JACC: CARDIOVASCULAR INTERVENTIONS VOL. 9, NO. 5, 2016

ISSN 1936-8798/$36.00
PUBLISHED BY ELSEVIER http://dx.doi.org/10.1016/j.jcin.2015.11.031

STATE-OF-THE-ART REVIEW

Cardiovascular Magnetic Resonance Imaging for Structural and Valvular Heart Disease Interventions

João L. Cavalcante, MD,[a] Omosalewa O. Lalude, MBBS,[b] Paul Schoenhagen, MD,[c] Stamatios Lerakis, MD[b]

JACC: CARDIOVASCULAR INTERVENTIONS CME

This article has been selected as this issue's CME activity, available online at http://www.acc.org/jacc-journals-cme by selecting the CME tab on the top navigation bar.

Accreditation and Designation Statement

The American College of Cardiology Foundation (ACCF) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

The ACCF designates this Journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit(s)*™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Method of Participation and Receipt of CME Certificate

To obtain credit for this CME activity, you must:

1. Be an ACC member or *JACC: Cardiovascular Interventions* subscriber.
2. Carefully read the CME-designated article available online and in this issue of the journal.
3. Answer the post-test questions. At least 2 out of the 3 questions provided must be answered correctly to obtain CME credit.
4. Complete a brief evaluation.
5. Claim your CME credit and receive your certificate electronically by following the instructions given at the conclusion of the activity.

CME Objective for This Article: At the end of this activity the reader should be able to: 1) recognize the advantages and limitations of cardiac magnetic resonance imaging in structural and valvular heart disease interventions; 2) discuss the utility of late gadolinium enhancement imaging in the evaluation of patients with aortic stenosis pre- and post-intervention; and 3) describe the role of cardiac magnetic resonance imaging and phase contrast velocity mapping in the assessment of valvular stenosis/regurgitation and cardiac shunts.

CME Editor Disclosure: *JACC: Cardiovascular Interventions* CME Editor Bill Gogas, MD, PhD, has received research grant support from NIH T32, Gilead Sciences, and Medtronic Inc.

Author Disclosures: Dr. Cavalcante has received research grant support from Medtronic Inc. Dr. Lerakis is a consultant for Edwards Lifesciences. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Medium of Participation: Print (article only); online (article and quiz).

CME Term of Approval

Issue Date: March 14, 2016
Expiration Date: March 13, 2017

From the [a]Department of Medicine, Division of Cardiology, UPMC Heart & Vascular Institute, University of Pittsburgh, Pittsburgh, Pennsylvania; [b]Department of Medicine, Division of Cardiology, Emory University School of Medicine, Atlanta, Georgia; and the [c]Robert and Suzanne Tomsich Department of Cardiovascular Medicine, Cleveland Clinic, Imaging Institute and Heart & Vascular Institute, Cleveland, Ohio. Dr. Cavalcante has received research grant support from Medtronic Inc. Dr. Lerakis is a consultant for Edwards Lifesciences. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received October 22, 2015; revised manuscript received November 30, 2015, accepted November 30, 2015.

JACC: CARDIOVASCULAR INTERVENTIONS VOL. 9, NO. 5, 2016
MARCH 14, 2016:399–425

Cardiovascular Magnetic Resonance Imaging for Structural and Valvular Heart Disease Interventions

ABSTRACT

The field of percutaneous interventions for the treatment of structural and valvular heart diseases has been expanding rapidly in the last 5 years. Noninvasive cardiac imaging has been a critical part of the planning, procedural guidance, and follow-up of these procedures. Although echocardiography and cardiovascular computed tomography are the most commonly used and studied imaging techniques in this field today, advances in cardiovascular magnetic resonance imaging continue to provide important contributions in the comprehensive assessment and management of these patients. In this comprehensive paper, we will review and demonstrate how cardiovascular magnetic resonance imaging can be used to assist in diagnosis, treatment planning, and follow-up of patients who are being considered for and/or who have undergone interventions for structural and valvular heart diseases. (J Am Coll Cardiol Intv 2016;9:399–425)

Cardiac magnetic resonance (CMR) is a noninvasive imaging modality that allows detailed visualization of cardiac anatomy and functional assessment, including wall motion analysis, quantification of chambers size and volume, systolic and diastolic function, and myocardial tissue characterization, without exposure to ionizing radiation. Similar to cardiovascular computed tomography, CMR also provides imaging with excellent spatial resolution and ability for 3-dimensional (3D) multiplanar reconstruction. Strengths, limitations, and contraindications of this technique are listed in **Table 1**.

OVERVIEW OF CMR IMAGING TECHNIQUE

Initial routine axial images are obtained along the entire thorax providing an overview of the cardiothoracic morphology and anatomy (1). Subsequently, more specific views are acquired to define the structure and/or pathology of interest. A particular strength of CMR is the capability to assess cardiac function using cine sequences with high temporal and spatial resolution, while not being limited by a specific imaging plane. Quantification of left ventricular (LV) and right ventricular (RV) mass, volumes, and systolic function with CMR is considered the gold-standard for noninvasive imaging. This is typically performed applying breath-holding techniques, in the short-axis orientation covering the entire left and right ventricles from the base to the apex. Either manual tracing or semiautomated contour detection of the endocardial and epicardial borders is then performed. The end-diastolic and -systolic frames are identified as the frames with the largest and smallest areas, respectively. These contours are used to calculate end-diastolic and -systolic volumes, stroke volumes, and ejection fraction (2) (**Figure 1**). Technological advances now allow adequate free-breathing imaging acquisition, which is advantageous in patients with advanced heart failure, in those unable to perform breath-hold, and/or in those with cardiac arrhythmias.

Cine images can also provide excellent evaluation of valvular morphology and function. Quantification of disease severity (stenosis or regurgitation) is usually performed with the combination of 2-dimensional (2D) cine imaging and flow quantification using the phase-contrast technique. Furthermore, CMR can also ascertain the effects of the valvular disease on chamber remodeling, which is not only important for decision making, but also prognostically relevant.

Additional volumetric data acquisition allows 3D multiplanar reconstruction, similar to multidetector computed tomography (MDCT) or 3D echocardiography. This is especially helpful for the patient with complex cardiovascular disease before and after corrective surgery. Use of navigator-echo methods, like noncontrast electrocardiography (ECG)-gated 3D steady-state free precession magnetic resonance angiography, synchronizes respiratory and cardiac gating, allowing 3D dataset acquisitions without the need for intravenous contrast (hereafter abbreviated as *3D whole heart*), which can be reconstructed with excellent spatial resolution (**Figure 2**).

Another strength of CMR is the capability of providing tissue characterization. Most CMR contrast agents are gadolinium chelates, which in normal circumstances remain in the blood pool because