# RadCases Cardiac Imaging

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# **Cardiac Imaging**





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Thieme Medical Publishers, Inc. 333 Seventh Ave. New York, NY 10001

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Library of Congress Cataloging-in-Publication Data

Radcases cardiac imaging / edited by Carlos Santiago Restrepo, Dianna M.E. Bardo. p.; cm. Includes bibliographical references and index. ISBN 978-1-60406-185-7 1. Heart-Imaging-Case studies. 2. Heart-Diseases-Diagnosis-Case studies. I. Restrepo, Carlos Santiago. II. Bardo, Dianna M. E. [DNLM: 1. Heart Diseases-diagnosis-Case Reports. 2. Diagnostic Imagin-methods-Case Reports. WG 141 R312 2010] RC683.5.I42R33 2010 616.1'20754-dc22

2009031579

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Printed in China

978-1-60406-185-7

# Dedication

To my husband John, who makes it possible to work with passion and makes the rewards of that work worthwhile. —Dianna M. E. Bardo

To my parents, Ovidio and Marielena, with all my love. And to my wife, Marta, and my children, Catalina, Juan, and Alejandro, the joy of my life.

-Carlos Santiago Restrepo

# **Series Preface**

The ability to assimilate detailed information across the entire spectrum of radiology is the Holy Grail sought by those preparing for their trip to Louisville. As enthusiastic partners in the Thieme RadCases series who formerly took the examination, we understand the exhaustion and frustration shared by residents and the families of residents engaged in this quest. It has been our observation that despite ongoing efforts to improve Web-based interactive databases, residents still find themselves searching for material they can review while preparing for the radiology board examinations and remain frustrated by the fact that only a few printed guidebooks are available, which are limited in both format and image quality. Perhaps their greatest source of frustration is the inability to easily locate groups of cases across all subspecialties of radiology that are organized and tailored for their immediate study needs. Imagine being able to immediately access groups of high-quality cases to arrange study sessions, quickly extract and master information, and prepare for theme-based radiology conferences. Our goal in creating the RadCases series was to combine the popularity and portability of printed books with the adaptability, exceptional quality, and interactive features of an electronic case-based format.

The intent of the printed book is to encourage repeated priming in the use of critical information by providing a portable group of exceptional core cases that the resident can master. The best way to determine the format for these cases was to ask residents from around the country to weigh in. Overwhelmingly, the residents said that they would prefer a concise, point-by-point presentation of the Essential Facts of each case in an easy-to-read, bulleted format. Differentials are limited to a maximum of three, and the first is always the actual diagnosis. This approach is easy on exhausted eyes and provides a quick review of Pearls and Pitfalls as information is absorbed during repeated study sessions. We worked hard to choose cases that could be presented well in this format, recognizing the limitations inherent in reproducing highquality images in print. Unlike other case-based radiology review books, we removed the guesswork by providing clear annotations and descriptions for all images. In our opinion, there is nothing worse than being unable to locate a subtle finding on a poorly reproduced image even after one knows the final diagnosis.

The electronic cases expand on the printed book and provide a comprehensive review of the entire subspecialty. Thousands of cases are strategically designed to increase the resident's knowledge by providing exposure to additional case examples—from basic to advanced—and by exploring "Aunt Minnie's," unusual diagnoses, and variability within a single diagnosis. The search engine gives the resident a fighting chance to find the Holy Grail by creating individualized, daily study lists that are not limited by factors such as radiology subsection. For example, tailor today's study list to cases involving tuberculosis and include cases in every subspecialty and every system of the body. Or study only thoracic cases, including those with links to cardiology, nuclear medicine, and pediatrics. Or study only musculoskeletal cases. The choice is yours.

As enthusiastic partners in this project, we started small and, with the encouragement, talent, and guidance of Tim Hiscock at Thieme, we have continued to raise the bar in our effort to assist residents in tackling the daunting task of assimilating massive amounts of information. We are passionate about continuing this journey, planning to expand the cases in our electronic series, adapt cases based on direct feedback from residents, and increase the features intended for board review and selfassessment. As the National Board of Medical Examiners converts the American Board of Radiology examination from an oral to an electronic format, our series will be the one best suited to meet the needs of the next generation of overworked and exhausted residents in radiology.

> Jonathan Lorenz, MD Hector Ferral, MD Chicago, IL

# Preface

The opportunity to present a large group of cases to you in Cardiac Imaging, part of the RadCases series, is a real privilege for us. Working in academic medicine provides us the ability to teach and learn from residents and fellows as well as the chance to diagnose a broad range of common and uncommon cardiac diseases, and also further advance cardiac imaging modalities through research.

The high prevalence of cardiovascular diseases in the western world, as well as the amazing evolution of imaging technology available to us makes this book more relevant today than ever before. It is critical that radiologists are capable of diagnosing cardiovascular diseases.

The power of this cardiac case base is the presentation of strengths of both CT and MRI through 100 printed and an additional 150 electronic cases. The 250 cases we have prepared include not only common presentations, but uncommon presentations of common problems and examples of cases you must diagnosis immediately to avert potential disaster. The cases we have written prepare you for your opportunities to shine when confronted with cardiac cases whether that is on a board examination or in practice.

We hope this case base review series will be beneficial for you as you prepare for medical board examinations. This case base series and the learning experiences during your training are the foundation for a lifetime of learning you will experience throughout your career.

> Dianna M.E. Bardo, MD Carlos Santiago Restrepo, MD

#### Acknowledgments

I wish to acknowledge my colleagues Craig S. Broberg, MD; Michael D. Shapiro, DO; and Thanjavur Bragadeesh, MB, ChB, who generously shared their cases for this text and who teach and inspire excellence in cardiac imaging.

#### Dianna M. E. Bardo, MD

I want to thank Santiago Martinez, MD (Duke University); Terry Bauch, MD (The University of Texas HSC, San Antonio); Jorge Carrillo, MD (Universidad Nacional, Bogota, Colombia); Ramon Reina, MD (Clinica de Marly, Bogota, Colombia); Julio Lemos, MD (University of Vermont); and Eric Kimura, MD (Instituto Nacional de Cardiologia Ignacio Chavez, Mexico), for their valuable contributions.

Carlos Santiago Restrepo, MD



# Clinical Presentation

The electrical system of the heart performs critical functions in synchronized depolarization, resulting in contraction of the atria and ventricles and ejection of blood into the pulmonary and systemic vascular beds. The important structures and events in cardiac electrical activity and the usual vascular supply to these structures are described.

#### Imaging Findings

Components of the electrical conduction system and coronary arteries have been drawn over four-chamber, short-axis, and two-chamber views of the heart.



(A) The sinoatrial (SA) node (*green dot*) is at the superior and posterior margin of the right atrium. Internodal pathways (*dotted yellow arrows*) span the SA and the atrioventricular (AV) nodes (*red dot*). The right (*white arrow*) and left (*black arrow*) bundle branches (*orange lines*) and Purkinje fibers (*black circle*) propagate depolarization through the ventricles. (B) The SA (*green dot*) and AV (*red dot*) nodes are supplied by the SA nodal (*small white arrow*) and AV nodal (*black arrow*) arteries; both are usually branches of the right

#### coronary artery (*open white arrow*). Occasionally, the AV nodal branch arises from the left circumflex artery (*white arrow*). **(C)** The left anterior descending artery supplies septal branches that perforate the interventricular septum to supply the bundle branches (*orange line*). The P and T waves and the QRS complex of the electrocardiogram (ECG) trace are described below.

#### Differential Diagnosis

• *Normal cardiac conduction system:* The myocardial muscle cells and tissue of a specialized conduction system allow conduction of electrical impulses. Specialized cells in the conductive tissue depolarize spontaneously.

#### Essential Facts

- Components of the conduction system include the following:
- The SA node suppresses depolarization of other pacing cells and is therefore the dominant pacemaker of the heart. It excites the internodal pathways and the atrial myocardium.
- Anterior, middle, and posterior internodal tracts are activated by the SA node, propagating the electrical signal to the AV node, the His bundle, the bundle branches, the Purkinje network, and the ventricular myocardium.
- The AV node, located at the crux cordis, depolarizes to assist in propagating conduction of electrical activity to the His bundle.
- The His bundle and the right and left bundle branches are organized groups of cells that propagate electrical activity through the ventricles in an organized manner.
- Anterosuperior and posteroinferior divisions of the left bundle and the Purkinje network increase the speed of depolarization through the ventricles.

- The main components of the ECG trace are the following:
- *P wave:* The P wave represents the combination of right atrial activation and the slightly delayed activation of the left atrium; resulting in atrial systole.
- *QRS complex:* The electrical representation of ventricular muscle depolarization; resulting in ventricular systole.
- *T wave:* Recovery of the ventricular myocardium; ventricular diastole begins as the ventricles relax.

## Other Imaging Findings

• In patients with arrhythmia, look for thrombus in the left atrial appendage.

#### ✓ Pearls & X Pitfalls

- Myocardial infarction and ischemia can result in arrhythmia.
- Variability of coronary artery dominance results in a minor inconsistency in the vascular supply of the conduction system.



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# Clinical Presentation

Shortness of breath and chest pain in a 45-year-old man

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#### Imaging Findings



(A) Axial T1-weighted and (B) gradient echo (GRE) images at the level of the heart demonstrate a large mass in the left atrium (*white arrow*, Fig. A)



attached to the interatrial septum and protruding through the mitral valve into the upper left ventricle.

# Differential Diagnosis

- *Atrial myxoma:* A well-delineated, smooth, oval left atrial mass attached to the interatrial septum is characteristic of an atrial myxoma. When large enough, an atrial myxoma may protrude into the left ventricle through the mitral valve.
- Atrial thrombus: An atrial thrombus more commonly arises from the posterior or lateral wall of an enlarged left atrium.
- *Sarcoma:* An atrial sarcoma typically involves the right atrium and presents as an irregular infiltrative mass of soft-tissue density.

#### Essential Facts

- Myxomas account for one half of all primary cardiac tumors and are the most common primary cardiac neoplasms.
- Women are affected more than men. The mean age at diagnosis is 50 years.
- Large left atrial myxomas commonly cause mitral valve obstruction (60%).
- Constitutional symptoms (fever, malaise, and weight loss), cardiac arrhythmias, and embolic manifestations are the most common clinical complaints.
- Myxomas are attached to the endocardium, and origin from the fossa ovalis of the interatrial septum is characteristic.
- Seventy-five percent of myxomas arise in the left atrium and 20% in the right atrium.
- On computed tomography, > 50% exhibit calcification.

# Other Imaging Findings

- On magnetic resonance imaging (MRI), atrial myxomas have heterogeneous signal intensity.
- On T1-weighted images, they have low signal intensity.
- On cine GRE images, atrial myxomas exhibit contrast enhancement after gadolinium injection.

# Pearls & X Pitfalls

- The majority of atrial myxomas are sporadic, but 7% are associated with a familial predisposition or manifest as multicentric myxomas with skin pigmentation, endocrine disorders, and other tumors (Carney complex).
- Atrial myxomas and thrombi can have a similar appearance on MRI. Contrast-enhanced MRI can help differentiate between these two conditions because myxomas exhibit enhancement and thrombi do not.



# Clinical Presentation

A 50-year-old woman presents with a stroke and a heart murmur on physical examination.

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# Imaging Findings

On cardiac-gated multidetector computed tomography angiography:



(A) Axial image at the level of the aortic valve. A well-defined, low-density polypoid lesion is appreciated on the inferior surface of the aortic valve leaflets. (B) Coronal image at the level of the aortic valve. A well-defined,



## Differential Diagnosis

- **Papillary fibroelastoma:** Contrast-enhanced cardiac-gated computed tomography (CT) shows a soft-tissue-density polypoid mass arising from an aortic valve leaflet. The lesion exhibits smooth contour, consistent with the typical appearance and location of a papillary fibroelastoma.
- *Endocarditis vegetation:* Infective and noninfective endocarditis can present with a similar appearance as a result of an aortic valve vegetation. In cases of infective endocarditis, typically more significant damage and dysfunction of the involved valve are present, and the clinical history and presentation favor an infectious process.
- Other valvular tumors: In general, valvular tumors other than papillary fibroelastomas are rare. Myxomas, lipomas, and hematic cysts have been reported originating from cardiac valves.

# Essential Facts

- Despite being an uncommon tumor, papillary fibroelastoma is the most common valvular neoplasm. More than 90% are attached to valves.
- The most common location is in the aortic valve (45%), followed by the mitral valve (36%).
- Papillary fibroelastoma is the third most common benign cardiac tumor, after myxoma and lipoma.
- Papillary fibroelastomas are usually small (< 20 mm in diameter), mobile, single lesions.
- The mean age at the time of diagnosis is 60 years.

• Papillary fibroelastomas can be an incidental finding in asymptomatic patients evaluated for unrelated conditions, or they can be associated with a distal arterial embolization (e.g., stroke and transient ischemic attack) or valvular dysfunction.

## Other Imaging Findings

 On echocardiography, a papillary fibroelastoma appears as a small round or oval echogenic polypoid lesion < 2 cm in diameter with a homogeneous echotexture. It is usually mobile and has a small stalk attached to the commissure of a cardiac valve.

Pearls & X Pitfalls

- Papillary fibroelastomas are benign, rare gelatinous tumors derived from the endocardium, primarily of the left-sided cardiac valves, with the potential for embolization.
- These small lesions can be easily overlooked in a nongated cross-sectional imaging examination.



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# Clinical Presentation

A 57-year-old man presents with a history of recent myocardial infarction with ST wave elevation on electrocardiogram. The apex was not moving normally on echo, and the ejection fraction was measured at 17%.

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#### Imaging Findings



(A) A left ventricular (LV) outflow tract view shows a rounded shape and apparent thickening of the LV apex (*black arrow*). (B) This four-chamber white blood image of the heart shows apparent thickening of the rounded apex (*black arrow*). (C,D) Following intravenous administration of

# Differential Diagnosis

- *LV apical infarction; aneurysm with thrombus formation:* The LV apex is rounded and the wall thickness decreased. Linear enhancement of the subendocardial surface of the myocardium and no enhancement within the crescent-shaped thrombus are typical of this diagnosis.
- *Hypertrophic cardiomyopathy:* Although the apical myocardium appears thickened before gadolinium is given, the wall is clearly markedly thinned once the endocardium is defined. Localized hypertrophic cardiomyopathy usually affects the septal wall.
- Apical cardiac metastasis: The appearance of the apex prior to gadolinium administration could suggest an infiltrating metastatic lesion; however, the patient does not have a known malignancy.

#### Essential Facts

- Most thrombi that form in the LV following myocardial infarction occur within the first 2 weeks, but as early as 48 hours.
- Inflammatory cells infiltrate necrotic myocardium following infarction, inducing platelet and fibrin deposition on the endocardial surface of the myocardium, encouraging thrombus formation.
- Inflammatory markers such as C-reactive protein may help to predict in which patients thrombi are more likely to form.
- Potential embolic complications from LV thrombi portend a poor prognosis.

gadolinium, delayed images in a four-chamber and a two-chamber view show rim enhancement of a mass in the apex (*white arrows*), a thrombus that has formed on the endocardial surface of the infarcted myocardium. The thrombus does not enhance (*open white arrow*).

# Other Imaging Findings

- Look for areas of wall motion abnormality, akinesis, marked hypokinesis, or aneurysm as a site of thrombus formation.
- Calcium within or on the surface of the LV thrombus is a sign of chronicity.
- Calcium may be missed on magnetic resonance imaging but should be obvious on computed tomography (CT).

# ✓ Pearls & X Pitfalls

- Describe wall motion abnormalities in a systematic manner:
  - If the face of a clock is used for reference, 12:00 is the anterior wall, 3:00 the lateral wall, 6:00 the inferior wall, and 9:00 the septal wall.
  - Between these are regions called the *anteroseptal*, *inferolateral*, *inferoseptal*, and *anteroseptal segments*.
- ✗ On CT, the mixing of contrast with non−contrastenhanced blood is an unusual finding in the LV, but it may be seen in the right side of the heart.



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# Clinical Presentation

A 29-year-old man presents with a murmur. What is the high-signal structure adjacent to the spine, parallel to the aorta? Explain how this structure and the abnormal morphology of the heart (Fig. B) are related.

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