

Stem Cell Biology and Regenerative Medicine

Series Editor

Kursad Turksen, Ph.D.
kturksen@ohri.ca

For further volumes:
<http://www.springer.com/series/7896>

David S. Allan • Dirk Strunk
Editors

Regenerative Therapy Using Blood-Derived Stem Cells

 Humana Press

Editors

David S. Allan
Ottawa Hospital Research Institute
University of Ottawa
ON, Canada
daallan@ohri.ca

Dirk Strunk
Center for Medical Research (ZMF)
Medical University of Graz
Graz, Austria
dirk.strunk@medunigraz.at

ISBN 978-1-61779-470-4 e-ISBN 978-1-61779-471-1

DOI 10.1007/978-1-61779-471-1

Springer New York Dordrecht Heidelberg London

Library of Congress Control Number: 2011939470

© Springer Science+Business Media, LLC 2012

All rights reserved. This work may not be translated or copied in whole or in part without the written permission of the publisher (Humana Press, c/o Springer Science+Business Media, LLC, 233 Spring Street, New York, NY 10013, USA), except for brief excerpts in connection with reviews or scholarly analysis. Use in connection with any form of information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed is forbidden.

The use in this publication of trade names, trademarks, service marks, and similar terms, even if they are not identified as such, is not to be taken as an expression of opinion as to whether or not they are subject to proprietary rights.

Printed on acid-free paper

Humana Press is part of Springer Science+Business Media (www.springer.com)

Preface

Blood has long been viewed as a conduit for therapy, stemming from the ancient days of phlebotomy to remove evil humors to the development of successful blood transfusions to replace missing blood components. The identification and characterization of hematopoietic stem cells by Drs. Till and McCulloch revolutionized the field and soon after, non-hematopoietic stem and progenitor cells were characterized from the blood and bone marrow. Some of these cell types and various blood-derived cell lineages are involved in the repair of various types of tissue damage that span the spectrum of medical disorders. The goal of this book is to provide an up-to-date review of the various types of blood-derived cells with regenerative capacity, identify opportunities for intervention by examining specific clinical applications, and recognize the regulatory environment that will encompass future therapies in regenerative medicine.

Through the contributors to this volume, we have succeeded in providing insight on numerous blood-derived cell types, including endothelial progenitors, mesenchymal stromal/stem cells, umbilical cord blood-derived undifferentiated somatic stem cells and others. Further, the concept of using umbilical cord blood is discussed throughout the book and several authors describe the current status of regenerative therapy for cardiac disease and neurological disorders. Technical and conceptual issues such as *ex vivo* expansion and the generation of induced pluripotent stem cells are covered and regulatory insight from various jurisdictions provides a degree of clinical relevance that may shape the immediate future of regenerative medicine.

We wish to thank the many contributors for their tremendous commitment and their precious time in preparing the insightful chapters that comprise this book. Some are long-time friends and contacts while others are new and welcome collaborators. All the contributors are dedicated to advancing our collective knowledge regarding the field of regenerative therapy. The cooperation and contributions from our colleagues and fellow authors has been inspirational. The guidance and support from the series editor, Dr. Kursad Turksen has been most valuable and the staff at Springer has been especially helpful in making this project a reality. In particular, we are indebted to the administrative assistance and invaluable editing performed by Monica Farrell and Stéphanie Rochette.

We hope this book will stimulate enquiring minds and future investigation in this exciting and evolving field of research. The community of dedicated researchers and health care providers will need to engage at all levels to continue the push towards viable treatments that improve the lives of patients around the globe.

Ottawa, Canada
Graz, Austria

David S. Allan
Dirk Strunk

Contents

| | |
|---|------------|
| 1 Undertaking Regenerative Medicine Studies with Blood Stem Cells | 1 |
| Sowmya Viswanathan and Armand Keating | |
| 2 Defining Endothelial Progenitor Cells | 9 |
| Julie Mund, David A. Ingram, and Mervin C. Yoder | |
| 3 Blood-Derived ALDH^{hi} Cells in Tissue Repair | 21 |
| David M. Putman, Gillian I. Bell, and David A. Hess | |
| 4 Mesenchymal Stem Cells and Tissue Repair | 35 |
| Daniel L. Coutu, Moïra François, and Jacques Galipeau | |
| 5 Animal Protein-Free Expansion of Human Mesenchymal Stem/Progenitor Cells | 53 |
| Katharina Schallmoser, Nathalie Etchart, Dirk Strunk, and Eva Rohde | |
| 6 Defining Hierarchies of Unrestricted Somatic Stem Cells and Mesenchymal Stem Cells in Cord Blood | 71 |
| Gesine Kögler | |
| 7 Induced Pluripotent Stem Cells from Blood..... | 87 |
| Ulrich Martin | |
| 8 Endothelial Progenitors and Repair of Cardiovascular Disease | 97 |
| Benjamin Hibbert, Trevor Simard, and Edward R. O'Brien | |
| 9 Bone Marrow-Derived Cells as Treatment Vehicles in the Central Nervous System | 109 |
| Coral-Ann B. Lewis, Fabio M. Rossi, and Charles Krieger | |
| 10 Regenerative Potential of Blood Stem Cell Products Used in Hematopoietic Stem Cell Transplantation..... | 125 |
| Laura Labonté and David S. Allan | |

| | |
|--|------------|
| 11 Concepts to Facilitate Umbilical Cord Blood Transplantation | 141 |
| Andreas Reinisch and Dirk Strunk | |
| 12 Cord Blood Banking for Regenerative Therapy | 157 |
| Jennifer Klowak, Yuan Chung, and David S. Allan | |
| 13 Regulatory Questions in the Development of Blood Stem Cell Products for Regenerative Therapy | 167 |
| Michael Rosu-Myles, Liz Anne Gillham-Eisen, Francisca R. Agbanyo, and Peter R. Ganz | |
| 14 Cell Therapy Regulations from a European Perspective | 191 |
| Giani Oancea, Beate Wagner, and Reinhard Henschler | |
| 15 EBMT Registry of Nonhematopoietic Stem Cells and Regenerative Therapy (Cellular and Engineered Tissue Therapies in Europe) | 205 |
| Helen Baldomero, Ivan Marin, Katarina Le Blanc, Jan Cornelissen, Jakob Passweg, and Dietger Niederwieser | |
| Index | 211 |

Contributors

Francisca R. Agbanyo Biologics and Genetic Therapies Directorate,
Health Products and Food Branch, Ottawa, ON, Canada

David S. Allan Regenerative Medicine Program, Ottawa Hospital
Research Institute, Blood and Marrow Transplant Program, The Ottawa Hospital,
Ottawa, ON, Canada

Departments of Medicine and Biochemistry, Microbiology & Immunology,
University of Ottawa, Ottawa, ON, Canada

Helen Baldomero Department of Hematology, University of Basel,
Basel, Switzerland

Gillian I. Bell Department of Physiology & Pharmacology,
The University of Western Ontario, Vascular Biology Group,
Krembil Centre for Stem Cell Biology, Robarts Research Institute,
London, ON, Canada

Yuan Chung Regenerative Medicine Program, Ottawa Hospital Research
Institute, Ottawa, ON, Canada

Jan Cornelissen Department of Hematology, Erasmus University Medical Center,
Rotterdam, The Netherlands

Daniel L. Coutu Division of Experimental Medicine, McGill University Lady
Davis Institute for Medical Research, Montreal, QC, Canada

Nathalie Etchart Stem Cell Research Unit, Department of Hematology
and Stem Cell Transplantation, University Clinic of Blood Group Serology
and Transfusion Medicine, and Medical University of Graz, Graz, Austria

Moïra François Division of Experimental Medicine, McGill University Lady
Davis Institute for Medical Research, Montreal, QC, Canada

Peter R. Ganz Biologics and Genetic Therapies Directorate,
Health Products and Food Branch, Health Canada, Ottawa, ON, Canada

Jacques Galipeau Department of Hematology & Medical Oncology
and Department of Pediatrics, Emory University, Atlanta, GA, USA

Liz Anne Gillham-Eisen Biologics and Genetic Therapies Directorate,
Health Products and Food Branch, Health Canada, Ottawa, ON, Canada

Reinhard Henschler Institute of Transfusion Medicine and Immune Hematology,
German Red Cross Blood Center, Frankfurt, Germany

David A. Hess Department of Physiology & Pharmacology, The University
of Western Ontario, Vascular Biology Group, Krembil Centre for Stem Cell
Biology, Robarts Research Institute, London, ON, Canada

Benjamin Hibbert Vascular Biology Laboratory, Division of Cardiology,
Department of Biochemistry, University of Ottawa Heart Institute,
Ottawa, ON, Canada

David A. Ingram Department of Pediatrics, Herman B Wells Center
for Pediatric Research, Indiana University School of Medicine,
Indianapolis, IN, USA

Armand Keating Cell Therapy Program, Princess Margaret Hospital,
University of Toronto, Toronto, Canada

Division of Hematology, Department of Medicine, University of Toronto,
Toronto, Canada

Jennifer Klowak Regenerative Medicine Program, Ottawa Hospital Research
Institute, Ottawa, ON, Canada

Gesine Kögler Institute for Transplantation Diagnostics and Cell Therapeutics,
University of Duesseldorf Medical School, Duesseldorf, Germany

Charles Krieger Division of Neurology, Department of Medicine,
Neuromuscular Disease Unit, VHHSC, Vancouver, BC, Canada

Laura Labonté Regenerative Medicine Program, Ottawa Hospital Research
Institute, Blood and Marrow Transplant Program, The Ottawa Hospital,
Ottawa, ON, Canada

Departments of Medicine and Biochemistry, Microbiology & Immunology,
University of Ottawa, Ottawa, ON, Canada

Katarina Le Blanc Karolinska Institute, Division of Clinical Immunology,
Karolinska University, Stockholm, Sweden

Coral-Ann B. Lewis Department of Biomedical Physiology and Kinesiology,
Simon Fraser University, Burnaby, BC, Canada

Ivan Martin Biomedicine and Surgery, University of Basel, Basel, Switzerland

Ulrich Martin Leibniz Research Laboratories for Biotechnology and Artificial Organs (LEBAO), Department of Cardiac, Thoracic-, Transplantation and Vascular Surgery, REBIRTH-Cluster of Excellence, Hannover Medical School, Hannover, Germany

Julie Mund Department of Pediatrics, Herman B Wells Center for Pediatric Research, Indiana University School of Medicine, Indianapolis, IN, USA

Dietger Niederwieser Division of Hematology and Medical Oncology, University of Leipzig, Leipzig, Germany

Giani Oancea Institute of Transfusion Medicine and Immune Hematology, German Red Cross Blood Center, Frankfurt, Germany

Edward R. O'Brien Vascular Biology Laboratory, Division of Cardiology, Department of Biochemistry, University of Ottawa Heart Institute, Ottawa, ON, Canada

Jakob Passweg Department of Hematology, University of Basel, Basel, Switzerland

David M. Putman Department of Physiology & Pharmacology, The University of Western Ontario, Vascular Biology Group, Krembil Centre for Stem Cell Biology, Robarts Research Institute, London, ON, Canada

Andreas Reinisch Stem Cell Research Unit and Department of Hematology and Stem Cell Transplantation, Medical University of Graz, Graz, Austria

Eva Rohde Stem Cell Research Unit, Medical University of Graz, Graz, Austria
University Clinic of Blood Group Serology and Transfusion Medicine, Paracelsus Medical University of Salzburg, Salzburg, Austria

Fabio M. Rossi Department of Medical Genetics, University of British Columbia, Vancouver, BC, Canada

Michael Rosu-Myles Biologics and Genetic Therapies Directorate, Health Products and Food Branch, Health Canada, Ottawa, ON, Canada

Katharina Schallmoser Stem Cell Research Unit and University Clinic of Blood Group Serology and Transfusion Medicine, Medical University of Graz, Graz, Austria

Trevor Simard Vascular Biology Laboratory, Division of Cardiology, Department of Biochemistry, University of Ottawa Heart Institute, Ottawa, ON, Canada

Dirk Strunk Stem Cell Research Unit and Department of Hematology and Stem Cell Transplantation, Medical University of Graz, Graz, Austria

Sowmya Viswanathan Cell Therapy Program, Princess Margaret Hospital, University Health Network, Toronto, ON, Canada

Beate Wagner Department of Transfusion Medicine and Hemostaseology, Clinics of the Ludwig Maximilians University Munich, Munich, Germany

Mervin C. Yoder Department of Pediatrics, Herman B Wells Center for Pediatric Research, Indiana University School of Medicine, Indianapolis, IN, USA