

Grossman's Cardiac Catheterization, Angiography, and Intervention

SEVENTH EDITION

EDITOR

■ **DONALD S. BAIM, MD**

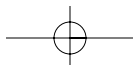
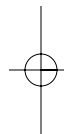
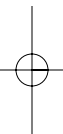
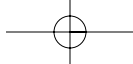
Professor of Medicine
Harvard Medical School
Director, Center for Minimally Invasive Therapy
Brigham and Women's Hospital
Boston, Massachusetts

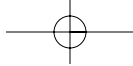


LIPPINCOTT WILLIAMS & WILKINS

A **Wolters Kluwer** Company

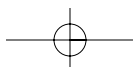
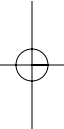
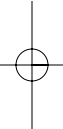
Philadelphia • Baltimore • New York • London
Buenos Aires • Hong Kong • Sydney • Tokyo

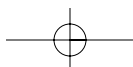
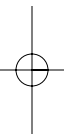
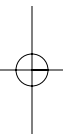
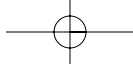




To my friend, mentor, and colleague—Bill Grossman—for his vision and persistence in creating and then sustaining this textbook over the past 25 years.

And to my wife and children, for bearing with me over the many months of night and weekend work required to create this seventh edition.





Contents

Preface vii

SECTION I: GENERAL PRINCIPLES 1

1. Cardiac Catheterization—History and Current Practice Standards 3
Donald S. Baim
2. Cineangiographic Imaging, Radiation Safety, and Contrast Agents 14
Stephen Balter and Donald S. Baim
3. Complications and the Optimal Use of Adjunctive Pharmacology 36
Donald S. Baim and Daniel I. Simon

SECTION II: BASIC TECHNIQUES 77

4. Percutaneous Approach, Including Trans-septal and Apical Puncture 79
Donald S. Baim and Daniel I. Simon
5. Brachial Cutdown Approach 107
Ronald P. Caputo and William Grossman
6. Diagnostic Catheterization in Childhood and Adult Congenital Heart Disease 118
Michael J. Landzberg and James E. Lock

SECTION III: HEMODYNAMIC PRINCIPLES 131

7. Pressure Measurement 133
William Grossman
8. Blood Flow Measurement: Cardiac Output and Vascular Resistance 148
William Grossman
9. Shunt Detection and Quantification 163
William Grossman
10. Calculation of Stenotic Valve Orifice Area 173
Blase A. Carabello and William Grossman

SECTION IV: ANGIOGRAPHIC TECHNIQUES 185

11. Coronary Angiography 187
Donald S. Baim

12. Cardiac Ventriculography 222
Donald S. Baim
13. Pulmonary Angiography 234
Nils Kucher and Samuel Z. Goldhaber
14. Angiography of the Aorta and Peripheral Arteries 254
Michael R. Jaff, Brian D. MacNeill, and Kenneth Rosenfield

SECTION V: EVALUATION OF CARDIAC FUNCTION 281

15. Stress Testing During Cardiac Catheterization: Exercise and Pacing Tachycardia 283
William Grossman
16. Measurement of Ventricular Volumes, Ejection Fraction, Mass, Wall Stress, and Regional Wall Motion 304
Michael A. Fifer and William Grossman
17. Evaluation of Systolic and Diastolic Function of the Ventricles and Myocardium 315
William Grossman

SECTION VI: SPECIAL CATHETER TECHNIQUES 333

18. Evaluation of Myocardial Blood Flow and Metabolism 335
Morton J. Kern and Michael Lim
19. Intravascular Imaging Techniques 371
Yasuhiro Honda, Peter J. Fitzgerald, and Paul G. Yock
20. Endomyocardial Biopsy 395
Kenneth L. Baughman and Donald S. Baim
21. Intra-Aortic Balloon Counterpulsation and Other Circulatory Assist Devices 412
Daniel Burkhoff

SECTION VII: INTERVENTIONAL TECHNIQUES 431

22. Percutaneous Balloon Angioplasty and General Coronary Intervention 433
Donald S. Baim
23. Coronary Atherectomy, Thrombectomy, and Embolic Protection 467
Campbell Rogers and Donald S. Baim

Au: Is change to "Brian" correct?

vi Contents

24. **Coronary Stenting** 492
Gregg W. Stone
25. **Percutaneous Therapies for Valvular Heart Disease** 543
Ted Feldman
26. **Peripheral Intervention** 562
Brian MacNeill and Kenneth Rosenfield
27. **Intervention for Pediatric and Adult Congenital Heart Disease** 604
Robert Summer
28. **Profiles in Valvular Heart Disease** 637
Ted Feldman and William Grossman
29. **Profiles in Coronary Artery Disease** 660
Jeffrey J. Popma and Judith L Meadows
30. **Profiles in Pulmonary Embolism and Pulmonary Hypertension** 677
Samuel Z. Goldhaber, Nils Kucher, and Michael J. Landzberg
31. **Profiles in Cardiomyopathy and Congestive Heart Failure** 694
Jim Fang and Andrew Eisenhauer
32. **Profiles in Pericardial Disease** 725
John F. Robb and Roger J. Laham
33. **Profiles in Congenital Heart Disease** 744
Michael J. Landzberg and Robert Summer
34. **Profiles in Aortic and Peripheral Vascular Disease** 759
Stephen R. Ramee, Jose A. Silva, and Christopher J. White

SECTION VIII: Profiles of Specific Disorders 635

AU: Pl.
verify
spelling of
name.

Preface to the 7th Edition

This seventh edition of Grossman's *Cardiac Catheterization, Angiography, and Intervention* represents a major milestone in the history of this text: After 30 years of brilliantly shaping this book since publication of the first edition of *Cardiac Catheterization and Angiography* in 1974, William Grossman has stepped down as a co-editor. His legacy, however, remains clear in the title of the book, in the content of the hemodynamic chapters, and in the (we hope) lucid style that always seeks to balance theory and evidence-based medicine with practical technical tips.

The basic structure of recent editions has been retained, with sections devoted to general principles, basic techniques, hemodynamic principles, angiographic techniques, evaluation of cardiac function, special catheter techniques, interventional techniques, and profiles of specific disorders. But in accord with the major and ongoing shifts from the use of the cardiac catheter as a purely diagnostic tool to an important therapeutic tool, the emphasis in this 7th edition of Grossman's has been shifted even further toward interventional techniques.

The returning reader will find many major enhancements throughout this edition. The treatment of digital x-ray systems and radiation biology has been updated, the treatment of complications and adjunctive pharmacology have been enhanced, the percutaneous radial artery approach to left heart catheterization is discussed more fully, and the treatment of both pediatric and adult congenital heart disease has been strengthened. The sections on pulmonary angiography and pulmonary embolism have been recast, as have the chapters on endomyocardial biopsy and circulatory assist devices. The interventional section has been totally revamped as pertains to atherectomy, thrombectomy, and distal embolic protection devices; bare metal and drug-eluting stents; percutaneous valve therapies (including new catheter approaches to catheter reduction of mitral regurgitation and percutaneous valve replacement for aortic stenosis); and the interventional treatment of pediatric and adult congenital heart disease. The coverage of peripheral vascular disease has continued with three chapters devoted to head-to-foot diagnostic methods, interventional techniques, and case examples.

Those represent only a few of the most prominent changes that were made in the effort to capture the major progress in this field since the sixth edition was published in 2000. We have also revised and expanded the companion CD-ROM compared with that of the previous edition, and it now includes more than 100 digital cases that show a full

spectrum of normal anatomy, anatomic variations, diagnostic and interventional procedures, and a variety of complications. This companion CD-ROM also includes more than 20 animations that illustrate the principle of action of various invasive and interventional devices. These materials should be seen as an important supplement and significant extension of the printed text, and are intentionally encoded in unprotected standard media formats to enable their extraction for use in teaching materials or presentations.

The growing clinical use of interventional techniques, the rapid evolution of those techniques, and the ongoing introduction of important new methods only underscore the importance of providing a comprehensive, balanced, and up-to-date reference in this field. This resource will be valuable to both new entrants to invasive and interventional cardiology (Fellows and new catheterization laboratory staff) and to the more than 10,000 practitioners of this specialty worldwide. Because the pace of development in this area is continuing to accelerate, readers are encouraged to monitor new publications and trial results frequently or keep abreast of new developments in this area through such resources as Up-to-date www.uptodate.com/index.asp.

Even while working to provide the latest current information, I have tried not to lose the incremental (layer on layer) historical flavor and theoretical background (including approaches that were tried and abandoned) that were such an integral part of Bill Grossman's original vision for this textbook. This adds to our understanding and can be particularly valuable as discarded procedures re-enter mainstream practice (e.g., trans-septal puncture)! Most important, I hope that my efforts and those of the contributing authors in describing the scope and depth of invasive and interventional cardiology will translate into the better patient outcomes that should derive from improved understanding on the part of those who perform and interpret cardiac catheterization procedures.

Beyond the list of contributing authors, I wish to thank our many colleagues across the country and throughout the world whose shared experiences have been woven into much of the material contained in the book, as well as several generations of our Cardiology Fellows for their questions and research efforts that have led to many of the principles and techniques described throughout this book.

Donald S. Baim, M.D.
Boston, Massachusetts