BRAUNWALD'S
HEART DISEASE
A Textbook of Cardiovascular Medicine
BRAUNWALD’S
HEART DISEASE
A Textbook of Cardiovascular Medicine
NINTH EDITION

Edited by

Robert O. Bonow, MD
Max and Lilly Goldberg Distinguished Professor of Cardiology
Vice Chairman, Department of Medicine
Director, Center for Cardiac Innovation
Northwestern University Feinberg School of Medicine
Chicago, Illinois

Douglas L. Mann, MD
Lewin Chair and Professor of Medicine, Cell Biology and Physiology
Chief, Division of Cardiology
Washington University School of Medicine in St. Louis
Cardiologist-in-Chief
Barnes Jewish Hospital
Saint Louis, Missouri

Douglas P. Zipes, MD
Distinguished Professor Emeritus of Medicine, Pharmacology, and Toxicology
Director Emeritus, Division of Cardiology and the Krannert Institute of Cardiology
Indiana University School of Medicine
Indianapolis, Indiana

Peter Libby, MD
Mallinckrodt Professor of Medicine
Harvard Medical School
Chief, Cardiovascular Division
Brigham and Women’s Hospital
Boston, Massachusetts

Founding Editor and Online Editor

Eugene Braunwald, MD, MD(Hon), ScD(Hon), FRCP
Distinguished Hersey Professor of Medicine
Harvard Medical School
Chairman, TIMI Study Group
Brigham and Women’s Hospital
Boston, Massachusetts

ELSEVIER
SAUNDERS
Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary. Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

With respect to any drug or pharmaceutical products identified, readers are advised to check the most current information provided (i) on procedures featured or (ii) by the manufacturer of each product to be administered, to verify the recommended dose or formula, the method and duration of administration, and contraindications. It is the responsibility of practitioners, relying on their own experience and knowledge of their patients, to make diagnoses, to determine dosages and the best treatment for each individual patient, and to take all appropriate safety precautions.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.
Dedication

We are proud to dedicate the ninth edition of *Braunwald’s Heart Disease* to its founder, Eugene Braunwald, MD. The first edition of this work, published 30 years ago, established a standard of excellence that is rarely, if ever, achieved in publishing. Dr. Braunwald personally wrote half of the book and expertly edited the rest. He did the same for the next four editions, taking a 6-month sabbatical every 4 to 5 years to accomplish that. For the sixth edition, published in 2001, he invited two of us (PL, DPZ) to share the experience with him, increasing the editors by one (ROB) for the seventh edition. A new editor (DLM) joined for the eighth edition, and Dr. Braunwald no longer directly participated in the day-to-day editing of the print text, while still contributing some of the key chapters. However, he kept his finger on the pulse of the text and for that edition began *twice-weekly* electronic updates. Incorporating the most recent research, reviews, and opinions into the electronic text has continued through this ninth edition, making *Braunwald’s Heart Disease* truly a living work and setting it apart from other texts. Dr. Braunwald, through his research, teaching, and mentorship, has shaped much of contemporary cardiovascular medicine, and it is with gratitude and admiration that we dedicate this edition of *his work* to him.

Robert O. Bonow  
Douglas L. Mann  
Douglas P. Zipes  
Peter Libby
Acknowledgments

The editors gratefully acknowledge communication and correspondence from colleagues all over the world who have offered insightful suggestions to improve this text. We particularly wish to acknowledge the following individuals who have provided careful and studious commentary on numerous chapters: Shabnam Madadi, MD, Cardiac Imaging Center, Shahid Rajaee Heart Center, Tehran, Iran; Azin Alizadeh Asl, MD, Tabriz University of Medical Sciences and Madani Heart Hospital, Tabriz, Iran; Leili Pouraflkari, MD, Razi Hospital, Tabriz, Iran; Banasiak Waldemar, MD, Centre for Heart Disease, Military Hospital, Wroclaw, Poland; Carlos Benjamin Alvarez, MD, PhD, Sacré Coeur Institute, Buenos Aires, Argentina; Elias B. Hanna, MD, Division of Cardiology, Louisiana State University, New Orleans, Louisiana.

We are also indebted to Dr. Jun-o Deguchi, Dr. Michael Markl, Dr. Vera Rigolin, and Dr. Carol Warnes for the images used on the cover.

Dr. Libby thanks Sara Karwacki for expert editorial assistance.
To:
Pat, Rob, and Sam
Laura, Stephanie, Jonathan, and Erica
Joan, Debra, Jeffrey, and David
Beryl, Oliver, and Brigitte
Contributors
Christopher P. Cannon, MD
Associate Professor of Medicine, Harvard Medical School; Senior Investigator, TIMI Study Group, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts

John M. Canty, Jr., MD
Albert and Elizabeth Rekate Professor of Medicine; Chief, Division of Cardiovascular Medicine, University at Buffalo, Buffalo, New York
Coronary Blood Flow and Myocardial Ischemia

Agustín Castellanos, MD
Professor of Medicine, University of Miami Miller School of Medicine; Director, Clinical Electrophysiology, University of Miami/Jackson Memorial Medical Center, Miami, Florida
Cardiac Arrest and Sudden Cardiac Death

Bernard R. Chaitman, MD
Professor of Medicine; Director, Cardiovascular Research, St. Louis University School of Medicine, Division of Cardiology, St. Louis, Missouri
Exercise Stress Testing; Guidelines: Exercise Stress Testing

Ming Hui Chen, MD, MMSc
Assistant Professor of Medicine, Harvard Medical School; Director, Cardiac Health for Hodgkin's Lymphoma Survivors; Associate in Cardiology Department of Cardiology, Children's Hospital Boston, Boston, Massachusetts
The Cancer Patient and Cardiovascular Disease

Heidi M. Connolly, MD
Professor of Medicine, Mayo Clinic College of Medicine; Consultant, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota
Echocardiography

Mark A. Creager, MD
Professor of Medicine, Harvard Medical School; Director, Vascular Center, Brigham and Women's Hospital; Boston, Massachusetts
Peripheral Artery Diseases

Edéciu Cunha-Neto MD, PhD
Associate Professor of Immunology, University of São Paulo; Researcher of the Cardiac Immunology Laboratory, The Heart Institute (INCOR), University of São Paulo Medical School, São Paulo, Brazil
Chagas' Disease

Charles J. Davidson, MD
Professor of Medicine; Medical Director, Bluhm Cardiovascular Institute; Clinical Chief, Division of Cardiology, Northwestern University Feinberg School of Medicine, Chicago, Illinois
Cardiac Catheterization

Vasken Dilsizian, MD
Professor of Medicine and Diagnostic Radiology; Chief, Division of Nuclear Medicine; Director, Cardiovascular Nuclear Medicine and PET Imaging, University of Maryland School of Medicine, Baltimore, Maryland
Nuclear Cardiology

Stefanie Dimmeler, PhD
Professor and Director of the Institute of Cardiovascular Regeneration, Centre for Molecular Medicine, Goethe-University Frankfurt, Frankfurt, Germany
Emerging Therapies and Strategies in the Treatment of Heart Failure

Pamela S. Douglas, MD
Ursula Geller Professor of Research in Cardiovascular Diseases, Division of Cardiovascular Medicine, Duke University Medical Center, Durham, North Carolina
Cardiovascular Disease in Women

Andrew C. Eisenhauer, MD
Assistant Professor of Medicine, Harvard Medical School; Director, Interventional Cardiovascular Medicine Service; Associate Director, Cardiac Catheterization Laboratory, Brigham and Women's Hospital; Director, Cardiac Quality Assurance, Partners Health Care, Boston, Massachusetts
Endovascular Treatment of Noncoronary Obstructive Vascular Disease

Linda L. Emanuel, MD, PhD
Buehler Professor of Geriatric Medicine; Director, The Buehler Center on Aging, Northwestern University Feinberg School of Medicine, Chicago, Illinois
Care of Patients with End-Stage Heart Disease

Edzard Ernst, MD, PhD, FMed Sci, FRCP, FRCP(Edin)
Chair in Complementary Medicine, Peninsula Medical School, University of Exeter, Exeter, United Kingdom
Complementary and Alternative Approaches to Management of Patients with Heart Disease

James C. Fang, MD
Professor of Medicine, Division of Cardiovascular Medicine, Case Western Reserve University School of Medicine, Harrington-McLaughlin Heart and Vascular Institute, University Hospitals, Cleveland, Ohio
Diagnosis and Management of Acute Heart Failure Syndromes

Gerasimos S. Filippatos, MD
Head, Heart Failure Unit, Attikon University Hospital, Department of Cardiology, University of Athens, Athens, Greece
Diagnosis and Management of Acute Heart Failure Syndromes

Stacy D. Fisher, MD
Director of Women's and Complex Heart Disease, Department of Cardiology, University of Maryland Comprehensive Heart Center, Baltimore, Maryland
Cardiovascular Abnormalities in HIV-Infected Individuals

Lee A. Fleisher, MD
Roberts D. Dripps Professor and Chair of Anesthesiology and Critical Care; Professor of Medicine, University of Pennsylvania School of Medicine, Philadelphia, Pennsylvania
Anesthesia and Noncardiac Surgery in Patients with Heart Disease; Guidelines: Reducing Cardiac Risk with Noncardiac Surgery

Thomas Force, MD
Wilson Professor of Medicine, Thomas Jefferson University; Clinical Director, Center for Translational Medicine, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania
The Cancer Patient and Cardiovascular Disease
CONTRIBUTORS

J. Michael Gaziano, MD, MPH
Professor of Medicine, Harvard Medical School; Chief, Division of Aging, Brigham and Women's Hospital; Director, Massachusetts Veterans Epidemiology and Research Information Center (MAVERIC), VA Boston Healthcare System, Boston, Massachusetts
Global Burden of Cardiovascular Disease

Thomas A. Gaziano MD, MSc
Assistant Professor, Harvard Medical School; Associate Physician, Cardiovascular Medicine, Brigham & Women’s Hospital, Boston, Massachusetts
Global Burden of Cardiovascular Disease

Jacques Genest, MD
Professor of Medicine; Scientific Director, Center for Innovative Medicine, McGill University Health Center, McGill University; Montreal, Quebec, Canada
Lipoprotein Disorders and Cardiovascular Disease

Miha Gheorghiade, MD
Professor of Medicine and Surgery; Director, Experimental Therapeutics/Center for Cardiovascular Innovation; Northwestern University Feinberg School of Medicine, Chicago, Illinois; Co-Director, Duke Cardiovascular Center for Drug Development, Raleigh, North Carolina
Diagnosis and Management of Acute Heart Failure Syndromes

Ary L. Goldberger, MD
Professor of Medicine, Harvard Medical School & Wyss Institute for Biologically Inspired Engineering at Harvard University; Director, Margret and H.A. Rey Institute for Nonlinear Dynamics in Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts
Electrocardiography; Guidelines: Electrocardiography

Samuel Z. Goldhaber, MD
Professor of Medicine, Harvard Medical School; Director, Venous Thromboembolism Research Group; Staff Cardiologist, Cardiovascular Medicine Division, Brigham and Women’s Hospital, Boston, Massachusetts
Pulmonary Embolism

Larry B. Goldstein, MD
Professor, Department of Medicine (Neurology), Duke Stroke Center; Center for Clinical Health Policy Research, Duke University and Durham VA Medical Center, Durham, North Carolina
Prevention and Management of Stroke

Richard J. Gray, MD
Medical Director, Sutter Pacific Heart Centers, California Pacific Medical Center, San Francisco, California
Medical Management of the Patient Undergoing Cardiac Surgery

Barry Greenberg, MD
Professor of Medicine; Director, Advanced Heart Failure Treatment Program, University of California, San Diego, California
Clinical Assessment of Heart Failure

Bartley P. Griffith, MD
The Thomas E. and Alice Marie Hales Distinguished Professor/Professor of Surgery & Chief, Division of Cardiac Surgery, Department of Surgery, Division of Cardiac Surgery, University of Maryland School of Medicine, Baltimore, Maryland
Assisted Circulation in the Treatment of Heart Failure

William J. Groh, MD, MPH
Associate Professor of Medicine, Division of Cardiology, Indiana University; Indianapolis, Indiana
Neurologic Disorders and Cardiovascular Disease

Joshua M. Hare, MD
Louis Lemberg Professor of Medicine; Professor of Biomedical Engineering; Professor of Molecular and Cellular Pharmacology; Director, Interdisciplinary Stem Cell Institute, University of Miami Miller School of Medicine, Miami, Florida
The Dilated, Restrictive, and Infiltrative Cardiomyopathies

Gerd Hasenfuss, MD
Professor and Chair, Department of Cardiology and Pneumology, Heart Center, University of Goettingen; Chair of Heart Research Center, Goettingen, Germany
Mechanisms of Cardiac Contraction and Relaxation

David L. Hayes, MD
Professor of Medicine, College of Medicine; Consultant, Division of Cardiovascular Diseases, Mayo Clinic, Rochester, Minnesota
Pacemakers and Implantable Cardioverter-Defibrillators; Guidelines: Cardiac Pacemakers and Cardioverter-Defibrillators

Maria de Lourdes Higuchi, MD
Director of Laboratory of Research on Cardiac Inflammation and Infection, Heart Institute (INCOR), University of São Paulo Medical School, São Paulo, Brazil
Chagas' Disease

L. David Hillis, MD
Professor and Chair Internal Medicine, University of Texas Health Science Center, San Antonio, Texas
Toxins and the Heart

Farouc A. Jaffer, MD, PhD
Assistant Professor of Medicine, Cardiology Division and Cardiovascular Research Center, Department of Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts
Molecular Imaging in Cardiovascular Disease

Mariell Jessup, MD
Professor of Medicine; Associate Chief for Clinical Affairs, Cardiovascular Division, University of Pennsylvania School of Medicine; Medical Director, Penn Heart and Vascular Center, University of Pennsylvania Health System, Philadelphia, Pennsylvania
Surgical Management of Heart Failure

Andrew M. Kahn, MD, PhD
Assistant Professor of Medicine, University of California, San Diego, California
Clinical Assessment of Heart Failure

Jan Kajstura, PhD
Associate Professor, Departments of Anesthesia and Medicine, and Cardiovascular Division, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts
Cardiovascular Regeneration and Tissue Engineering

Norman M. Kaplan, MD
Clinical Professor of Internal Medicine, University of Texas Southwestern Medical Center at Dallas, Dallas, Texas
Systemic Hypertension: Therapy; Guidelines: Treatment of Hypertension
Adolf W. Karchmer, MD  
Professor of Medicine, Harvard Medical School; Division of Infectious Disease, Beth Israel Deaconess Medical Center, Boston, Massachusetts  
*Endocarditis*

Irwin Klein, MD  
Professor of Medicine and Cell Biology; Associate Chairman, Department of Medicine, North Shore University Hospital, Manhasset, New York  
*Endocrine Disorders and Cardiovascular Disease*

Harlan M. Krumholz, MD, SM  
Harold H. Hines, Jr, Professor of Medicine and Epidemiology and Public Health; Section of Cardiovascular Medicine, Department of Medicine, Section of Health Policy and Administration, School of Public Health, Yale University School of Medicine; Center for Outcomes Research and Evaluation, Yale–New Haven Hospital, New Haven, Connecticut  
*Clinical Decision Making in Cardiology*

Raymond Y. Kwong, MD, MPH  
Assistant Professor of Medicine, Harvard Medical School; Director of Cardiovascular Magnetic Resonance Imaging, Cardiovascular Division, Brigham and Women's Hospital, Boston, Massachusetts  
*Cardiovascular Magnetic Resonance Imaging: Appropriate Use Criteria: Cardiovascular Magnetic Resonance*

Philippe L. L'Allier, MD  
Associate Professor of Medicine, Department of Medicine; Director, Interventional Cardiology; Desgroseillers-Bénard Chair in Interventional Cardiology, Montreal Heart Institute, University of Montreal, Montreal, Canada  
*Intravascular Ultrasound Imaging*

Richard A. Lange, MD  
Professor and Executive Vice Chairman, Medicine, University of Texas Health Science Center, San Antonio, Texas  
*Toxins and the Heart*

Thomas H. Lee, MD  
Professor of Medicine, Harvard Medical School; Network President, Partners Healthcare System, Boston, Massachusetts  
*Measurement and Improvement of Quality of Cardiovascular Care; Guidelines: Pregnancy and Heart Disease*

Annarosa Leri, MD  
Associate Professor, Departments of Anesthesia and Medicine and Cardiovascular Division, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts  
*Cardiovascular Regeneration and Tissue Engineering*

Martin M. LeWinter, MD  
Professor of Medicine and Molecular Physiology and Biophysics; Director, Heart Failure and Cardiomyopathy Program, University of Vermont College of Medicine; Attending Cardiologist, Fletcher Allen Health Care, Burlington, Vermont  
*Pericardial Diseases*

Peter Libby, MD  
Malinckrodt Professor of Medicine, Harvard Medical School; Chief of Cardiovascular Medicine, Brigham and Women's Hospital, Boston, Massachusetts  
*Molecular Imaging in Cardiovascular Disease; The Vascular Biology of Atherosclerosis; Risk Markers for Atherothrombotic Disease; Lipoprotein Disorders and Cardiovascular Disease; Primary and Secondary Prevention of Coronary Heart Disease; Peripheral Artery Diseases*

Steven E. Lipshultz, MD  
George Batchelor Professor and Chairman, Department of Pediatrics; Batchelor Family Endowed Chair in Pediatric Cardiology; Professor of Epidemiology and Public Health; Professor of Medicine (Cardiology); Associate Executive Dean for Child Health, Leonard M. Miller School of Medicine, University of Miami; Chief of Staff, Holtz Children's Hospital of the University of Miami–Jackson Memorial Medical Center; Director, Batchelor Children's Research Institute; Associate Director, Mailman Center for Child Development; Member, the Sylvester Comprehensive Cancer Center, Miami, Florida  
*Cardiovascular Abnormalities in HIV-Infected Individuals*

Peter Liu, MD  
Heart & Stroke/Polo Professor of Medicine and Physiology; Peter Munk Cardiac Centre, University Health Network, University of Toronto; Scientific Director, Institute of Circulatory and Respiratory Health, Canadian Institutes of Health Research, Toronto, Ontario, Canada  
*Myocarditis*

Brian F. Mandell, MD, PHD  
Professor and Chairman, Department of Medicine, Cleveland Clinic Foundation Lerner College of Medicine of Case Western Reserve University; Center for Vasculitis Care and Research, Department of Rheumatic and Immunologic Disease, The Cleveland Clinic, Cleveland, Ohio  
*Rheumatic Diseases and the Cardiovascular System*

Douglas L. Mann, MD  
Lewin Chair and Professor of Medicine, Cell Biology, and Physiology, Chief, Division of Cardiology; Washington University School of Medicine in St. Louis; Cardiologist-in-Chief, Barnes Jewish Hospital, Saint Louis, Missouri  
*Pathophysiology of Heart Failure; Management of Heart Failure Patients with Reduced Ejection Fraction; Guidelines: Management of Heart Failure; Emerging Therapies and Strategies in the Treatment of Heart Failure*

Barry J. Maron, MD  
Director, Hypertrophic Cardiomyopathy Center, Minneapolis Heart Institute Foundation, Minneapolis, Minnesota  
*Hypertrophic Cardiomyopathy*

Kenneth L. Mattoo, MD  
Professor and Vice Chairman, Distinguished Service Professor, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, Texas  
*Traumatic Heart Disease*

Peter A. McCullough, MD, MPH  
Consultant Cardiologist, Chief Academic and Scientific Officer, St. John Providence Health System, Providence Park Heart Institute, Novi, Michigan  
*Interface Between Renal Disease and Cardiovascular Illness*

Darren K. McGuire, MD, MHSc  
Associate Professor, Internal Medicine, The University of Texas Southwestern Medical Center at Dallas, Dallas, Texas  
*Diabetes and the Cardiovascular System*

Bruce McManus, MD, PhD  
Professor of Pathology and Laboratory Medicine, Faculty of Medicine, University of British Columbia; Co-Director, Institute for Heart and Lung Health; Director, NCE CECR Centre of Excellence for Prevention of Organ Failure (PROOF Centre); Director, UBC James Hogg Research Centre, St. Paul's Hospital, University of British Columbia, Vancouver, British Columbia, Canada  
*Primary Tumors of the Heart*
Stuart Rich, MD
Professor of Medicine, Section of Cardiology, Center for Pulmonary Hypertension, University of Chicago, Chicago, Illinois
Pulmonary Hypertension

Paul M Ridker, MD, MPH
Eugene Braunwald Professor of Medicine, Harvard Medical School; Director, Center for Cardiovascular Disease Prevention, Brigham and Women's Hospital, Boston, Massachusetts
Risk Markers for Atherosclerotic Disease; Primary and Secondary Prevention of Coronary Heart Disease

Dan M. Roden, MD
Professor of Medicine and Pharmacology; Director, Oates Institute for Experimental Therapeutics; Assistant Vice-Chancellor for Personalized Medicine, Vanderbilt University School of Medicine, Nashville, Tennessee
Principles of Drug Therapy

Michael Rubart, MD
Assistant Professor of Pediatrics, Indiana University School of Medicine, Indianapolis, Indiana
Genesis of Cardiac Arrhythmias: Electrophysiologic Considerations

Marc S. Sabatine, MD, MPH
Associate Professor of Medicine, Harvard Medical School; Vice Chair, TIMI Study Group; Associate Physician, Division of Cardiovascular Medicine, Brigham and Women's Hospital, Boston, Massachusetts
Approach to the Patient with Chest Pain

Luis A. Sanchez, MD
Professor of Surgery and Radiology, Section of Vascular Surgery, Department of Surgery, Washington University School of Medicine, St. Louis, Missouri
Diseases of the Aorta

Janice B. Schwartz, MD
Clinical Professor of Medicine and Bioengineering and Therapeutic Sciences, University of California, San Francisco; Director, Research, Jewish Home of San Francisco, San Francisco, California
Cardiovascular Disease in the Elderly

Christine E. Seidman, MD
Thomas W. Smith Professor of Medicine and Genetics, Department of Medicine and Genetics, Brigham & Women's Hospital, Harvard Medical School, Howard Hughes Medical Institute, Boston, Massachusetts
Inherited Causes of Cardiovascular Disease

J. G. Seidman, PhD
Henrietta B. and Frederick H. Bugher Professor of Genetics, Department of Genetics, Harvard Medical School, Boston, Massachusetts
Inherited Causes of Cardiovascular Disease

Dhun H. Sethna, MD
Staff Cardiologist, Carilion Clinic, Christiansburg, Virginia
Medical Management of the Patient Undergoing Cardiac Surgery

Jeffrey F. Smallhorn, MBBS, FRACP, FRCP(C)
Professor of Pediatrics; Program Director, Pediatric Cardiology, Department of Pediatrics, University of Alberta, Edmonton, Alberta
Congenital Heart Disease

Virend K. Somers, MD, PhD
Professor of Medicine, Division of Cardiovascular Diseases, Mayo Clinic: College of Medicine, Rochester, Minnesota
Sleep Apnea and Cardiovascular Disease; Cardiovascular Manifestations of Autonomic Disorders

Andrei C. Sposito
Associate Professor of Cardiology, University of Campinas; Past Director of The Heart Institute (INCOR), Brasilia, São Paulo, Brazil
Chagas’ Disease

Charles D. Swedlow, MD
Clinical Professor of Medicine, David Geffen School of Medicine at UCLA; Cedars-Sinai Heart Institute, Los Angeles, California
Pacemakers and Implantable Cardioverter-Defibrillators; Guidelines: Cardiac Pacemakers and Cardiomerter-Defibrillators

Jean-Claude Tardif, MD
Professor of Medicine, University of Montreal; Director, Montreal Heart Institute Research Center; Endowed Research Chair in Atherosclerosis, Montreal Heart Institute, Université de Montréal, Montreal, Canada
Intravascular Ultrasound Imaging

Allen J. Taylor, MD
Professor of Medicine, Georgetown University; Director, Advanced Cardiovascular Imaging, Cardiology Section, Washington Hospital Center and Medstar Health Cardiovascular Research Institute, Washington, DC
Cardiac Computed Tomography; Appropriate Use Criteria: Cardiac Computed Tomography

David J. Tester, BS
Senior Research Technologist II, Supervisor, Mayo Clinic, Windland Smith Rice Sudden Death Genomics Laboratory, Rochester, Minnesota
Genetics of Cardiac Arrhythmias

Judith Therrien, MD
Associate Professor of Medicine, Department of Cardiology, McGill University, Montreal, Quebec, Canada
Congenital Heart Disease

Paul D. Thompson, MD
Professor of Medicine, University of Connecticut, Farmington, Connecticut; Director, Cardiology, Hartford Hospital, Hartford, Connecticut
Exercise-Based, Comprehensive Cardiac Rehabilitation

Robert W. Thompson, MD
Professor, Surgery, Division of General Surgery, Vascular Surgery Section, Radiology, and Cell Biology and Physiology, Washington University, St. Louis, Missouri
Diseases of the Aorta

Marc D. Tischler, MD
Associate Professor of Medicine, University of Vermont College of Medicine; Director, Cardiac Ultrasound Laboratory; Co-Director, Cardiac Magnetic Resonance Unit, Department of Internal Medicine, Burlington, Vermont
Pericardial Diseases

Peter I. Tsai, MD
Assistant Professor, Division of Cardiothoracic Surgery, Michael E. DeBakey Department of Surgery, Ben Taub General Hospital, Baylor College of Medicine, Houston, Texas
Traumatic Heart Disease

Zoltan G. Turi, MD
Professor of Medicine, Robert Wood Johnson Medical School; Director, Section of Vascular Medicine; Director, Cooper Structural Heart Disease Program, Cooper University Hospital, Camden, New Jersey
Rheumatic Fever
James E. Udelson, MD
Professor of Medicine, Department of Medicine; Chief, Division of Cardiology; The Cardiovascular Center, Tufts Medical Center and Tufts University School of Medicine, Boston, Massachusetts
Nuclear Cardiology; Appropriate Use Criteria: Nuclear Cardiology

Viola Vaccarino, MD, PhD
Professor and Chair, Department of Epidemiology, Emory University Rollins School of Public Health; Professor, Department of Medicine, Division of Cardiology, Emory University School of Medicine, Atlanta, Georgia
Psychiatric and Behavioral Aspects of Cardiovascular Disease

Ronald G. Victor, MD
Burns and Allen Professor of Medicine; Associate Director, Clinical Research; Director, Hypertension Center, The Heart Institute, Cedars-Sinai Medical Center, Los Angeles, California
Systemic Hypertension: Mechanisms and Diagnosis

Alexandra Villa-Forte, MD, MPH
Center for Vasculitis Care and Research, Department of Rheumatic and Immunologic Diseases, Cleveland Clinic, Cleveland, Ohio
Rheumatic Diseases and the Cardiovascular System

Matthew J. Wall, Jr., MD
Professor, Michael E. DeBakey Department of Surgery, Baylor College of Medicine; Deputy Chief of Surgery, Ben Taub General Hospital, Houston, Texas
Traumatic Heart Disease

Carole A. Warnes, MD, FRCP
Professor of Medicine, Mayo Clinic College of Medicine; Consultant, Division of Cardiovascular Diseases, Internal Medicine and Pediatric Cardiology, Mayo Clinic College of Medicine, Rochester, Minnesota
Pregnancy and Heart Disease; Guidelines: Pregnancy and Heart Disease

Gary D. Webb, MD
Professor, University of Cincinnati College of Medicine; Director, Cincinnati Adolescent and Adult Congenital Heart Center, Cincinnati Children’s Hospital Heart Institute, Cincinnati, Ohio
Congenital Heart Disease

John G. Webb, MD
MacLeod Professor of Heart Valve Intervention, University of British Columbia; Director Cardiac Catheterization, St. Paul’s Hospital, Vancouver, Canada
Percutaneous Therapies for Structural Heart Disease in Adults

Ralph Weissleder, MD, PhD
Professor, Harvard Medical School; Center for Systems Biology and Department of Radiology, Massachusetts General Hospital, Boston, Massachusetts
Molecular Imaging in Cardiovascular Disease

Jeffrey I. Weitz, MD, FRCP(C)
Professor of Medicine & Biochemistry, McMaster University; HSFO/J.F. Mustard Chair in Cardiovascular Research; Canada Research Chair (Tier 1) in Thrombosis; Executive Director, Thrombosis and Atherosclerosis Research Institute, Hamilton General Hospital Campus, Hamilton, Ontario, Canada
Hemostasis, Thrombosis, Fibrinolysis, and Cardiovascular Disease

Christopher J. White, MD
Professor of Medicine; Chairman, Department of Cardiology, Ochsner Clinic Foundation, New Orleans, Louisiana
Endovascular Treatment of Noncoronary Obstructive Vascular Disease

Stephen D. Wiviott, MD
Instructor of Medicine, Harvard Medical School; Investigator, TIMI Study Group; Associate Physician, Division of Cardiology, Brigham and Women’s Hospital, Boston, Massachusetts
Guidelines: Management of Patients with ST-Segment Elevation Myocardial Infarction

Clyde W. Yancy, MD
Professor of Medicine; Chief, Division of Cardiology, Northwestern University Feinberg School of Medicine, Chicago, Illinois
Heart Disease in Varied Populations

Andreas M. Zeiher, MD
Professor of Cardiology; Chair, Department of Medicine, University of Frankfurt, Frankfurt, Germany
Emerging Therapies and Strategies in the Treatment of Heart Failure

Douglas P. Zipes, MD
Distinguished Professor; Professor Emeritus of Medicine, Pharmacology and Toxicology; Director Emeritus, Division of Cardiology and the Krannert Institute of Cardiology, Indiana University School of Medicine, Indianapolis, Indiana
Genesis of Cardiac Arrhythmias: Electrophysiologic Considerations; Diagnosis of Cardiac Arrhythmias; Guidelines: Ambulatory Electrocardiographic and Electrophysiologic Testing; Therapy for Cardiac Arrhythmias; Pacemakers and Implantable Cardioverter-Defibrillators; Guidelines: Cardiac Pacemakers and Cardioverter-Defibrillators; Specific Arrhythmias: Diagnosis and Treatment; Atrial Fibrillation: Clinical Features, Mechanisms, and Management; Guidelines: Atrial Fibrillation; Hypotension and Syncope; Cardiovascular Disease in the Elderly; Neurologic Disorders and Cardiovascular Disease
Advances in cardiovascular science and practice continue at a breathtaking rate. As the knowledge base expands, it is important to adapt our learning systems to keep up with progress in our field. We are pleased to present the ninth edition of *Braunwald’s Heart Disease: A Textbook of Cardiovascular Medicine* as the hub of an ongoing, advanced learning system designed to provide practitioners, physicians-in-training, and students at all levels with the tools needed to keep abreast of rapidly changing scientific foundations, clinical research results, and evidence-based medical practice.

In keeping with the tradition established by the previous editions of *Braunwald’s Heart Disease*, the ninth edition covers the breadth of cardiovascular practice, highlighting new advances and their potential to transform the established paradigms of prevention, diagnosis, and treatment. We have thoroughly revised this edition to keep the content vibrant, stimulating, and up-to-date. Twenty-four of the 94 chapters are entirely new, including nine chapters that cover topics not addressed in earlier editions. We have added 46 new authors, all highly accomplished and recognized in their respective disciplines. All chapters carried over from the eighth edition have been thoroughly updated and extensively revised. This edition includes nearly 2500 figures, most of which are in full color, and 600 tables. We have continued to provide updated sections on current guidelines recommendations that complement each of the appropriate individual chapters.

A full accounting of these changes in the new edition cannot be addressed in the space of this Preface, but we are pleased to present a number of the highlights. The ninth edition includes two entirely new chapters—ethics in cardiovascular medicine by Paul Mueller and design and conduct of clinical trials by Elliot Antman—that supplement the initial section on the fundamentals of cardiovascular disease. Thomas Gaziano has joined J. Michael Gaziano in authoring the first chapter on the global burden of cardiovascular disease. With recognition of the increasing relevance of genetics, J.G. Seidman joins Reed Pyeritz and Christine Seidman in the updated chapter on inherited causes of cardiovascular disease, and David Tester and Michael Ackerman have contributed a new chapter on the genetics of cardiac arrhythmias.

Acknowledging the unrelenting burden and societal impact of heart failure, the section on heart failure receives continued emphasis and has undergone extensive revision, including five new chapters. Barry Greenberg teams with Andrew Kahn in addressing the clinical approach to the patient with heart failure; Mihai Georgiade, Gerasimos Filippatos, and Michael Felker provide a fresh look at the evaluation and management of acute heart failure; Michael Acker and Mariell Jessup address advances in surgical treatment the failing heart; Mandep Mehra and Bartley Griffith discuss the role of device therapy in assisted circulation; and William Abraham reviews the emerging role of devices for monitoring and managing heart failure.

The chapters that address cardiovascular imaging have kept abreast of all of the exciting advances in this field. Raymond Kwong and Allen Taylor have written excellent and comprehensive new chapters on cardiac magnetic resonance and cardiac computed tomography, respectively, with accompanying sections addressing the American College of Cardiology appropriate use criteria for the use of these advanced technologies. Updated ACC appropriate use criteria also follow the chapters on echocardiography and nuclear cardiology. In addition, the imaging section has been further enhanced by the inclusion of two new chapters focusing on the evolving applications of intravascular ultrasound, authored by Jean-Claude Tardif and Philippe L’Allier and cardiovascular molecular imaging, provided by Peter Libby, Farouc Jaffer, and Ralph Weissleder.

In recognition of the growing importance of atrial fibrillation in cardiovascular practice, a new chapter devoted to the evaluation and treatment of this rhythm disturbance, authored by Fred Morady and Douglas Zipes, has been added to the section on cardiac arrhythmias. The other updated chapters in the heart rhythm section continue to inform our readers on the current state-of-the-art in this important aspect of heart disease.

Darshish Mozaffarian and Edzard Ernst have added expertly authored new chapters on nutrition and complementary medicine, respectively, to the section on preventive cardiology. In the atherosclerotic disease section, Marc Sabatine joins Chris Cannon in the revised discussion of the approach to the patient with chest pain, and William Boden joins David Morrow in a new chapter on stable ischemic heart disease. Deepak Bhatt teams with Jeffrey Popma in creating a new chapter on percutaneous coronary intervention, and he joins Andrew Eisenhauer and Christopher White in updating the discussion on endovascular treatment of noncoronary vascular disease. We welcome John Webb to our authorship team with his new chapter on catheter-based interventions in structural heart disease that includes discussion of the exciting novel catheter-based techniques for repair and replacement of cardiac valves. Our other new chapters include a fresh commentary on diseases of the aorta by Alan Bervarman, Robert Thompson, and Luis Sanchez; diabetes and cardiovascular disease by Darren McGuire; hemostasis, thrombosis, and fibrinolysis by Jeffrey Weitz; and psychiatric and behavioral aspects of cardiovascular disease by Viola Vaccarino and Douglas Bremner. Finally, we are delighted that José Ramires, Andrei Sposito, Edécio Cunha-Neto, and Maria de Lourdes Higuchi have expanded our discussion of the global nature of cardiovascular disease by contributing an excellent chapter on the pathophysiology, evaluation, and treatment of Chagas’ disease.

We are indebted to all of our authors for their considerable time, effort, and commitment to maintaining the high standards of *Braunwald’s Heart Disease*. As excited as we are about bringing this edition of the text to fruition, we are even more energized regarding the expanding *Braunwald’s Heart Disease* website. The electronic version of this work on the companion Expert Consult website includes greater content in terms of figures and tables than the print version can accommodate. Figures and tables can be downloaded directly from the website for electronic slide presentations. In addition, we have a growing portfolio of video and audio content that supplements the print content of many of our chapters. Dr. Braunwald personally updates the chapter content on a weekly basis, thus creating a truly unique living textbook with expanding content that includes the latest research, clinical trials, and expert opinions.

Moreover, the family of *Braunwald’s Heart Disease* companion texts continues to expand, providing detailed expert content for the subspecialist across the broad spectrum of cardiovascular conditions. These include: *Clinical Lipidology*, edited by Christie Ballantyne; *Clinical Arrhythmology and Electrophysiology*, authored by Ziad Issa, John Miller, and Douglas Zipes; *Heart Failure*, edited by Douglas Mann; *Valvular Heart Disease*, by Catherine Otto and Robert Bonow; *Acute Coronary Syndromes*, by Pierre Théroux; *Preventive Cardiology*, by Roger Blumenthal, JoAnne Foody, and Nathan Wong; *Cardiovascular Nursing*, by Debra Moser and Barbara Riegel; *Mechanical Circulatory Support*, by Robert Kormos and Leslie Miller; *Hypertension*, by Henry Black and William Elliott; *Cardiovascular Therapeutics*, by Elliott Antman and Marc Sabatine; *Vascular Medicine*, by Marc Creager, Joshua
Beckman, and Joseph Loscalzo; and recent atlases on cardiovascular imaging such as *Cardiovascular Magnetic Resonance*, by Christopher Kramer and Gregory Hundley; *Cardiovascular Computed Tomography*, by Allen Taylor; and *Nuclear Cardiology*, by Ami Iskandrian and Ernest Garcia.

The ninth edition of *Braunwald’s Heart Disease* does indeed represent the central hub of a burgeoning cardiovascular learning system that can be tailored to meet the needs of all individuals engaged in cardiovascular medicine, from the accomplished subspecialist practitioner to the beginning student of cardiology. *Braunwald’s Heart Disease* aims to provide the necessary tools to navigate the ever-increasing flow of complex information seamlessly.

Robert O. Bonow
Douglas L. Mann
Douglas P. Zipes
Peter Libby
Cardiovascular disease is the greatest scourge affecting the industrialized nations. As with previous scourges—bubonic plague, yellow fever, and smallpox—cardiovascular disease not only strikes down a significant fraction of the population without warning but also causes prolonged suffering and disability in an even larger number. In the United States alone, despite recent encouraging declines, cardiovascular disease is still responsible for almost 1 million fatalities each year and more than half of all deaths; almost 5 million persons afflicted with cardiovascular disease are hospitalized each year. The cost of these diseases in terms of human suffering and material resources is almost incalculable. Fortunately, research focusing on the causes, diagnosis, treatment, and prevention of heart disease is moving ahead rapidly.

In order to provide a comprehensive, authoritative text in a field that has become as broad and deep as cardiovascular medicine, I chose to enlist the aid of a number of able colleagues. However, I hoped that my personal involvement in the writing of about half of the book would make it possible to minimize the fragmentation, gaps, inconsistencies, organizational difficulties, and impersonal tone that sometimes plague multiauthored texts.

Since the early part of the 20th century, clinical cardiology has had a particularly strong foundation in the basic sciences of physiology and pharmacology. More recently, the disciplines of molecular biology, genetics, developmental biology, biophysics, biochemistry, experimental pathology, and bioengineering have also begun to provide critically important information about cardiac function and malfunction. Although Heart Disease: A Textbook of Cardiovascular Medicine is primarily a clinical treatise and not a textbook of fundamental cardiovascular science, an effort has been made to explain, in some detail, the scientific bases of cardiovascular diseases.

Eugene Braunwald
1980
PART I  FUNDAMENTALS OF CARDIOVASCULAR DISEASE

CHAPTER 1  Global Burden of Cardiovascular Disease  1
            Thomas A. Gaziano and J. Michael Gaziano

CHAPTER 2  Heart Disease in Varied Populations  21
            Clyde W. Yancy

CHAPTER 3  Ethics in Cardiovascular Medicine  30
            Paul S. Mueller

CHAPTER 4  Clinical Decision Making in Cardiology  35
            Harlan M. Krumholz

CHAPTER 5  Measurement and Improvement of Quality of Cardiovascular Care  42
            Thomas H. Lee

CHAPTER 6  Design and Conduct of Clinical Trials  49
            Elliott M. Antman

PART II  MOLECULAR BIOLOGY AND GENETICS

CHAPTER 7  Principles of Cardiovascular Molecular Biology and Genetics  57
            Elizabeth G. Nabel

CHAPTER 8  Inherited Causes of Cardiovascular Disease  70
            J.G. Seidman, Reed E. Pyeritz, and Christine E. Seidman

CHAPTER 9  Genetics of Cardiac Arrhythmias  81
            David J. Tester and Michael J. Ackerman

CHAPTER 10 Principles of Drug Therapy  91
            Dan M. Roden

CHAPTER 11 Cardiovascular Regeneration and Tissue Engineering  99
            Piero Anversa, Jan Kajstura, and Annarosa Leri

PART III  EVALUATION OF THE PATIENT

CHAPTER 12 The History and Physical Examination: An Evidence-Based Approach  107
            James C. Fang and Patrick T. O’Gara

CHAPTER 13 Electrocardiography  126
            David M. Mirvis and Ary L. Goldberger

            Guidelines: Electrocardiography  165
            David M. Mirvis and Ary L. Goldberger

CHAPTER 14 Exercise Stress Testing  168
            Bernard R. Chaitman

            Guidelines: Exercise Stress Testing  192
            Bernard R. Chaitman

CHAPTER 15 Echocardiography  200
            Heidi M. Connolly and Jae K. Oh

            Appropriate Use Criteria: Echocardiography  200
            Robert O. Bonow

CHAPTER 16 The Chest Radiograph in Cardiovascular Disease  277
            Michael A. Bettmann

CHAPTER 17 Nuclear Cardiology  293
            James E. Udelson, Vasken Dilisizian, and Robert O. Bonow

            Appropriate Use Criteria: Nuclear Cardiology  336
            James E. Udelson

CHAPTER 18 Cardiovascular Magnetic Resonance Imaging  340
            Raymond Y. Kwong

            Appropriate Use Criteria: Cardiovascular Magnetic Resonance  359
            Raymond Y. Kwong

CHAPTER 19 Cardiac Computed Tomography  362
            Allen J. Taylor

            Appropriate Use Criteria: Cardiac Computed Tomography  379
            Allen J. Taylor

CHAPTER 20 Cardiac Catheterization  383
            Charles J. Davidson and Robert O. Bonow
CHAPTER 21 Coronary Arteriography 406
Jeffrey J. Popma

Guidelines: Coronary Arteriography 433
Jeffrey J. Popma

CHAPTER 22 Intravascular Ultrasound Imaging 441
Jean-Claude Tardif and Philippe L. L’Allier

CHAPTER 23 Molecular Imaging in Cardiovascular Disease 448
Peter Libby, Farouc A. Jaffer, and Ralph Weissleder

PART IV HEART FAILURE

CHAPTER 24 Mechanisms of Cardiac Contraction and Relaxation 459
Lionel H. Opie and Gerd Hasenfuss

CHAPTER 25 Pathophysiology of Heart Failure 487
Douglas L. Mann

CHAPTER 26 Clinical Assessment of Heart Failure 505
Barry Greenberg and Andrew M. Kahn

CHAPTER 27 Diagnosis and Management of Acute Heart Failure Syndromes 517
Mihai Gheorghiade, Gerasimos S. Filippatos, and G. Michael Felker

CHAPTER 28 Management of Heart Failure Patients With Reduced Ejection Fraction 543
Douglas L. Mann

Guidelines: Management of Heart Failure 569
Douglas L. Mann

CHAPTER 29 Devices for Monitoring and Managing Heart Failure 578
William T. Abraham

CHAPTER 30 Heart Failure with Normal Ejection Fraction 586
Margaret M. Redfield

CHAPTER 31 Surgical Management of Heart Failure 601
Michael A. Acker and Mariell Jessup

CHAPTER 32 Assisted Circulation in the Treatment of Heart Failure 617
Mandeep R. Mehra and Bartley P. Griffith

CHAPTER 33 Emerging Therapies and Strategies in the Treatment of Heart Failure 627
Stefanie Dimmeler, Douglas L. Mann, and Andreas M. Zeiher

CHAPTER 34 Care of Patients with End-Stage Heart Disease 644
Linda L. Emanuel and Robert O. Bonow

PART V ARRHYTHMIAS, SUDDEN DEATH, AND SYNCOPE

CHAPTER 35 Genesis of Cardiac Arrhythmias: Electrophysiologic Considerations 653
Michael Rubart and Douglas P. Zipes

CHAPTER 36 Diagnosis of Cardiac Arrhythmias 687
John M. Miller and Douglas P. Zipes

Guidelines: Ambulatory Electrocardiographic and Electrophysiologic Testing 702
John M. Miller and Douglas P. Zipes

CHAPTER 37 Therapy for Cardiac Arrhythmias 710
John M. Miller and Douglas P. Zipes

CHAPTER 38 Pacemakers and Implantable Cardioverter-Defibrillators 745
Charles D. Swerdlow, David L. Hayes, and Douglas P. Zipes

Guidelines: Cardiac Pacemakers and Cardioverter-Defibrillators 765
Charles D. Swerdlow, David L. Hayes, and Douglas P. Zipes

CHAPTER 39 Specific Arrhythmias: Diagnosis and Treatment 771
Jeffrey Olgin and Douglas P. Zipes

CHAPTER 40 Atrial Fibrillation: Clinical Features, Mechanisms, and Management 825
Fred Morady and Douglas P. Zipes

Guidelines: Atrial Fibrillation 838
Fred Morady and Douglas P. Zipes

CHAPTER 41 Cardiac Arrest and Sudden Cardiac Death 845
Robert J. Myerburg and Agustin Castellanos

CHAPTER 42 Hypotension and Syncope 885
Hugh Calkins and Douglas P. Zipes

PART VI PREVENTIVE CARDIOLOGY

CHAPTER 43 The Vascular Biology of Atherosclerosis 897
Peter Libby

CHAPTER 44 Risk Markers for Atherothrombotic Disease 914
Paul M Ridker and Peter Libby
CHAPTER 45  Systemic Hypertension: Mechanisms and Diagnosis  935
Ronald G. Victor

CHAPTER 46  Systemic Hypertension: Therapy  955
Norman M. Kaplan
Guidelines: Treatment of Hypertension  972
Norman M. Kaplan

CHAPTER 47  Lipoprotein Disorders and Cardiovascular Disease  975
Jacques Genest and Peter Libby

CHAPTER 48  Nutrition and Cardiovascular Disease  996
Dariush Mozaffarian

CHAPTER 49  Primary and Secondary Prevention of Coronary Heart Disease  1010
J. Michael Gaziano, Paul M. Ridker, and Peter Libby

CHAPTER 50  Exercise-Based, Comprehensive Cardiac Rehabilitation  1036
Paul D. Thompson

CHAPTER 51  Complementary and Alternative Approaches to Management of Patients with Heart Disease  1042
Edzard Ernst

PART VII  Atherosclerotic Cardiovascular Disease

CHAPTER 52  Coronary Blood Flow and Myocardial Ischemia  1049
John M. Canty, Jr.

CHAPTER 53  Approach to the Patient with Chest Pain  1076
Marc S. Sabatine and Christopher P. Cannon

CHAPTER 54  ST-Segment Elevation Myocardial Infarction: Pathology, Pathophysiology, and Clinical Features  1087
Elliott M. Antman

CHAPTER 55  ST-Segment Elevation Myocardial Infarction: Management  1111
Elliott M. Antman and David A. Morrow
Guidelines: Management of Patients with ST-Segment Elevation Myocardial Infarction  1171
Stephen D. Wiviott and Elliott M. Antman

CHAPTER 56  Unstable Angina and Non–ST Elevation Myocardial Infarction  1178
Christopher P. Cannon and Eugene Braunwald
Guidelines: Unstable Angina and Non–ST Elevation Myocardial Infarction  1201
Christopher P. Cannon and Eugene Braunwald

CHAPTER 57  Stable Ischemic Heart Disease  1210
David A. Morrow and William E. Boden
Guidelines: Chronic Stable Angina  1258
David A. Morrow and William E. Boden

CHAPTER 58  Percutaneous Coronary Intervention  1270
Jeffrey J. Popma and Deepak L. Bhatt
Guidelines: Percutaneous Coronary Intervention  1290
Jeffrey J. Popma and Deepak L. Bhatt

CHAPTER 59  Percutaneous Therapies for Structural Heart Disease in Adults  1301
John G. Webb

CHAPTER 60  Diseases of the Aorta  1309
Alan C. Braverman, Robert W. Thompson, and Luis A. Sanchez

CHAPTER 61  Peripheral Artery Diseases  1338
Mark A. Creager and Peter Libby

CHAPTER 62  Prevention and Management of Stroke  1359
Larry B. Goldstein

CHAPTER 63  Endovascular Treatment of Noncoronary Obstructive Vascular Disease  1368
Andrew C. Eisenhauer, Christopher J. White, and Deepak L. Bhatt

CHAPTER 64  Diabetes and the Cardiovascular System  1392
Darren K. McGuire

PART VIII  Diseases of the Heart, Pericardium, and Pulmonary Vasculature Bed

CHAPTER 65  Congenital Heart Disease  1411
Gary D. Webb, Jeffrey F. Smallhorn, Judith Therrien, and Andrew N. Redington

CHAPTER 66  Valvular Heart Disease  1468
Catherine M. Otto and Robert O. Bonow
Guidelines: Management of Valvular Heart Disease  1530
Robert O. Bonow and Catherine M. Otto
CHAPTER 67 Infective Endocarditis 1540
Adolf W. Karchmer

Guidelines: Infective Endocarditis 1558
Robert O. Bonow

CHAPTER 68 The Dilated, Restrictive, and Infiltrative Cardiomyopathies 1561
Joshua M. Hare

CHAPTER 69 Hypertrophic Cardiomyopathy 1582
Barry J. Maron

CHAPTER 70 Myocarditis 1595
Peter Liu and Kenneth L. Baughman

CHAPTER 71 Chagas’ Disease 1611
José A.F. Ramires, Andrei C. Sposito, Edécio Cunha-Neto, and Maria de Lourdes Higuchi

CHAPTER 72 Cardiovascular Abnormalities in HIV-Infected Individuals 1618
Stacy D. Fisher and Steven E. Lipshultz

CHAPTER 73 Toxins and the Heart 1628
Richard A. Lange and L. David Bills

CHAPTER 74 Primary Tumors of the Heart 1638
Bruce McManus

CHAPTER 75 Pericardial Diseases 1651
Martin M. LeWinter and Marc D. Tischler

CHAPTER 76 Traumatic Heart Disease 1672
Matthew J. Wall, Jr., Peter I. Tsai, and Kenneth L. Mattux

CHAPTER 77 Pulmonary Embolism 1679
Samuel Z. Goldhaber

CHAPTER 78 Pulmonary Hypertension 1696
Stuart Rich

CHAPTER 79 Sleep Apnea and Cardiovascular Disease 1719
Virend K. Somers

PART IX CARDIOVASCULAR DISEASE IN SPECIAL POPULATIONS

CHAPTER 80 Cardiovascular Disease in the Elderly 1727
Janice B. Schwartz and Douglas P. Zipes

CHAPTER 81 Cardiovascular Disease in Women 1757
L. Kristin Newby and Pamela S. Douglas

CHAPTER 82 Pregnancy and Heart Disease 1770
Carole A. Warnes

Guidelines: Pregnancy and Heart Disease 1780
Carole A. Warnes and Thomas H. Lee

CHAPTER 83 Exercise and Sports Cardiology 1784
Gary J. Balady and Philip A. Ades

CHAPTER 84 Medical Management of the Patient Undergoing Cardiac Surgery 1793
Richard J. Gray and Dhun H. Sethna

CHAPTER 85 Anesthesia and Noncardiac Surgery in Patients with Heart Disease 1811
Lee A. Fleisher and Joshua Beckman

Guidelines: Reducing Cardiac Risk with Noncardiac Surgery 1824
Lee A. Fleisher and Joshua Beckman

PART X CARDIOVASCULAR DISEASE AND DISORDERS OF OTHER ORGANS

CHAPTER 86 Endocrine Disorders and Cardiovascular Disease 1829
Irwin Klein

CHAPTER 87 Hemostasis, Thrombosis, Fibrinolysis, and Cardiovascular Disease 1844
Jeffrey I. Weitz

CHAPTER 88 Rheumatic Fever 1868
B. Soma Raju and Zoltan G. Turi

CHAPTER 89 Rheumatic Diseases and the Cardiovascular System 1876
Alexandra Villa-Forte and Brian F. Mandell

CHAPTER 90 The Cancer Patient and Cardiovascular Disease 1893
Thomas Force and Ming Hui Chen

CHAPTER 91 Psychiatric and Behavioral Aspects of Cardiovascular Disease 1904
Viola Vaccarino and J. Douglas Bremner

CHAPTER 92 Neurologic Disorders and Cardiovascular Disease 1916
William J. Groh and Douglas P. Zipes

CHAPTER 93 Interface Between Renal Disease and Cardiovascular Illness 1934
Peter A. McCullough

CHAPTER 94 Cardiovascular Manifestations of Autonomic Disorders 1949
Virend K. Somers
Look for these other titles in the Braunwald’s Heart Disease Family

Braunwald’s Heart Disease Companions

PIERRE THÉROUX
Acute Coronary Syndromes

ELLIOTT M. ANTMAN & MARC S. SABATINE
Cardiovascular Therapeutics

CHRISTIE M. BALLANTYNE
Clinical Lipidology

ZIAD ISSA, JOHN M. MILLER, & DOUGLAS P. ZIPES
Clinical Arrhythmology and Electrophysiology

DOUGLAS L. MANN
Heart Failure

HENRY R. BLACK & WILLIAM J. ELLIOTT
Hypertension

ROGER S. BLUMENTHAL, JOANNE M. FOODY, & NATHAN D. WONG
Preventive Cardiology

ROBERT L. KORMOS & LESLIE W. MILLER
Mechanical Circulatory Support

CATHERINE M. OTTO & ROBERT O. BONOW
Valvular Heart Disease

MARC A. CREAGER, JOSHUA A. BECKMAN, & JOSEPH LOSCALZO
Vascular Disease

Braunwald’s Heart Disease Imaging Companions

ALLEN J. TAYLOR
Atlas of Cardiac Computed Tomography

CHRISTOPHER M. KRAMER & W. GREGORY HUNDELEY
Atlas of Cardiovascular Magnetic Resonance

AMI E. ISKANDRIAN & ERNEST V. GARCIA
Atlas of Nuclear Imaging