

Preface

Me vero primum dulces ante omnia Musae, Quarum sacra fero ingenti perculsus amore, Accipiant, caelique vias et sidera monstrent; Defectus Solis varios, Lunaque labores: Unde tremor terris, qua vi maria alta tumescant Obicibus ruptis, rursusque in seipsa resident: Quid tantum Oceano properent se tingere soleshiberni: vel quae tardis mora noctibus obstet. [But most beloved, ye Muses, at whose fane, Led by pure zeal, I consecrate my strain, Me first accept! And to my search unfold, Heaven and her host in beauteous order rolled, The eclipse that dims the golden orb of day, And changeful labour of the lunar ray; Whence rocks the earth, by what vast force the main Now bursts its barriers, now subsides again; Why wintry suns in ocean swiftly fade, Or what delays night's slow-descending shade.] (P. Vergilius Maro [c.-70–c.-19], *Georgics*, Book II)

The first volumes including Vols. 1–5, review main events and their associated signal transduction processes in cells and biological tissues, that is, at the nano-, micro-, and mesoscopic scales in normal conditions. Because of the amount of accumulated data on the physiology and pathophysiology of the circulatory and ventilatory apparatus, the initially scheduled one-volume book (referred to as Vol. 6 *Circulatory and Ventilatory Conduits in Normal and Pathological Conditions* in previous volumes of the series *Biomathematical and Biomechanical Modeling of the Circulatory and Ventilatory Systems*) has been split. Volume 6 mainly targets the organ scale, that is, the macroscopic scale, in normal conditions (i.e., anatomy and physiology of blood circulation and the body's ventilation), although it reviews histological and biochemical data for a better understanding of macroscopic scale processes. Volumes 7 and 8 focus on pathological conditions that affect the heart (Vol. 7), vasculature, and the respiratory tract (Vol. 8) in a modeling perspective rather than a clinical point of view. They mainly deal with diseases of the cardiovascular and ventilatory apparatus investigated using biomechanical modeling. Some diseases have a mechanical origin; most are associated with a mechanical disorder. Local flow disturbances can actually trigger pathophysiological processes or, conversely, result from diseases of the pump or conduit walls or their environment. The ability to model these phenomena is essential to the development of a personalized medicine and manufacturing of medical devices, which incorporates a stage of numerical tests in addition to experimental procedures.

Programs in computational medicine rely on a software-coupling platform aimed at incorporating structural (anatomical) and functional data at various length and time scales to simulate functioning of the physiological apparatus in both normal and pathological conditions, thereby promoting personalized, predictive, and, if possible, preventive healthcare. Modeling supports computer-aided diagnosis and treatment planning, as well as prediction of therapeutic outcomes and prognosis.

Modeling is associated with numerical simulations of physical and chemical processes. Problem formulation and mathematical analysis lead to the construction of solution algorithms. Approximations result from inherent errors of mathematical models of natural processes that arise from partial understanding of these phenomena and their random nature, as well as measurement uncertainties. Moreover, model equations cannot be commonly solved analytically. Problem equations are converted to a set of algebraic equations (numerical approximations). Numerical procedures introduce truncation errors associated with numerical approximations and round-off errors, as a finite number of digits are used to represent numbers.

On the other hand, biomedical informatics aims at integrating the collection of biochemical data, physiological signals, medical images, biological rhythms, epidemiological factors, clinical history events, and simulation results into usable information to foster the creation of new diagnostic and therapeutic methods and improve both life quality and healthcare cost.

Bioinformatics supports the development of knowledge and data management platforms to identify predisposition to diseases and biomarkers for early diagnosis and therapy adaptation in a framework of individualized medicine. Tasks incorporate data mining and information retrieval, indexing, and representation.

At nunc per maria ac terras sublimaque caeli multa modis multis varia ratione moveri cernimus ante oculos. . .” [But by seas, lands, and heights of heaven many things move in many ways for various reasons before our eyes]

(T. Lucretius Carus [c.-99–c.-55], *De Rerum Natura* [On the Nature of Things], Book I)

Physiological flow behavior in pathological conditions is described by a set of conservation equations. The Navier–Stokes equations (Vols. 1, Chap. 1, Cells and Tissues; and 9, Chap. 1, Hemodynamics), derive from the continuum mechanics theory. This equation set predicts transient flow behavior of a fluid of given properties in a given domain of the highly deformable cardiac pump using proper boundary conditions and values of flow-governing dimensionless parameters.

Mathematical modeling also targets maladaptive tissue growth that causes mural pathologies, especially in the heart (hypertension-initiated cardiac hypertrophy) or results from medical device implantation. Tissue remodeling can be investigated at a macroscopic scale and all micro- and mesoscopic scale phenomena lumped in parameters that are incorporated in a system of nonlinear, coupled, parametric, partial differential equations. This type of equation set is used in continuous-type models that rely on mixture theory. However, this solving procedure necessitates an efficient identification stage to estimate involved parameters.

Like Vol. 6, the present book mainly refers to the macroscopic scale, although nano- and microscale pathophysiological mechanisms are described. It includes nine

chapters. Chapters 1 and 2 describe the context, factors, and processes involved in pathogenesis of cardiac diseases. Chapter 3 is devoted to adverse cardiac remodeling, that is, fibrosis and hypertrophy, Chap. 4 to cardiomyopathies, Chap. 5 to rhythm and conduction alterations, Chap. 6 to cardiac valve diseases, Chap. 7 to heart failure, Chap. 8 to coronary artery disease and myocardial infarction, and Chap. 9 to interventional medicine and surgery of cardiac diseases.

Acknowledgments The author acknowledges the patience of his wife Anne, daughter Maud, sons Alrik and Damien, and their respective French (Julien, Jean, and Louis), American (Raphaëlle, Matthieu, and Alexandre), and Polish (Joanna and Frédéric) families.

Diseases of the Cardiac Pump

Thiriet, M.

2015, XVI, 631 p. 7 illus., 1 illus. in color., Hardcover

ISBN: 978-3-319-12663-0