

Manual of Cardiovascular Medicine

FOURTH EDITION

Editor

Brian P. Griffin

Associate Editors

Thomas D. Callahan

Venu Menon

Guest Editors

Willis M. Wu

Clay A. Cauthen

Justin M. Dunn



Wolters Kluwer
Health

Lippincott
Williams & Wilkins

Manual of

CARDIOVASCULAR MEDICINE

FOURTH EDITION

EDITOR

Brian P. Griffin, MD, FACC

The John and Rosemary Brown Endowed Chair in Cardiovascular Medicine
Director, Cardiovascular Medicine Fellowship Program
Cleveland Clinic
Cleveland, Ohio

Associate Editors

Thomas D. Callahan, IV, MD, FACC, FHRS

Associate Director, Cardiology Fellowship
Cleveland Clinic
Cleveland, Ohio

Venu Menon, MD

Director, Coronary Care Unit
Cardiovascular Medicine
Cleveland Clinic
Cleveland, Ohio

Guest Editors

Willis M. Wu, MD

Chief Fellow
Department of Cardiovascular Medicine
Cleveland Clinic
Cleveland, Ohio

Clay A. Cauthen, MD

Fellow
Cardiovascular Medicine
Heart and Vascular Institute
Cleveland Clinic
Cleveland, Ohio

Justin M. Dunn, MD, MPH

Chief Fellow
Cardiovascular Medicine
Cleveland Clinic
Cleveland, Ohio



Wolters Kluwer | Lippincott Williams & Wilkins

Health

Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

Acquisitions Editor: Julie Goolsby
Product Manager: Leanne Vandetty
Vendor Manager: Alicia Jackson
Senior Manufacturing Manager: Benjamin Rivera
Marketing Manager: Kimberly Schonberger
Creative Director: Doug Smock
Production Service: Integra Software Services

© 2013 by LIPPINCOTT WILLIAMS & WILKINS, a WOLTERS KLUWER business

Two Commerce Square
2001 Market Street
Philadelphia, PA 19103 USA
LWW.com

Third Edition © 2009 by Lippincott Williams & Wilkins, a Wolters Kluwer Business

Second Edition © 2004 by Lippincott Williams & Wilkins

First Edition © 2000 by Lippincott Williams & Wilkins

All rights reserved. This book is protected by copyright. No part of this book may be reproduced in any form by any means, including photocopying, or utilized by any information storage and retrieval system without written permission from the copyright owner, except for brief quotations embodied in critical articles and reviews. Materials appearing in this book prepared by individuals as part of their official duties as U.S. government employees are not covered by the above-mentioned copyright.

Printed in People's Republic of China

Library of Congress Cataloging-in-Publication Data

Manual of cardiovascular medicine/editor, Brian P. Griffin; associate editors, Thomas D. Callahan, Venu Menon; guest editors, Willis M. Wu, Clay A. Cauthen, Justin M. Dunn. -- 4th ed.

p. ; cm.

Includes bibliographical references and index.

ISBN 978-1-4511-3160-4 -- ISBN 1-4511-3160-7

I. Griffin, Brian P., 1956-

[DNLM: 1. Heart Diseases--diagnosis. 2. Cardiac Surgical Procedures--methods. 3. Heart Diseases--therapy. WG 141]

616.1'2--dc23

2012007462

Care has been taken to confirm the accuracy of the information presented and to describe generally accepted practices. However, the authors, editors, and publisher are not responsible for errors or omissions or for any consequences from application of the information in this book and make no warranty, expressed or implied, with respect to the currency, completeness, or accuracy of the contents of the publication. Application of the information in a particular situation remains the professional responsibility of the practitioner.

The authors, editors, and publisher have exerted every effort to ensure that drug selection and dosage set forth in this text are in accordance with current recommendations and practice at the time of publication. However, in view of ongoing research, changes in government regulations, and the constant flow of information relating to drug therapy and drug reactions, the reader is urged to check the package insert for each drug for any change in indications and dosage and for added warnings and precautions. This is particularly important when the recommended agent is a new or infrequently employed drug.

Some drugs and medical devices presented in the publication have Food and Drug Administration (FDA) clearance for limited use in restricted research settings. It is the responsibility of the health care provider to ascertain the FDA status of each drug or device planned for use in their clinical practice.

To purchase additional copies of this book, call our customer service department at (800) 638-3030 or fax orders to (301) 223-2320. International customers should call (301) 223-2300.

Visit Lippincott Williams & Wilkins on the Internet: at LWW.com. Lippincott Williams & Wilkins customer service representatives are available from 8:30 am to 6 pm, EST.

10 9 8 7 6 5 4 3 2 1

CCS0812

Manual of

**CARDIOVASCULAR
MEDICINE**

FOURTH EDITION

Section Editors

Leslie Cho, MD, FACC

Section Head

Preventive Cardiology & Rehabilitation

Director, Womens Cardiovascular Center

Cleveland Clinic

Cleveland, Ohio

Esther S.H. Kim, MD, MPH

Staff Physician

Sections of Vascular Medicine and Preventive Cardiology

Cleveland Clinic

Cleveland, Ohio

Richard A. Krasuski, MD

Director

Adult Congenital Heart Disease Services

Cardiovascular Medicine

Cleveland Clinic

Cleveland, Ohio

W.H. Wilson Tang, MD, FACC, FAHA

Staff Cardiologist

Department of Cardiovascular Medicine,

Heart and Vascular Institute

Cleveland Clinic

Cleveland, Ohio



*To our families and to the fellows and staff of
the Department of Cardiovascular Medicine,
Cleveland Clinic
—BG, VM, TC, WW, CC, JD*

CONTRIBUTORS

Unless otherwise noted, the following contributors are affiliated with the Cleveland Clinic Foundation, Cleveland, Ohio.

JoEllyn M. Abraham, MD

Cardiology Fellow
Cardiovascular Medicine

Kia Afshar, MD

Fellow
Department of Cardiovascular Medicine

Shikhar Agarwal, MD, MPH, CPH

Fellow
Cardiovascular Medicine

Imran N. Ahmad, MD

Interventional Cardiology Fellow
Department of Interventional Cardiology
Heart and Vascular Institute

Salim H. Ahmed, MD

Fellow
Cardiovascular Medicine

Olcay Aksoy, MD

Interventional Cardiology Fellow
Department of Cardiovascular Medicine

Saif Anwaruddin, MD

Fellow in Interventional Cardiology

Bryan J. Baranowski, MD

Staff
Department of Cardiovascular Medicine
Section of Cardiac Pacing and
Electrophysiology

Mosi K. Bennett, MD, PhD

Fellow
Cardiovascular Medicine

Michael P. Brunner, MD

Fellow in Cardiovascular Medicine
Cardiovascular Medicine

Matthew C. Bunte, MD

Fellow in Cardiovascular Medicine
Robert and Suzanne Tomsich Department
of Cardiovascular Medicine

Thomas D. Callahan, IV, MD, FACC, FHRS

Associate Director, Cardiology Fellowship

Clay A. Cauthen, MD

Fellow
Cardiovascular Medicine
Heart and Vascular Institute

João L. Cavalcante, MD

Chief, Advanced Cardiovascular Imaging
Fellow
Cardiovascular Medicine

Matthew A. Cavender, MD

Fellow
Heart and Vascular Institute

Leslie Cho, MD, FACC

Section Head, Preventive Cardiology &
Rehabilitation
Director, Womens Cardiovascular Center
Department of Cardiovascular Medicine
Heart and Vascular Institute

Edmond M. Cronin, MB, MRCPi

Electrophysiology Fellow
Section of Electrophysiology and Pacing
Department of Cardiovascular Medicine

Arun Dahiya, MD

Cardiac Imaging
Department of Cardiac Imaging

Milind Desai, MD, FACC, FAHA, FESC

Associate Professor of Medicine,
Department of Cardiovascular Medicine
Heart and Vascular Institute

Sandeep Duggal, DO

Physician, Cardiovascular Disease

Justin M. Dunn, MD, MPH

Chief Fellow
Cardiovascular Medicine

Hemal Gada, MD, MBA

Cardiovascular Medicine Fellow
Cardiovascular Medicine

Sachin S. Goel, MD

Clinical Associate
Cardiovascular Medicine

Adam S. Goldberg, MD

Cardiovascular Medicine Fellow
Heart and Vascular Institute

Gonzalo Gonzalez-Stawinski, MD

Staff Cardiac Surgeon

Eiran Z. Gorodeski, MD, MPH

Assistant Professor of Medicine
Department of Cardiovascular Medicine
Lerner College of Medicine
Associate Staff
Department of Cardiovascular Medicine

Adam W. Grasso, MD, PhD, FACC

Staff Cardiologist,
Director of Cardiology Consult Service
Cardiovascular Medicine

Brian P. Griffin, MD, FACC

The John and Rosemary Brown Endowed
Chair in Cardiovascular Medicine
Director, Cardiovascular Medicine
Fellowship Program

Mary T. Quinn Griffin, PhD, RN

Associate Professor
Frances Payne Bolton School of Nursing
Case Western Reserve University
Cleveland, Ohio

Chetan Vagesh Hampole, MD

Fellow
Department of Cardiovascular Medicine

Mazen Hanna, MD

Staff Cardiologist

Anthony Hart, MD

Fellow
Cardiovascular Medicine

James E. Harvey, MD, MSc

Chief Interventional Cardiology Fellow
Heart and Vascular Institute

Christopher M. Huff, MD

Cardiovascular Medicine Fellow
Heart and Vascular Institute

Christopher Ingelmo, MD

Chief Cardiac Electrophysiology Fellow
Heart and Vascular Institute

Michael A. Jolly, MD

Interventional Cardiology Fellow
Department of Cardiovascular Medicine

Samir R. Kapadia, MD

Director, Sones Cardiac Catheterization
Laboratories
Director, Interventional Cardiology
Fellowship
Department of Cardiovascular Medicine

Esther S.H. Kim, MD, MPH

Staff Physician
Sections of Vascular Medicine and
Preventive Cardiology
Department of Cardiovascular Medicine
Cleveland Clinic Heart and Vascular
Institute

Richard A. Krasuski, MD

Director of Adult Congenital Heart Disease
Services
Cardiovascular Medicine

Amar Krishnaswamy, MD

Staff Physician
Division of Interventional Cardiology

Praneet Kumar, MD

Fellow
Cardiovascular Medicine

James E. Lai, MD

Fellow
Department of Cardiovascular Medicine

Evan Lau, MD

Interventional Cardiology Fellow
Cardiology

**Lee Fong Ling, MBBS, MMed,
MRCP, FAMS**

Consultant Cardiologist
Department of Cardiology
KTPH, Alexandra Health
Republic of Singapore

Jun-Yang Lou, MD, PhD

Fellow
Department of Cardiovascular Medicine

Christopher H. May, MD

Fellow in Cardiovascular Medicine
Department of Cardiovascular Medicine

Venu Menon, MD

Director Coronary Care Unit
Cardiovascular Medicine

Maria M. Mountis, DO

Cardiologist

Santosh S. Oommen, MD

Cardiac Electrophysiology Fellow
Department of Cardiovascular Medicine

Parag R. Patel, MD

Fellow
Department of Cardiovascular Medicine

Femi Philip, MD

Cardiology Fellow
Cardiovascular Medicine

Andrew N. Rassi, MD

Interventional Cardiology Fellow
Division of Cardiology
Massachusetts General Hospital
Boston, Massachusetts

Russell E. Raymond, DO

Cardiologist
Department of Cardiovascular Medicine

John Rickard, MD

Cardiac Electrophysiology Fellow

Marwa A. Sabe, MD

Fellow
Cardiovascular Medicine

Michael A. Samara, MD

Fellow
Department of Cardiovascular Medicine
Section of Advanced Heart Failure and
Transplant Cardiology

Jay D. Sengupta, MD

Fellow
Cardiovascular Medicine

Firas Al Solaiman, MD

Fellow
Heart and Vascular Institute

Tyler L. Taigen, MD

Cardiology Fellow
Department of Cardiovascular
Medicine

W. H. Wilson Tang, MD, FACC, FAHA

Staff Cardiologist
Department of Cardiovascular
Medicine,
Heart and Vascular Institute

Maran Thamilarasan, MD

Staff Cardiologist
Cardiovascular Medicine

Gus Theodos, MD

Interventional Cardiology Fellow
Interventional Cardiology

Donald Underwood, MD

Head, Electrocardiography Laboratory
Robert and Suzanne Tomsich Department
of Cardiovascular Medicine
Sydell and Arnold Miller Family Heart &
Vascular Institute

Amanda R. Vest, MBBS

Fellow in Cardiovascular Medicine
Heart and Vascular Institute

Willis M. Wu, MD

Chief Fellow
Department of Cardiovascular
Medicine

Omeed Zardkoobi, MD

Fellow in Cardiac Electrophysiology
and Pacing
Department of Cardiovascular
Medicine

**Peter Zimbwa, MBChB, MSc, DPhil,
MRCP, DTM&H**

Fellow
Cardiovascular Medicine

Edwin T. Zishiri, MD

Fellow
Cardiac Electrophysiology

The 4th edition of the *Manual of Cardiovascular Medicine* has been extensively updated and revised. New chapters on diabetes and the heart, pulmonary hypertension, cardiovascular manifestations of systemic disease, percutaneous management of structural heart disease, and troubleshooting ventricular assist devices have been added. Examples of key electrocardiographic tracings have been added as has a quick reference list of often needed formulae. Our aim has been to make this an easy-to-use, up-to-date, portable reference for all those involved in the management of cardiovascular disease. We have included current guidelines from the American Heart Association/American College of Cardiology and other national and international cardiovascular societies where appropriate. We appreciate the feedback we have received concerning prior editions and suggestions as to how to improve the book.

This manual has been written by the current and past fellows and staff of the Department of Cardiovascular Medicine, Cleveland Clinic. I wish to thank all those who contributed to this and previous editions, especially Eric Topol, coeditor in prior editions and now at Scripps, San Diego, and Steve Marso now at Mid America Heart Center, Kansas City, coeditor of the 1st edition. I wish to recognize the associate editors of this edition, Venu Menon and Tom Callahan, who are associate directors of the Cardiovascular Disease Training Program at Cleveland Clinic and who have done a superb job in helping edit the manual and keeping it topical. The guest editors, Willis M. Wu, Clay A. Cauthen, and Justin M. Dunn, are or have been Chief Fellows in the Cardiovascular Training Program at Cleveland Clinic and have done a fine job of ensuring that the contributions were on time and comprehensive. The section editors, Leslie Cho, Esther S.H. Kim, Richard A. Krasuski, and W.H. Wilson Tang, have done a great job in ensuring the quality and topicality of their sections.

I wish to thank Lois Adamski, the educational coordinator of the Cardiovascular Disease Training Program at Cleveland Clinic, for having anchored the program over many years. Fran DeStefano, Leanne Vandetty, and everyone at Wolters Kluwer have been wonderful to work with. I remain deeply indebted to John and Rosemary Brown for endowing a Chair in Cardiovascular Medicine that supports my academic activity and for their wonderful friendship. I have learned much over the years from my colleagues and fellows at the Department of Cardiovascular Medicine at Cleveland Clinic and from my surgical colleagues in the Heart and Vascular Institute, Cleveland Clinic, and I thank all of them for their collegiality and kindness. Finally, I wish to express my immense gratitude to my family: to my parents for instilling in me a thirst for knowledge and to my wife Mary without whose support, patience, and fortitude this and all other endeavors would have been impossible.

Brian P. Griffin, MD

Contributors vii

Preface xi

SECTION I

Ischemic Heart Disease 1

Editor: Venu Menon

- 1** Acute Myocardial Infarction 2
Christopher M. Huff

- 2** Unstable Angina and Non–ST-Segment Elevation Myocardial Infarction 36
James E. Harvey

- 3** Complications of Acute Myocardial Infarction 60
Michael P. Brunner and Venu Menon

- 4** Cardiogenic Shock Complicating Acute Myocardial Infarction 77
Michael P. Brunner and Venu Menon

- 5** Post–Myocardial Infarction Risk Stratification and Management 86
Willis M. Wu and Venu Menon

- 6** Stable Angina 97
Amar Krishnaswamy and Samir R. Kapadia

- 7** Other Ischemic Syndromes: Silent Ischemia and Syndrome X 120
Gus Theodos

SECTION II

Heart Failure and Transplant 125Editor: [W.H. Wilson Tang](#)

-
- 8** Heart Failure with Systolic Dysfunction 126
Michael A. Samara and W.H. Wilson Tang
-
- 9** Heart Failure with Preserved Ejection Fraction and Restrictive Cardiomyopathy 150
Evan Lau and W.H. Wilson Tang
-
- 10** Hypertrophic Cardiomyopathy 160
Anthony Hart and Eiran Z. Gorodeski
-
- 11** Myocarditis 176
Mosi K. Bennett and W.H. Wilson Tang
-
- 12** Nontransplantation Surgical Treatment for Chronic Heart Failure 187
Clay A. Cauthen, Gonzalo Gonzalez-Stawinski, and Mazen Hanna
-
- 13** Cardiac Transplantation 199
Peter Zimbwa
-
- 14** Pulmonary Hypertension 224
Praneet Kumar and W.H. Wilson Tang
-

SECTION III

Valvular Heart Disease 237Editor: [Brian P. Griffin](#)

-
- 15** Aortic Valve Disease 238
Olca Aksoy and Brian P. Griffin
-
- 16** Mitral Valve Disease 265
Amanda R. Vest and Brian P. Griffin
-
- 17** Tricuspid Valve Disease, Pulmonary Valve Disease, and Drug-Induced Valve Disease 295
Shikhar Agarwal and Brian P. Griffin
-

- 18** Prosthetic Heart Valves 308
João L. Cavalcante
-

- 19** Infective Endocarditis 327
Marwa A. Sabe and Brian P. Griffin
-

- 20** Rheumatic Fever 347
Chetan Vagesh Hampole
-

SECTION IV

Arrhythmias 357

Editor: Thomas D. Callahan

- 21** Tachyarrhythmias 358
Omeed Zardkoohi
-

- 22** Bradyarrhythmias, Atrioventricular Block, Asystole,
and Pulseless Electrical Activity 390
Santosh S. Oommen
-

- 23** Sudden Cardiac Death 411
Edmond M. Cronin
-

- 24** Atrial Fibrillation 424
Edwin T. Zishiri and Thomas D. Callahan
-

SECTION V

Vascular and Pericardial Disease 445

Editor: Esther S.H. Kim

- 25** Venous Thromboembolism and Hypercoagulable
States 446
Firas Al Solaiman and Esther S.H. Kim
-

- 26** Aortic Aneurysm and Aortic Dissection 459
Matthew C. Bunte and Maran Thamilarasan
-

27 Peripheral Arterial Disease 480Femi Philip

28 Carotid Artery Disease 492Hemal Gada

SECTION VI

Adult Congenital Heart Disease 509Editor: **Richard A. Krasuski****29** Atrial Septal Defect and Patent Foramen Ovale 510Justin M. Dunn and Richard A. Krasuski

30 Ventricular Septal Defect 519Christopher H. May

31 Patent Ductus Arteriosus and Coarctation
of the Aorta 527Adam S. Goldberg and Richard A. Krasuski

32 Complex Congenital Heart Disease 537Matthew A. Cavender and Richard A. Krasuski

SECTION VII

Clinical Cardiology 559Editor: **Brian P. Griffin****33** Syncope 560Salim H. Ahmed

34 Assessing and Managing Cardiac Risk in Noncardiac Surgical
Procedures 575Chetan Vagesh Hampole

35 Hypertensive Crisis 592Kia Afshar

- 36** Evaluation of Chest Pain in the Emergency Department 605
Sachin S. Goel and Samir R. Kapadia
-
- 37** Cardiac Trauma 613
Imran N. Ahmad
-
- 38** Pregnancy and Cardiovascular Disease 618
Amanda R. Vest, Brian P. Griffin, and Russell E. Raymond
-
- 39** Cardiovascular Manifestations of Systemic Disease 637
Sachin S. Goel
-
- 40** Pericardial Disease 646
Arun Dahiya
-
- 41** Cardiac Tumors 672
Parag R. Patel
-
- 42** Common Genetic Issues in Cardiovascular Disease 679
Mary T. Quinn Griffin and Saif Anwaruddin
-

SECTION VIII**Preventive Cardiology 693**Editor: [Leslie Cho](#)

- 43** Dyslipidemia 694
James E. Lai and Leslie Cho
-
- 44** Nonlipid Cardiovascular Risk Factors 713
Clay A. Cauthen and Adam W. Grasso
-
- 45** Diabetes and the Heart 730
Amanda R. Vest and Leslie Cho
-
- 46** Heart Disease in Women 754
Jun-Yang Lou
-

SECTION IX

Noninvasive Assessment 767Editor: **Brian P. Griffin**

-
- 47** Exercise Electrocardiographic Testing 768
Michael A. Jolly
-
- 48** Nuclear Cardiac Imaging 791
Santosh S. Oommen
-
- 49** Stress Echocardiography 808
Michael P. Brunner
-
- 50** Testing for Viable Myocardium 824
Arun Dahiya
-
- 51** Cardiovascular Magnetic Resonance Imaging 832
João L. Cavalcante
-
- 52** Cardiovascular Computed Tomography 845
Parag R. Patel and Milind Desai
-

SECTION X

Electrophysiologic Procedures 857Editor: **Thomas D. Callahan**

-
- 53** Electrophysiologic Studies 858
Jay D. Sengupta
-
- 54** Cardiac Pacing 883
Tyler L. Taigen
-
- 55** Antitachycardia Devices 911
Christopher Ingelmo
-
- 56** Cardiac Resynchronization Therapy 920
John Rickard
-

SECTION XI

Common Cardiology Procedures 931Editors: **Brian P. Griffin, Thomas D. Callahan, and Venu Menon**

-
- 57** Common ECG Patterns 932
Salim H. Ahmed, Thomas D. Callahan, and Donald Underwood
-
- 58** Temporary Cardiac Pacing 963
JoEllyn M. Abraham and Bryan J. Baranowski
-
- 59** Electrical Cardioversion 968
Sandeep Duggal
-
- 60** Right Heart Catheterization 977
Jun-Yang Lou and Venu Menon
-
- 61** Endomyocardial Biopsy 992
Mosi K. Bennett and W.H. Wilson Tang
-
- 62** Management of Continuous-Flow Ventricular Assist Systems:
Troubleshooting and Complications 997
Clay A. Cauthen and Maria M. Mountis
-
- 63** Intraaortic Balloon Counterpulsation 1003
Olçay Aksoy
-
- 64** Left Heart Catheterization 1015
Andrew N. Rossi
-
- 65** Percutaneous Coronary Intervention 1041
Amar Krishnaswamy and Samir R. Kapadia
-
- 66** Percutaneous Structural Heart Disease Procedures 1062
Shikhar Agarwal and Amar Krishnaswamy
-
- 67** Transthoracic Echocardiography 1077
Kia Afshar
-