds. Finally, Heart Valve Tissue Engineering (Chester et al.) presents the engineering of heart valves.

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