Cardiovascular Emergencies

Amal Mattu, MD, FACEP, Editor-in-Chief
Professor and Vice Chair
Director, Emergency Cardiology Fellowship
Department of Emergency Medicine
University of Maryland School of Medicine
Baltimore, Maryland

William J. Brady, MD, FACEP, Associate Editor
Professor of Emergency Medicine and Medicine
Chair, Medical Emergency Response Committee
Medical Director, Emergency Management
University of Virginia
Charlottesville, Virginia

Sarah A. Stahmer, MD, Associate Editor
Associate Professor Emergency Medicine
Department of Emergency Medicine
University of North Carolina at Chapel Hill

Michael Jay Bresler, MD, FACEP, Associate Editor
Clinical Professor
Division of Emergency Medicine
Stanford University School of Medicine
Stanford, California

Jeffrey A. Tabas, MD, FACEP, Associate Editor
Professor, Department of Emergency Medicine
University of California, San Francisco
San Francisco, California

Scott M. Silvers, MD, FACEP, Associate Editor
Chair, Department of Emergency Medicine
Assistant Professor of Emergency Medicine
Mayo Clinic College of Medicine
Jacksonville, Florida

American College of Emergency Physicians

ADVANCING EMERGENCY CARE
The American College of Emergency Physicians (ACEP) makes every effort to ensure that contributors to its publications are knowledgeable subject matter experts. Readers are nevertheless advised that the statements and opinions expressed in this publication are provided as the contributors' recommendations at the time of publication and should not be construed as official College policy. ACEP recognizes the complexity of emergency medicine and makes no representation that this publication serves as an authoritative resource for the prevention, diagnosis, treatment, or intervention for any medical condition, nor should it be the basis for the definition of or standard of care that should be practiced by all health care providers at any particular time or place. Drugs are generally referred to by generic names. In some instances, brand names might be added for easier recognition. Device manufacturer information, if provided, is listed according to style conventions of the American Medical Association. ACEP received no commercial support for this publication. To the fullest extent permitted by law, and without limitation, ACEP expressly disclaims all liability for errors or omissions contained within this publication, and for damages of any kind or nature, arising out of use, reference to, reliance on, or performance of such information. To contact ACEP, write to PO Box 619911, Dallas TX 75261-9911; or call toll-free 800-798-1822, or 972-550-0911.
About the Editors

Amal Mattu, MD, FACEP. Since joining the faculty at the University of Maryland School of Medicine in 1996, Dr. Mattu has had a passion for teaching and writing about emergency cardiology. His commitment to teaching has earned him more than twenty teaching awards, including national awards from the American College of Emergency Physicians (ACEP) and local honors including the Teacher of the Year for the University of Maryland at Baltimore campus and the Maryland State Emergency Physician of the Year Award. He is a regular speaker at national and international conferences on topics pertaining to emergency cardiology. Dr. Mattu has authored or edited 16 textbooks in emergency medicine, including seven focused on emergency cardiology and electrocardiography. He is also the only emergency physician to serve as primary Guest Editor for Cardiology Clinics, which he has done twice. Dr. Mattu is currently a tenured professor, Vice Chair, and director of the Emergency Cardiology Fellowship for the Department of Emergency Medicine at the University of Maryland School of Medicine.

William J. Brady, MD, FACEP. Dr. Brady is a tenured professor of emergency medicine and internal medicine at the University of Virginia School of Medicine and is a senator in the Faculty Senate of the University of Virginia. He is the chief medical officer and medical director of Allianz Global Assistance (United States and Canada). He lectures locally, regionally, nationally, and internationally on many topics, including the electrocardiogram, cardiac arrest resuscitation, acute coronary syndrome, and emergency preparedness and response. He is a member of the Academy of Distinguished Educators at the University of Virginia and has received numerous teaching awards, including ACEP’s National Faculty Teaching Award, the University of Virginia School of Medicine Dean’s Award for Excellence in Teaching, and the David A. Harrison Distinguished Educator Award. He has also published numerous scholarly works, written or edited multiple textbooks, and contributed to clinical policy guidelines for both ACEP and the American Heart Association.

Michael Jay Bresler, MD, FACEP. Dr. Bresler is a clinical professor in the Division of Emergency Medicine of the Stanford University School of Medicine. Well known as an educator, he is frequently invited to lecture throughout the United States and internationally. His publications in the medical literature include a number of textbooks, textbook chapters, and peer reviewed journal articles. Dr. Bresler has been quite active in the legislative process at both the state and federal levels. He has written portions of both Federal and California anti-dumping laws, as well as legislation that generates over $200 million annually in California for the emergency care of indigent patients. Dr. Bresler has won the highest awards for leadership from both ACEP and the California chapter of ACEP. He served for a number of years as Speaker of the National Council of ACEP, and before that as President of the California chapter. ACEP has honored Dr. Bresler as a Life Fellow of the College, an Honorary Member, and a Hero of Emergency Medicine.

Scott Silvers, MD, FACEP. Dr. Silvers attended medical school at the University of Rochester School of Medicine in Rochester, New York, and received his training in emergency medicine at the Harvard Affiliated Emergency Residency in Boston, Massachusetts. Currently, he is chief of the Department of Emergency Medicine at Mayo Clinic in Jacksonville, Florida, where he also serves as co-director of the Mayo Clinic Comprehensive Stroke Center and Chest Pain Center. Dr. Silvers is a member of both the ACEP Clinical Policies Committee as well as the American Heart Association’s Emergency Cardiovascular Care Committee where he contributes to the development of national, evidence-based guidelines. He was a co-author of the first Blueprints in Emergency Medicine study guide, and a co-editor of the Textbook of Emergency Cardiovascular Care and CPR. In coordination with the University of Miami’s Center for Research in Medical Education, Dr. Silvers contributed to the development of the national advanced stroke life support curriculum. He is a reviewer for several journals and a member of the editorial board of Emergency Medicine Practice.

Sarah A. Stahmer, MD. Dr. Stahmer is an associate professor of emergency medicine at the University of North Carolina, Chapel Hill. She has been a program training director in emergency medicine for 15 years, building the academic training programs at Hospital of the University of Pennsylvania, Cooper/RWJ University Hospital, and Duke University Hospital. Her academic interests are ultrasound in emergency medicine, cardiovascular emergencies, and medical education. She has lectured extensively on these and other topics regionally, nationally, and internationally. She has received numerous awards for leadership and teaching in medical education that include the 2013 Council of Residency Directors Michael Wainscott Award for leadership and teaching in residency education, the Socrates Teaching Award UNC Emergency Medicine Residency, and the Council of Residency Directors Impact Award. Her publications are numerous in the fields of medical education, ultrasound, and cardiac emergencies.

Jeffrey A. Tabas, MD, FACEP. Dr. Tabas is a professor of emergency medicine at the University of California San Francisco School of Medicine and practices at San Francisco General Hospital. He received degrees from Brown University and University of Pennsylvania School of Medicine and completed both internal medicine and emergency medicine residencies at University of California Los Angeles Medical Center. Dr. Tabas has worked with ACEP to teach emergency medicine, advanced procedural skills, and cardiovascular emergencies to a generation of students, residents, and physicians. He has been an active lecturer, author, and editor as well as course chair for ACEP Scientific Assembly and other popular emergency medicine conferences. When not pursuing clinical or academic activities, he is busy spending time with his wife and three children as well as pursuing his interest in sports, especially throwing hip checks in his ice hockey league for minimally skilled adult players.
Dedications

I would like to thank my wife, Sejal, for her constant support and encouragement; I thank my children, Nikhil, Eleena, and Kamran, for always reminding me of my proper priorities in life; I thank the residents and students at the University of Maryland School of Medicine for providing me the inspiration for the work I do every day; and finally, thanks to my colleagues and mentors, who continue to exemplify what I hope one day to become.

— Amal Mattu

I am most fortunate and am appreciative of many people—my parents, William and Joann Brady, for providing the opportunities; my wife, King Brady, for her support, patience, and love; my children, Lauren, Anne, Chip, and Katherine, for their love and inspiration; my chair, Robert O’Connor, MD, for his mentorship and leadership; and my colleagues in emergency medical care, both hospital- and prehospital-based, for their partnership in healthcare and dedication to the patient.

— William J. Brady

I would like to dedicate this work to my family, Adrienne, Ben, and Aaron, and to the thousands of emergency physicians whose efforts day and night provide care and comfort for our fellow human beings.

— Michael Jay Bresler

This book is dedicated to my parents for showing me how to live a life of integrity and devotion; to the love of my life, Avery, who is my greatest support and best friend; to my boys, Levi and Austin, who are my best buds and who motivate me to be the best that I can be; and to all of my many mentors in medicine who have challenged me to understand more about why we do what we do.

— Scott Silvers

For all those who let me teach the subtleties of ECG interpretation, medication effects on transmembrane potentials, and the evidence behind ACS risk stratification protocols…at 2 AM and feign to appear interested! I thank you for that gift.

— Sarah A. Stahmer

This text is dedicated to my wife, children, and parents for their support, love, and faith. I thank my colleagues at University of California San Francisco and at the American College of Emergency Physicians for their brilliance, fantastic attitude, and great friendship. I also thank the amazing staff at ACEP who made this all possible and finally, the amazing Amal Mattu, who continues to lead and inspire a generation of physicians.

— Jeffrey A. Tabas
Contributors

Benjamin S. Abella, MD, MPhil, FACEP
Center for Resuscitation Science
Department of Emergency Medicine
University of Pennsylvania
Philadelphia, Pennsylvania
Chapter 13, Post–Cardiac Arrest Syndrome

Tyler W. Barrett, MD, MSci, FACEP, FHRS
Associate Professor
Department of Emergency Medicine
Vanderbilt University Medical Center
Nashville, Tennessee
Chapter 8, Bradyarrhythmias

Christopher W. Baugh MD, MBA, FACEP
Director of Observation Medicine
Department of Emergency Medicine
Brigham and Women’s Hospital
Assistant Professor of Medicine
Harvard Medical School
Boston, Massachusetts
Chapter 20, Use of Emergency Department Observation Units for Cardiac Patients

J. Stephen Bohan, MS, MD, FACP, FACEP
Executive Vice Chair
Department of Emergency Medicine
Brigham and Women’s Hospital
Associate Professor
Harvard Medical School
Boston, Massachusetts
Chapter 20, Use of Emergency Department Observation Units for Cardiac Patients

William J. Brady, MD, FACEP, Associate Editor
Professor of Emergency Medicine and Medicine
Chair, Medical Emergency Response Committee
Medical Director, Emergency Management
University of Virginia
Charlottesville, Virginia
Operational Medical Director, Albemarle County Fire Rescue & Madison County EMS
Charlottesville, Virginia
Chief Medical Officer & Medical Director, Allianz Global Assistance
United States & Canada
Chapter 2, The Electrocardiogram in the Evaluation and Management of Acute Coronary Syndrome
Chapter 9, Narrow Complex Tachycardia: Diagnosis and Management in the Emergency Department

Michael Jay Bresler, MD, FACEP, Associate Editor
Clinical Professor
Division of Emergency Medicine
Stanford University School of Medicine
Stanford, California
Chapter 15, Hypertensive Emergencies and Elevated Blood Pressure
Chapter 21, Reducing the Risk of Malpractice

David F. M. Brown, MD, FACEP
Chair and Associate Professor
Department of Emergency Medicine
Massachusetts General Hospital
Harvard Medical School
Boston, Massachusetts
Chapter 10, Wide Complex Tachycardia

Theodore C. Chan, MD, FAAEM, FACEP
Professor and Chair
Department of Emergency Medicine
University of California, San Diego Health Sciences
San Diego, California
Chapter 19, Complications of Implanted Cardiac Devices

Emily K. Damuth, MD
Attending Physician
Division of Critical Care Medicine
Department of Emergency Medicine
Cooper University Hospital
Camden, New Jersey
Chapter 8, Bradyarrhythmias

Gail Delfin, MSN, RN
Clinical Research
Center for Resuscitation Science
University of Pennsylvania
Philadelphia, Pennsylvania
Chapter 13, Post–Cardiac Arrest Syndrome

Deborah B. Diercks, MD, MSc, FACEP
Professor and Vice Chair of Research
Department of Emergency Medicine
University of California, Davis Medical Center
Sacramento, California
Chapter 1, Approach to Acute Chest Pain

Laleh Gharahbaghian, MD, FACEP
Clinical Assistant Professor
Director, Emergency Ultrasound Program and Fellowship
Division of Emergency Medicine
Stanford University School of Medicine
Stanford, California
Chapter 4, Bedside Ultrasound for Emergency Cardiovascular Disorders
John C. Greenwood, MD  
Department of Pulmonary & Critical Care Medicine  
University of Maryland Medical Center  
Baltimore, Maryland  
*Chapter 17, Special Populations: Pulmonary Hypertension and Cardiac Transplant*

Tarlan Hedayati, MD, FACEP  
Associate Program Director  
Emergency Medicine Residency Program  
Assistant Professor  
Department of Emergency Medicine  
Cook County (Stroger) Hospital  
Rush University Medical Center  
Chicago, Illinois  
*Chapter 5, Acute Coronary Syndrome: Modern Treatment of STEMI and NSTEMI*

Korin B. Hudson, MD, FACEP  
Associate Professor  
Department of Emergency Medicine  
MedStar Georgetown University Hospital  
Washington, District of Columbia  
*Chapter 2, The Electrocardiogram in the Evaluation and Management of Acute Coronary Syndrome*

Keith A. Marill, MD  
Research Faculty  
Department of Emergency Medicine  
University of Pittsburgh  
Pittsburgh, Pennsylvania  
*Chapter 10, Wide Complex Tachycardia*

Amal Mattu, MD, FACEP, Editor-in-Chief  
Professor and Vice Chair  
Director, Emergency Cardiology Fellowship  
Department of Emergency Medicine  
University of Maryland School of Medicine  
Baltimore, Maryland  
*Chapter 1, Approach to Acute Chest Pain*

Norine A. McGrath, MD, FACEP  
Attending Physician  
Department of Emergency Medicine  
Chair, Bioethics Committee  
Medstar Washington Hospital Center  
Medstar Georgetown University Hospital  
Washington, DC  
*Chapter 2, The Electrocardiogram in the Evaluation and Management of Acute Coronary Syndrome*

Abhi Mehrotra, MD, FACEP  
Associate Professor  
Chief, Division of Quality and Performance  
Department of Emergency Medicine  
University of North Carolina School of Medicine  
Chapel Hill, North Carolina  
*Chapter 14, Pericarditis, Myocarditis, and Endocarditis*

Chadwick D. Miller, MD, MS, FACEP  
Associate Professor  
Executive Vice Chair and Director of Clinical Research  
Department of Emergency Medicine  
Wake Forest University School of Medicine  
Winston-Salem, North Carolina  
*Chapter 3, Acute Coronary Syndrome: Biomarkers and Imaging*

Siamak Moayedi, MD  
Assistant Professor  
Department of Emergency Medicine  
University of Maryland School of Medicine  
Baltimore, Maryland  
*Chapter 16, Cardiac Disease in Special Populations: HIV, Pregnancy, and Cancer*

James V. Quinn, MD, MS, FACEP  
Professor of Surgery/Emergency Medicine  
Stanford University  
Stanford, California  
*Chapter 11, Syncope*

Peter S. Pang, MD, MSc, FACEP, FAAEM, FACC, FAHA  
Associate Professor  
Indiana University School of Medicine  
Indianapolis, Indiana  
*Chapter 7, Acute Heart Failure*

Nathan Parker, MD  
Department of Emergency Medicine  
University of California, Davis Medical Center  
Sacramento, California  
*Chapter 4, Bedside Ultrasound for Emergency Cardiovascular Disorders*

Phillips Perera, MD, RDMS, FACEP  
Clinical Associate Professor  
Director, Emergency Ultrasound Research  
Associate Director, Emergency Ultrasound Division  
Division of Emergency Medicine  
Department of Surgery  
Stanford University Medical Center  
Stanford, California  
*Chapter 4, Bedside Ultrasound for Emergency Cardiovascular Disorders*

Joshua C. Reynolds, MD, MS  
Assistant Professor  
Department of Emergency Medicine  
College of Human Medicine  
Michigan State University  
Grand Rapids, Michigan  
*Chapter 12, Modern Management of Cardiac Arrest*

Matthew Salzman, MD  
Assistant Professor  
Medical Toxicologist  
Department of Emergency Medicine  
Cooper Medical School of Rowan University  
Camden, New Jersey  
*Chapter 18, Pharmacologic Approach to the Emergency Cardiac Patient*
Foreword

Emergency physicians serve as front-line clinicians who are expected to evaluate, stabilize, and begin treatment whenever an emergency patient presents to the emergency department (ED). As the specialty of emergency medicine has evolved and matured, so have the expectations for the expertise of the emergency physician. This creates a very exciting but also a very challenging work environment.

Gone are the days when all patients with chest pain get admitted for observation, every patient who is critically ill is whisked to an ICU before the initiation of critical care or a cardiologist is routinely called to the ED for patients with an unusual or unstable rhythm. Physicians working in an ED are now expected to have a high level of sophisticated knowledge in all areas of emergency care, with cardiovascular emergencies being one of the most important.

Cardiovascular Emergencies by Mattu, Brady, Bresler, Silvers, Stahmer, and Tabas brings together experts in our specialty to create an authoritative text for emergency providers. It is a book by emergency physicians for emergency physicians. It is also an excellent resource for physicians training in any specialty who will see cardiovascular emergencies. Each of the editors is a renowned educator and they have carefully selected authors for each topic. The text’s value is maximized by extremely clear ECGs and very high quality graphics and illustrations.

The best textbooks are broad enough to include all relevant information, but are focused on the core topics readers will need to develop expertise or to serve as a reference. The editors and authors drew on their many years of experience educating students, residents, and fellow physicians to create a comprehensive textbook of cardiovascular emergencies. They begin with a chapter on how to approach chest pain and follow with a chapter on the overt and subtle ECG signs of ischemia and infarction. The evolution of biomarkers as well as the “best” imaging study to evaluate patients for ischemia follows in separate chapters devoted to each topic. The text’s value is maximized by extremely clear ECGs and very high quality graphics and illustrations.

The best textbooks are broad enough to include all relevant information, but are focused on the core topics readers will need to develop expertise or to serve as a reference. The editors and authors drew on their many years of experience educating students, residents, and fellow physicians to create a comprehensive textbook of cardiovascular emergencies. They begin with a chapter on how to approach chest pain and follow with a chapter on the overt and subtle ECG signs of ischemia and infarction. The evolution of biomarkers as well as the “best” imaging study to evaluate patients for ischemia follows in separate chapters devoted to each topic. Up until a few years ago, only cardiologists performed cardiovascular ultrasound. Now emergency physicians are increasingly using ultrasound to evaluate the heart and great vessels for evidence of heart failure, tamponade, contractility, RV strain, and volume status; thus, a chapter is devoted to the ultrasound findings needed for acute diagnosis and treatment of cardiovascular emergencies. Finally, there is no emergency that is more central to emergency care than the treatment of an acute myocardial infarction. This text covers all facets of the acute therapy of both STEMI and NSTEMI.

Chapters are also devoted to the management of arrhythmias seen near daily in the ED, including wide and narrow complex tachycardias along with bradycardias and heart block. Critical care medicine and cardiology share a number of emergencies, and this text provides up-to-date management of acute decompensated heart failure, cardiogenic shock, cardiac arrest, and post-cardiac arrest care, covering each with a detailed but succinct chapter. Key Point sections throughout all chapters highlight the most important concepts and clinical insights of the authors.

Other topics also covered in Cardiovascular Emergencies are syncope and hypertension, two very common entities, as well as less common but important conditions such as pulmonary hypertension, myocarditis, and pericarditis; complications due to implanted devices including pacemakers, AICDs, and LVADs; and cardiovascular emergencies in pregnant patients. Cardiac pharmacology, as it applies to emergent patients, and the use of the ED for observation are also presented. Because missing a cardiovascular emergency such as a myocardial infarction leads all other causes in dollars lost to malpractice claims paid, the final chapter is devoted to reducing malpractice risks.

Corey M. Slovis, MD, FACEP, FACP, FAAEM
Professor of Emergency Medicine and Medicine
Chairman, Department of Emergency Medicine
Vanderbilt University Medical Center
Medical Director, Metro Nashville Fire Department and International Airport
Nashville, Tennessee
May 2014
Preface

Cardiovascular disease accounts for more deaths in the United States and most other first-world countries than any other cause. This number-one ranking has persisted for many years despite marked advances in preventive medicine, diagnostics, and therapeutics. Not only has this rank remained immobile, but the absolute number of deaths due to cardiac disease continues to rise. Most “experts” predict that this is not going to change in the near future. Therefore, if we in the health care field have any hope of changing these statistics, we must be optimally prepared to diagnose and treat patients when they present with acute cardiovascular conditions or complications.

The specialty of Emergency Medicine bears a great responsibility for the acute care of these patients. We must diagnose and initiate stabilizing treatment for patients with acute coronary syndromes, acute heart failure, pericarditis, myocarditis, arrhythmias, and many other conditions, and we are frequently the key providers who determine the prognosis of patients presenting with cardiac arrest. We are required to carry out these duties while working under significant time constraints; we are forced to make life-and-death decisions, often with minimal objective data; and we are often held to impossible standards of care by society and the legal profession.

The goal of this textbook is to facilitate the efficient and cutting-edge delivery of care to patients who present with acute cardiovascular conditions. To accomplish this goal, we brought together many of the brightest minds in Emergency Medicine from various institutions to collaborate and create best practices for emergency cardiovascular conditions. We believe we have formulated approaches to the workup and management that will optimize patient care.

In the pages that follow, we address many of the most common emergency cardiovascular conditions we face in Emergency Medicine as well as some conditions that are rising in import around the world. Initial chapters focus on the complicated evaluation and differential diagnosis of chest pain and modern approaches to “low-risk” chest pain. Acute coronary syndromes are covered in depth, and subsequent chapters address many of the complications associated with coronary artery disease, including acute heart failure, arrhythmias, and cardiogenic shock. Recent “hot topics” in the Emergency Medicine literature are addressed, including bedside echocardiography, observation units, cardiac arrest, and post-arrest care. Special populations are also discussed: oncologic patients, pregnant patients, transplant patients, patients with HIV, patients with pulmonary hypertension, and patients with implanted devices. A special chapter is devoted to issues related to malpractice.

In overseeing the development of this text, our goal has been to provide an easily understood, highly visual resource that is readable from cover to cover. Although this text might be considered a “bookshelf reference,” that designation is at odds with our goal of cover-to-cover readability. We have tried to format the chapters for quick reference during everyday patient care.

We hope you enjoy reading this book and welcome any and all of your feedback. We would like to thank Linda Kesselring, copyeditor at University of Maryland, and Mary Anne Mitchell, copyeditor at ACEP, whose persistence and insight saw this project through to completion and excellence. We would also like to thank our families for their patience and understanding while we worked on this project, and we thank our colleagues, students, and residents, who have been a constant source of inspiration for our work. We would especially like to thank you, the readers, for your unwavering dedication and commitment to patient care.

Amal Mattu
William J. Brady
Michael J. Bresler
Scott M. Silvers
Sarah A. Stahmer
Jeffrey A. Tabas
Contents

Foreword ................................................................. ix
Preface ................................................................. xi
1. Approach to Acute Chest Pain ................................................. 1
2. The Electrocardiogram in the Evaluation and Management of Acute Coronary Syndrome .................. 11
3. Acute Coronary Syndrome: Biomarkers and Imaging ........................................ 37
4. Bedside Ultrasound for Emergency Cardiovascular Disorders .......................... 53
5. Acute Coronary Syndrome: Modern Treatment of STEMI and NSTEMI ..................... 91
6. Cardiogenic Shock .......................................................... 103
7. Acute Heart Failure ............................................................ 111
8. Bradyarrhythmias ............................................................... 129
9. Narrow Complex Tachycardia: Diagnosis and Management in the Emergency Department ........ 143
10. Wide Complex Tachycardia .................................................... 161
11. Syncope .............................................................. 177
12. Modern Management of Cardiac Arrest ........................................ 187
13. Post–Cardiac Arrest Syndrome ............................................. 201
14. Pericarditis, Myocarditis, and Endocarditis .................................. 209
15. Hypertensive Emergencies and Elevated Blood Pressure ............................ 227
16. Cardiac Disease in Special Populations: HIV, Pregnancy, and Cancer .......................... 243
17. Special Populations: Pulmonary Hypertension and Cardiac Transplant .................. 255
18. Pharmacologic Approach to Cardiac Emergencies ........................................ 269
19. Complications of Implanted Cardiac Devices ........................................ 283
20. Use of Emergency Department Observation Units for Cardiac Patients ............... 293
21. Reducing the Risk of Malpractice ........................................... 301
Index ................................................................. 311