Consiglio Nazionale delle Ricerche

MODELLING CARDIOVASCULAR SYSTEM & MECHANICAL CIRCULATORY SUPPORT

Edited by
Claudio De Lazzari

SYSTEM
CIRCULATORY
SUPPORT
MECHANICAL
MODELLING
CARDIOVASCULAR

MODELLING CARDIOVASCULAR SYSTEM AND MECHANICAL CIRCULATORY SUPPORT

Prezzo € 70,00

ISBN 978-88-8080-081-1

CONSIGLIO NAZIONALE DELLE RICERCHE

MODELLING CARDIOVASCULAR SYSTEM AND MECHANICAL CIRCULATORY SUPPORT

Edited by
Claudio De Lazzari

Volume realizzato dall'Ufficio Pubblicazioni e Informazioni Scientifiche
Direttore: *Dr. Mario Apice*

Contents

CONTRIBUTING AUTHORS

Andrea Barison, MD.
Cardiac Thoracic and Vascular Department
University of Pisa
Pisa, Italy
Email: barison@sssup.it

Marek Darowski, Prof., Ph.D., Eng.
Institute of Biocybernetics and Biomedical Engineering
Polish Academy of Sciences
Warsaw, Poland
E-mail: mdar@ibib.waw.pl

Claudio De Lazzari, MS, Eng.
Institute of Clinical Physiology
National Research Council
Section of Rome, Italy
E-mail: claudio.delazzari@ifc.cnr.it

GianFranco Ferrari, MS, Eng.
Institute of Clinical Physiology
National Research Council
Section of Rome, Italy
E-mail: gfr.ferrari@ifc.cnr.it

Luca Formaggia, Prof.
Mathematics Department, "F. Brioschi"
Politecnico di Milano, Italy
E-mail: luca.formaggia@polimi.it

Tomasz Golczewski, Ph.D., Eng.
Institute of Biocybernetics and Biomedical Engineering
Polish Academy of Sciences
Warsaw, Poland
E-mail: tomasz.golczewski@ibib.waw.pl

Contributing Authors

Gabriele Grassi, Prof., MD, Ph.D.
Dipartimento di Biochimica, Biofisica e Chimica delle Macromolecole
University of Trieste, Piazzale Europa 1
Trieste, Italy.
E-mail: ggrassi@units.it

Mario Grassi, Prof.
Department of Chemical Engineering (DICAMP)
University of Trieste, Piazzale Europa 1
Trieste, Italy.
E-mail: mario.grassi@dicamp.units.it

Maciej Kozarski, Ph.D., Eng.
Institute of Biocybernetics and Biomedical Engineering
Polish Academy of Sciences
Warsaw, Poland

Antonio L'Abbate, Prof., MD.
Department of Internal Medicine
Scuola Superiore Sant'Anna
Pisa, Italy
E-mail: segrlabb@ifc.cnr.it

Danilo Neglia, MD, Ph.D.
Institute of Clinical Physiology
National Research Council
Pisa, Italy
Email: dneglia@ifc.cnr.it

Domenico M. Pisanelli, MS, Eng.
Institute of Cognitive Sciences and Technologies
National Research Council
Rome, Italy
E-mail: d.pisanelli@istc.cnr.it

Giuseppe Pontrelli, Dr.
Istituto per le Applicazioni del Calcolo
National Research Council
Roma, Italy
E-mail: g.pontrelli@iac.cnr.it

Luciano Teresi, Ph.D.
Department of Studies on Structures
University of "Roma Tre"
Rome, Italy
E-mail: teresi@uniroma3.it

M. Giovanna Trivella, MD.
Institute of Clinical Physiology
National Research Council
Pisa, Italy
E-mail: trivella@ifc.cnr.it

Alessandro Veneziani, Prof., Ph.D.
Mathematics Department "F. Brioschi"
Politecnico di Milano, Italy
E-mail: alessandro.veneziani@polimi.it

To Anna Maria

PREFACE

Numerical simulation is one of the methods to study the behaviour of the cardiovascular and respiratory systems in different physiological and pathological conditions.

Aim of this book is to illustrate some of the possible applications of cardiocirculatory and respiratory modelling.

The first part of the book illustrates some numerical and hybrid (numerical-physics) lumped parameters circulatory and respiratory models.

Next, “multiscale model” approach aimed at describing in detail the behaviour of a vessel section and its relationship with the remaining part of the circulatory system by a lumped parameter model is presented.

Finally, a mathematical model able to predict the drug distribution and its evolution in time over a cross-section of the wall arterial vessel is shown. This model can be used to identify simple indexes or clinical indicators of biomedical significance and to optimise drug elution for a desired tissue concentration.

In the second part of the book some applications of lumped parameter circulatory models are described. They include the analysis of the influence of mechanical ventilation on hemodynamics and ventricular energetics. A special attention is devoted to mechanical circulatory assistance that is represented here by the models of several pulsatile and continuous flow assist devices. They are used in conjunction with the circulatory model to demonstrate their influence on hemodynamics and ventricular energetics.

Finally, an application of circulatory model to the study of coronary circulation is presented.

This book does not want to be exhaustive in the presentation of circulatory modelling, but it is simply aimed at showing as simulation tools can help to analyse and interpret complex biological phenomena.

Other important applications of circulatory models involve the study of the effects of environmental conditions (diving low gravity) and last but not least their use for education, as training tools for medical and nursing staff and, finally, for the validation of prosthetic devices.