PROBLEM SOLVING IN RADIOLOGY

Problem Solving in

Cardiovascular Imaging

Suhny Abbara and Sanjeeva P. Kalva

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Cardiovascular Imaging

Suhny Abbara, MD, FSCCT
Associate Professor of Radiology
Harvard Medical School
Director, Cardiac Imaging Fellowship
Department of Radiology
Director of Education
Cardiac MR/PET/CT Program
Massachusetts General Hospital
Boston, Massachusetts

Sanjeeva P. Kalva, MD, FSIR
Associate Division Head
Vascular Imaging and Intervention
Director, Center for Image-Guided Cancer Therapy
Massachusetts General Hospital
Assistant Professor of Radiology
Harvard Medical School
Boston, Massachusetts

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1600 John F. Kennedy Blvd.
Ste 1800
Philadelphia, PA 19103-2899

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To Amanda and Tyler,
Marlene and Yasser,
Mona, Richard, Lenni, and Nora,
Susu, Martin, Mark, and Marie
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To Sanjeevarayudu and Bhagyalakshmi,
Vijaya, Praneeth, and Praveen,
Christos Athanasoulis, Mathew Cherian, and Subbarao Kakarla,
My mentors, colleagues, residents, and fellows
SPK

Foreword

Early in the twentieth century, physicians recognized the power of noninvasive imaging to guide diagnosis and patient management in cardiovascular disease. By the 1980s both echocardiography and rest and stress nuclear perfusion imaging had become part of routine patient assessment, which focused primarily on the assessment of left ventricle function and perfusion. At the time, however, assessment of coronary artery disease was limited to invasive coronary angiography, and structural imaging of the myocardium was not yet possible; thus imaging remained a small and easily overlooked field within cardiovascular medicine. We have come a long way since as we have seen a revolution in cardiovascular imaging driven by the introduction and development of cardiac computed tomography (CT) and magnetic resonance imaging (MRI).

In the early 1990s, IMATRON, a small company out of San Francisco, introduced cardiac electron beam CT (EBCT) to the general public, and that changed cardiovascular medicine forever. I remember how impressed I was as a medical student examining patients on an EBCT prototype in Erlangen, Germany, as part of my medical thesis. The EBCT scanner needed a second large room to accommodate the cooling system and computer power, but it allowed for the motion-free visualization of the coronary artery tree with an assessment of stenosis on a regular basis because an image could be acquired within 50 msec (while traditional CT scanners at the time needed 1 full second). The EBCT era culminated in an article by Stephan Achenbach in 1998 published in the *New England Journal of Medicine*, but surprisingly EBCT technology was used primarily to detect and quantify coronary artery calcification in the setting of primary prevention on the West Coast of the United States. However, it triggered the development of multidetector CT (MDCT), a technology developed by Willy Kalender from Erlangen. What started in the late 1990s with four-slice MDCT has now grown into a technology with submillimeter spatial resolution and an image acquisition time of less than 1 second that reliably allows noninvasive assessment of coronary artery stenosis and atherosclerotic plaque morphology and composition. With this improvement in CT technology came the ability to assess complex cardiac morphology, heart valves, and myocardial perfusion and function. Today more than 3000 cardiac imaging–capable units can be found in the United States alone.

Although cardiac MRI has been around more than 10 years longer than CT, it has matured more slowly. Probably the most important and novel finding was published in the *New England Journal of Medicine* in 2000 by Raymond Kim and Bob Bonow from Northwestern University in which they described the phenomenon of delayed myocardial enhancement, which allowed for the prediction of functional recovery after revascularization. This triggered further development of the assessment of myocardial structure and perfusion, and today we are able to differentiate and predict infarct territory, including the core of microvascular obstruction with irreversible loss of function from myocardial edema and reversible dysfunction. In fact, in coronary disease, coronary CT angiography has developed into the primary assessment tool for patients without known coronary artery disease, whereas MRI is a very potent guide for revascularization in patients with already known coronary artery disease, a group of patients that is steadily growing. MR technology has also developed from 1.5T to 3T magnets, and today cardiac MRI is a routine diagnostic tool available at most major institutions.

Thus today's imagers are faced with an ever-increasing choice of advanced and steadily evolving imaging techniques and increasing subspecialization in all aspects of the diagnosis and management of cardiovascular disease. Given today's economic constraints in the health care sector and the increasing need for efficient patient management, it is important to provide educational materials that comprehensively cover the multiple modalities across cardiovascular imaging and decision support for ordering physicians.

Drs. Abbara and Kalva, two well-recognized experts in the field, have brought together a wide range of authors who are leaders in their respective fields. All can be congratulated for providing unique and in-depth coverage to the entire spectrum of cardiovascular disease, including anatomy, diagnosis and patient management, and technical and risk benefit aspects across modalities.

Published within the well-known Problem Solving series, this book provides a compendium that also offers complimentary online access to regularly updated web content, which will ensure that readers can keep track of ongoing breakthroughs in this exciting field.

Problem Solving in Radiology: Cardiovascular Imaging is an excellent guide and source for residents, fellows, and practitioners in both cardiology and radiology and for those who want to refresh their knowledge in the multimodality field of cardiovascular imaging.

Udo Hoffmann, MD, MPH
Associate Professor of Radiology
Harvard Medical School
Division Head, Cardiac Imaging
Department of Radiology
Director, Cardiac MR/PET/CT Program
Massachusetts General Hospital
Boston, Massachusetts

Preface

This cardiovascular imaging textbook in the Problem Solving series publishes at a remarkable time. Since the early 2000s there have been dramatic developments in the field of cardiovascular medicine and imaging. These developments include (among many others) the creation and maturation of multidetector coronary computed tomographic angiography, newer noncontrast magnetic resonance angiography (MRA) and blood pool–contrast MRA, magnetic resonance imaging (MRI)-based scar and viability imaging, particle tracking and other novel techniques, the ripening of alternatives to radionuclide imaging to demonstrate myocardial ischemia, and many novel therapies. Most notable is the development of novel image-guided minimally invasive therapies, which often rely on noninvasive preprocedure imaging for planning purposes. These procedures include, but are not limited to, endoluminal stent graft placement to treat aortic aneurysms, pulmonary vein isolation procedures to treat atrial fibrillation, transcatheter device treatment of septal and other shunts, and transcatheter aortic valve implantation/replacement (TAVI/R) to treat stenotic aortic valves, just to name a few. Hence many new applications and indications for cross-sectional cardiac and vascular imaging have surfaced since 2000. New or underrecognized disease entities have been brought to light and the incidence of some anomalies, normal variants, or conditions have had to be revised now that we have better tools to visualize their respective structures. We have called upon a cadre of more than 90 expert contributors to systematically review the many new developments and present them in a didactically meaningful way.

The text is organized to systematically review the technical nuances and acquisition methods of the various imaging modalities at our disposal, including multidetector computerized tomography, MRI, radionuclide imaging, ultrasound and echocardiography, and catheter angiography. This is followed by a review and illustration of the respective appearance of cardiac and vascular anatomy within each of the imaging modalities and a critical review of when to use which test. After this general discussion, this book is organized by disease entities that affect the cardiovascular system. Each disease entity or spectrum of entities is reviewed in-depth, with a special emphasis on the role of imaging, problem solving, and the multimodality imaging appearance of the diseases and their differential diagnostic entities.

We hope that this initiative will prove useful in the day-to-day care of patients with cardiovascular disease, serve as a stimulus for future research in basic and clinical science, and provide a utilitarian reference source for all health care professionals, trainees, scientists, and biomedical researchers active in the field of cardiovascular medicine in the twenty-first century. Hopefully, in some way, all of the effort and expertise brought together here will help advance our field. And on behalf of all the authors, we truly hope that you will find this text informative, enjoyable, and helpful, whether you are a radiologist, cardiologist, nuclear medicine specialist, resident, fellow medical student, or technologist.

Suhny Abbara, MD, FSCCT
Sanjeeva P. Kalva, MD, FSIR

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I am very grateful to all the contributing authors and to my co-workers in radiology and cardiology, including our fellows, residents, students, and technologists, for their invaluable direct and indirect contributions. Their many contributions to this work, and to the field of cardiovascular imaging in general, may not always be directly apparent.

At the risk of overlooking some important contributors (if such is the case, please forgive me), special thanks go to Drs. Tom Brady, Sanjeev Francis, Brian Ghoshhajra, Udo Hoffmann, Fred Holmvang, and Jim Thrall for enabling this work, and to our outstanding technologists, Steve Bradley, Maggie Hird, Dave Brennan, Jim Hickey, Jake Calkins, and Steve Barry, to name just a few. Our students' and trainees' academic curiosity and various backgrounds challenge us to keep learning and truly enrich the academic environment—thank you. Special thanks go to Dr. Gladwin Hui for proofreading many of the chapters and to the editorial team at Elsevier for their excellent support.

Thanks also go to Dr. Sanjeeva Kalva for accepting my invitation to edit the vascular portion of this text; I know how many hours this took out of his academic and private life. His expertise was invaluable, and he did a phenomenal job seeing this through.

Last but not least, I am grateful to my wife, Dr. Amanda Fox. Juggling the clinical, on-call, and scholarly responsibilities for two professionals while maintaining a rich family life is not easy and requires extraordinary organizational talent. Thank you, Amanda, for making it all possible!

Suhny Abbara, MD, FSCCT

Sincere thanks to Dr. Suhny Abbara, who trusted me and invited me to edit the vascular section of this textbook. Thanks to all the contributors who spent their significant family and personal time to author their chapters.

No words of thanks are sufficient to express my gratitude to my mentors, teachers, colleagues, residents, and fellows who inspire me every day and contribute to my learning. Thanks to my nurses and technologists, who every day make my life easy with their excellent teamwork.

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Sanjeeva P. Kalva, MD, FSIR

Contributors

Suhny Abbara, MD, FSCCT
Associate Professor of Radiology
Harvard Medical School
Director, Cardiac Imaging Fellowship
Department of Radiology
Director of Education
Cardiac MR/PET/CT Program
Massachusetts General Hospital
Boston, Massachusetts
Comparative Anatomy
Cardiac Valves
Cardiac Devices
Cardiac Masses
Pericardial Disease
Thoracic Aorta and Its Branches

Gerald F. Abbott, MD
Associate Professor
Harvard Medical School
Associate Radiologist
Massachusetts General Hospital
Boston, Massachusetts
Pulmonary Arteries

Stephan Achenbach, MD
Professor of Medicine
Department of Cardiology
University of Giessen
Giessen, Germany
Coronary Arteries: Coronary Atherosclerotic Disease

Chaitanya Ahuja, MD
Clinical Fellow
Dotter Interventional Institute
Oregon Health and Science University
Portland, Oregon
Lower Extremity Arteries

Tharakeswara K. Bathala, MD
Assistant Professor
Department of Diagnostic Radiology
The University of Texas MD Anderson Cancer Center
Houston, Texas
Vascular Ultrasound

Sanjeev Bhalla, MD
Professor of Radiology
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St. Louis, Missouri
Imaging for Congenital Cardiovascular Disease

Ron Blankstein, MD, FACC
Co-Director, Noninvasive Cardiovascular Imaging Training Program
Cardiovascular Division and Department of Radiology
Brigham and Women's Hospital
Assistant Professor in Medicine and Radiology
Harvard Medical School
Boston, Massachusetts
When to Choose What Test (Cardiac)

Thorsten A. Bley, MD
Associate Professor of Radiology
Department of Radiology
University Medical Center Hamburg-Eppendorf
Hamburg, Germany
Inflammatory and Infectious Vascular Disorders

Matthew J. Budoff, MD
Professor of Medicine
David Geffen School of Medicine
University of California, Los Angeles
Los Angeles, California
Director of Cardiac CT
Los Angeles Biomedical Research Institute
Torrance, California
Atherosclerosis: Role of Calcium Scoring

Brett W. Carter, MD
Director and Section Chief, Thoracic Imaging
Baylor University Medical Center
Dallas, Texas
Cardiac Devices
Cardiac Masses
Pulmonary Arteries

Alexander Oscar Quiroz Casian, MD
Rush University Medical Center
Chicago, Illinois
Vascular Devices

Meghna Chadha, MD, DNB
Assistant Professor
Department of Radiology Wayne State University
Detroit, Michigan
Lower Extremity Arteries

Mathew P. Cherian, MD
Chief of Radiology Services
Director, Interventional Radiology
Department of Diagnostic and Interventional Radiology
Kovai Medical Center and Hospital
Coimbatore, India
Bronchial Arteries

Jonathan H. Chung, MD
Assistant Professor
Department of Radiology
National Jewish Health
Denver, Colorado
Thoracic Aorta and Its Branches

Kristopher W. Cummings, MD
Assistant Professor
Cardiothoracic Imaging
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St Louis, Missouri
Imaging for Congenital Cardiovascular Disease
Myocardial Nonischemic Cardiomyopathies

Stephan Danik, MD
Instructor in Medicine
Cardiology Division
Massachusetts General Hospital
Boston, Massachusetts
Role of Magnetic Resonance Imaging in Cardiomyopathies

Milind Y. Desai, MD, FACC, FAHA, FESC
Associate Professor of Medicine
Department of Cardiovascular Medicine
Heart and Vascular Institute
Cleveland Clinic
Cleveland, Ohio
Pulmonary Veins, Atria, and Atrial Appendage

Jonathan D. Dodd, MD, MSc, MRCPI, FFR(RCSI)
Consultant Radiologist
St. Vincent's University Hospital
Associate Professor
University College Dublin
Dublin, Ireland
Cardiac Anatomy on Magnetic Resonance Imaging
Coronary Arteries: Anomalies, Normal Variants, Aneurysms, and Fistulas

Sharmila Dorbala, MD, MPH
Director, Nuclear Cardiology
The Noninvasive Cardiovascular Imaging Program
Departments of Radiology (Division of Nuclear Medicine and Molecular Imaging) and Medicine (Cardiology)
Brigham and Women's Hospital
Boston, Massachusetts
Radionuclide Imaging (Cardiac)
Myocardial Ischemic Disease: Nuclear

Daniel W. Entrikin, MD
Associate Professor
Chief, Section of Cardiothoracic Radiology
Director of Computed Tomography
Departments of Radiology and Internal Medicine
Section on Cardiology
Wake Forest University School of Medicine
Winston-Salem, North Carolina
Valves: Computed Tomography

Chieh-Min Fan, MD
Associate Director
Division of Angiography and Interventional Radiology
Brigham and Women's Hospital
Assistant Professor
Department of Radiology
Harvard Medical School
Boston, Massachusetts
Venous Insufficiency

Khashayar Farsad, MD, PhD
Assistant Professor
Dotter Interventional Institute and Diagnostic Radiology
Oregon Health and Science University
Portland, Oregon
Bronchial Arteries
Abdominal Aorta and Branches

Kathryn J. Fowler, MD
Instructor of Radiology
Director, Abdominal and Pelvic MRI
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St. Louis, Missouri
Magnetic Resonance Angiography: Technique

Christopher J. François, MD
Assistant Professor
Cardiovascular and Chest Sections
Department of Radiology
University of Wisconsin School of Medicine and Public Health
Madison, Wisconsin
Inflammatory and Infectious Vascular Disorders

Matthias G. Friedrich, MD, FESC, FACC
Professor of Medicine
Department of Cardiology
Université de Montréal
Adjunct Professor of Medicine
Departments of Cardiac Sciences and Radiology
University of Calgary
Director, CMR Research at the Montreal Heart Institute
Hornstein Chair in Cardiovascular Imaging
Montreal Heart Institute
Montréal, Quebec, Canada
Current Role of Magnetic Resonance Imaging for Suspected Myocarditis

Felix M. Gonzalez, MD
Radiology Resident
Department of Diagnostic Radiology and Nuclear Medicine
University of Maryland
Baltimore, Maryland
Cardiac Computed Tomography for the Evaluation of Acute Coronary Syndrome in the Emergency Department

Nikhil Goyal, MD
Section Chief, Cardiac Imaging
Department of Radiology
Staten Island University Hospital
Staten Island, New York
Pericardial Disease

John D. Grizzard, MD
Associate Professor
Department of Radiology
Virginia Commonwealth University
Richmond, Virginia
Myocardial Ischemic Disease: Magnetic Resonance Imaging

Martin L. Gunn, MD
Associate Professor
Department of Radiology
University of Washington
Seattle, Washington
Thoracic Aorta and Its Branches

Jörg Hausleiter, MD
Professor of Medicine, Cardiology
Medizinische Klinik und Poliklinik I
Ludwig-Maximilians-Universität München
Munich, Germany
Radiation Issues

Sandeep S. Hedgire, MD
Clinical Research Fellow
Division of Abdominal Imaging and Intervention
Massachusetts General Hospital
Harvard Medical School
Boston, Massachusetts
Catheter Angiography (Vascular)
Upper Extremity Arteries

Travis S. Henry, MD
Assistant Professor of Radiology
Emory University School of Medicine
Atlanta, Georgia
Myocardial Nonischemic Cardiomyopathies

Laura E. Heyneman, MD
Associate Clinical Professor of Radiology
UNC Health Care
Chapel Hill, North Carolina
Imaging the Postoperative Thoracic Aorta

Gladwin Hui, MD, MPH
Clinical Fellow, Cardiac Imaging
Department of Radiology
Massachusetts General Hospital
Harvard Medical School
Boston, Massachusetts
Cardiac Devices

David T. Hunt, RVT, RDMS, RT(S)
Sonographer
Neurovascular Laboratory
Massachusetts General Hospital
Boston, Massachusetts
Carotid and Vertebral Arteries

Brian G. Hynes, MB, BCh
Fellow in Interventional Cardiology
Massachusetts General Hospital
Boston, Massachusetts
Coronary Angiography: Technique
Cardiac Anatomy on Coronary Angiography

Jill E. Jacobs, MD
Professor of Radiology
New York University Medical Center
New York, New York
Cardiac Anatomy on Computed Tomography

Carlos Jamis-Dow, MD
Associate Professor of Radiology
Penn State Milton S. Hershey Medical Center
Hershey, Pennsylvania
Cardiac Devices

Ik-Kyung Jang, MD, PhD
Professor of Medicine
Cardiology Division
Massachusetts General Hospital
Boston, Massachusetts
Coronary Angiography: Technique
Cardiac Anatomy on Coronary Angiography

Christoph J. Jensen, MD
Research Fellow
Duke Cardiovascular Magnetic Resonance Center
Duke University Medical Center
Durham, North Carolina
Myocardial Ischemic Disease: Magnetic Resonance Imaging

Philip R. John, MBChB, DCH, FRCR, FRCPC
Associate Professor
Department of Medical Imaging
University of Toronto
Director, Vascular Anomalies Clinic
Division Head, Interventional Radiology
The Hospital for Sick Children
Toronto, Ontario, Canada
Vascular Anomalies

Jason M. Johnson, MD, USAFR
Clinical Instructor in Radiology
Department of Radiology
Massachusetts General Hospital
Harvard Medical School
Boston, Massachusetts
Carotid and Vertebral Arteries

Sanjeeva P. Kalva, MD, FSIR
Associate Division Head
Vascular Imaging and Intervention
Director, Center for Image-Guided Cancer Therapy
Massachusetts General Hospital
Assistant Professor of Radiology
Harvard Medical School
Boston, Massachusetts
Catheter Angiography (Vascular)
Vascular Devices
Thoracic Aorta and Its Branches
Bronchial Arteries
Upper Extremity Arteries
Lower Extremity Arteries
Deep Venous Thrombosis

Avinash Kambadakone, MD, DNB, FRCR
Instructor of Radiology
Division of Abdominal Imaging and Intervention
Massachusetts General Hospital
Boston, Massachusetts
Computed Tomography Angiography (Vascular)
Vascular Anatomy and Variants

Niamh M. Kilcullen, MB, BCh
Clinical and Research Fellow in Medicine
Massachusetts General Hospital
Research Fellow in Medicine
Harvard Medical School
Boston, Massachusetts
Echocardiography
Valves: Echocardiography

Ronan Kileen, MB
Consultant Radiologist
Department of Radiology
Hermitage Medical Clinic
Dublin, Ireland
Cardiac Anatomy on Magnetic Resonance Imaging
Coronary Arteries: Anomalies, Normal Variants, Aneurysms, and Fistulas

Raymond J. Kim, MD
Professor of Medicine and Radiology
Director, Duke Cardiovascular Magnetic Resonance Center
Duke University Medical Center
Durham, North Carolina
Myocardial Ischemic Disease: Magnetic Resonance Imaging

Angela S. Koh, MBBS, MRCP(UK)
Clinical Fellow
Noninvasive Cardiovascular Imaging Program
Brigham and Women's Hospital
Harvard Medical School
Boston, Massachusetts
Consultant Cardiologist
National Heart Centre Singapore
Singapore
Radionuclide Imaging (Cardiac)
Myocardial Ischemic Disease: Nuclear

Raymond Y. Kwong, MD, MPH
Director of Cardiac Magnetic Resonance Imaging
Assistant Professor of Medicine
Brigham and Women's Hospital
Harvard Medical School
Boston, Massachusetts
Cardiac Magnetic Resonance Imaging: Techniques and Protocols

Sampson K. Kyere, MD, PhD
Resident
Department of Diagnostic Radiology
University of Maryland Medical Center
Baltimore, Maryland
Cardiac Computed Tomography for the Evaluation of Acute Coronary Syndrome in the Emergency Department

John P. Lichtenberger III, MD
Chief of Cardiothoracic Imaging
Department of Radiology
David Grant Medical Center
Travis Air Force Base, California
Assistant Professor
Department of Radiology and Radiological Sciences
Uniformed Services University of the Health Sciences
Bethesda, Maryland
Cardiac Devices
Cardiac Masses

Victoria L. Mango, MD
Assistant Professor of Radiology
Columbia University Medical Center
New York, New York
Cardiac Anatomy on Computed Tomography

Santiago Martínez-Jiménez, MD
Associate Professor of Radiology
Saint Luke's Hospital of Kansas City
University of Missouri, Kansas City
Kansas City, Missouri
Imaging the Postoperative Thoracic Aorta

Anna Meader, MD(c), BS
Neurovascular Sonographer
Tufts University School of Medicine
Department of Neuroradiology
Massachusetts General Hospital
Boston, Massachusetts
Carotid and Vertebral Arteries

Stephen W. Miller, MD
Thoracic Radiologist
Massachusetts General Hospital
Associate Professor of Radiology
Harvard Medical School
Boston, Massachusetts
Cardiovascular Anatomy and Pathology on Radiography

François-Pierre Mongeon, MD, SM, FRCPC
Clinical Assistant Professor of Medicine
Université de Montréal
Noninvasive Cardiology Service
Department of Medicine
Montreal Heart Institute
Montréal, Quebec, Canada
Cardiac Magnetic Resonance Imaging: Techniques and Protocols

Venkatesh L. Murthy, MD, PhD
Assistant Professor of Medicine and Radiology
Divisions of Cardiovascular Medicine, Nuclear Medicine, and Cardiothoracic Radiology
University of Michigan
Ann Arbor, Michigan
When to Choose What Test (Cardiac)

John W. Nance Jr., MD
House Officer
Russell H. Morgan Department of Radiology and Radiological Science
Johns Hopkins Hospital
Baltimore, Maryland
Myocardial Ischemic Disease: Computed Tomography

Vamsi R. Narra, MD, FRCR
Professor of Radiology
Chief, Abdominal Imaging Section
Chief of Radiology
Barnes-Jewish West County Hospital
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St. Louis, Missouri
Magnetic Resonance Angiography: Technique

Smita Patel, MBBS, MRCP, FRCR
Associate Professor
Division of Cardiothoratic Radiology
Cardiovascular Center
University of Michigan Health System
Ann Arbor, Michigan
Coronary Artery Bypass Grafts

Michael H. Picard, MD
Professor
Harvard Medical School
Director, Clinical Echocardiography
Massachusetts General Hospital
Boston, Massachusetts
Echocardiography
Valves: Echocardiography

Anil Kumar Pillai, MD
Assistant Professor
Department of Diagnostic Radiology
Rush University Medical Center
Chicago, Illinois
Vascular Devices

Ferenc Czeyda-Pommersheim, MD
Assistant Professor
Department of Radiology
University of Pittsburgh
Pittsburgh, Pennsylvania
Imaging for Congenital Cardiovascular Disease

Prabhakar Rajiah, MD, MBBS, FRCR
Clinical Fellow
Cleveland Clinic Foundation
Cleveland, Ohio
Pulmonary Veins, Atria, and Atrial Appendage

Constantine A. Raptis, MD
Assistant Professor of Radiology
Director, Thoracic MRI
Mallinckrodt Institute of Radiology
Washington University School of Medicine
St. Louis, Missouri
Magnetic Resonance Angiography: Technique

Gautham P. Reddy, MD, MPH
Professor of Radiology and Vice Chair for Education
University of Washington
Seattle, Washington
Valves: Magnetic Resonance Imaging

Otávio Rizzi Coelho-Filho, MD, MPH
Cardiac MRI and CT Program
State University of Campinas—UNICAMP
Campinas, São Paulo, Brazil
Cardiac Magnetic Resonance Imaging: Techniques and Protocols

Carlos Andres Rojas, MD
Assistant Professor
Department of Radiology
University of South Florida
Tampa, Florida
Comparative Anatomy
Pericardial Disease
Septal Defects and Other Cardiovascular Shunts

Javier M. Romero, MD
Director of Ultrasound
Staff Neuroradiologist
Associate Director of Neurovascular Laboratory
Massachusetts General Hospital
Assistant Professor of Radiology
Harvard Medical School
Boston, Massachusetts
Carotid and Vertebral Arteries

Sion K. Roy, MD
Cardiology Fellow
Harbor-University of California, Los Angeles
Torrance, California
Atherosclerosis: Role of Calcium Scoring

Jeremy Ruskin, MD
Cardiac Arrhythmia Service
Massachusetts General Hospital
Boston, Massachusetts
Role of Magnetic Resonance Imaging in Cardiomyopathies

U. Joseph Schoepf, MD, FAHA, FSCBT-MR, FSCCT
Professor of Radiology, Medicine, and Pediatrics
Director of Cardiovascular Imaging
Department of Radiology and Radiological Science
Medical University of South Carolina
Charleston, South Carolina
Myocardial Ischemic Disease: Computed Tomography

Vikram Venkatesh, MD
Cardiac Radiologist
Assistant Clinical Professor
(Adjunct) Radiology
McMaster University
Department of Radiology
Grand River Hospital
Kitchener, Ontario, Canada
Cardiac Valves

Emmanuelle Vermes, MD
Research Fellow
Stephenson Cardiovascular MR Centre
Libin Cardiovascular Institute of Alberta
Departments of Cardiac Sciences and Radiology
University of Calgary
Calgary, Alberta, Canada
Current Role of Magnetic Resonance Imaging for Suspected Myocarditis

Dharshan Raj Vummidi, MBBS, MRCP, FRCR
Division of Cardiothoratic Radiology
Cardiovascular Center
University of Michigan Health System
Ann Arbor, Michigan
Coronary Artery Bypass Grafts

Christopher M. Walker, MD
Cardiothoracic Imaging Fellow
Department of Radiology
Massachusetts General Hospital
Boston, Massachusetts
Valves: Magnetic Resonance Imaging

Arthur C. Waltman, MD
Staff Radiologist
Department of Radiology
Massachusetts General Hospital
Boston, Massachusetts
Upper Extremity Arteries

William Guy Weigold, MD
Director, Cardiac CT Program
MedStar Washington Hospital Center
Washington, District of Columbia
Cardiac Gated Computed Tomography

Charles S. White, MD
Professor of Radiology
Director of Thoracic Imaging
University of Maryland
Baltimore, Maryland
Cardiac Computed Tomography for the Evaluation of Acute Coronary Syndrome in the Emergency Department

James Kin Ho Woo, MD, BSc
Radiologist
Ellesmere X-ray Associates
Toronto, Ontario, Canada
Cardiovascular Anatomy and Pathology on Radiography

Joo Heung Yoon, MD
Research Fellow
Division of Cardiology
Massachusetts General Hospital
Boston, Massachusetts
Cardiac Anatomy on Coronary Angiography

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