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Preface: Cardiovascular Magnetic Resonance in Heart Failure

Subha V. Raman

When to Use Cardiovascular Magnetic Resonance in Patients with Heart Failure 1

Roopa A. Rao, Omar Jawaid, Christopher Janish, and Subha V. Raman

Use of cardiac magnetic resonance (CMR) to aid in diagnosis, management, and prognosis of ischemic and nonischemic cardiomyopathy has advanced tremendously in the past several decades. These advances have expanded our understanding of both ischemic and nonischemic cardiomyopathies while also allowing for new avenues of diagnosis and treatment. This review summarizes key concepts of CMR technology and CMR use in the diagnosis and prognosis in ischemic, infiltrative, inflammatory, and other nonischemic cardiomyopathies and discusses the use of CMR in the patient presenting with ventricular arrhythmia with unclear diagnosis and advances in CMR in the management cardiomyopathy.

Cardiac Magnetic Resonance Quantification of Structure-Function Relationships in Heart Failure 9

Kim-Lien Nguyen, Peng Hu, and J. Paul Finn

Video content accompanies this article at http://www.heartfailure.theclinics.com.

Classification of heart failure is based on the left ventricular ejection fraction (EF): preserved EF, midrange EF, and reduced EF. There remains an unmet need for further heart failure phenotyping of ventricular structure-function relationships. Because of high spatiotemporal resolution, cardiac magnetic resonance (CMR) remains the reference modality for quantification of ventricular contractile function. The authors aim to highlight novel frameworks, including theranostic use of ferumoxytol, to enable more efficient evaluation of ventricular function in heart failure patients who are also frequently anemic, and to discuss emerging quantitative CMR approaches for evaluation of ventricular structure-function relationships in heart failure.

Cardiovascular Magnetic Resonance in Heritable Cardiomyopathies 25

Daniel J. Hammersley, Richard E. Jones, Lukas Mach, Brian P. Halliday, and Sanjay K. Prasad

Cardiovascular magnetic resonance represents the imaging modality of choice for the investigation of patients with heritable cardiomyopathies. The combination of gold-standard volumetric analysis with tissue characterization can deliver precise phenotypic evaluation of both cardiac morphology and the underlying myocardial substrate. Cardiovascular magnetic resonance additionally has an established role in risk-stratifying patients with heritable cardiomyopathy and an emerging role in guiding therapies. This article explores the application and utility of cardiovascular magnetic resonance techniques with specific focus on the major heritable cardiomyopathies.

Role of Cardiovascular Magnetic Resonance in Ischemic Cardiomyopathy 41

Aneesh S. Dhore-Patil and Ashish Aneja

Ischemic heart disease is the most common cause of cardiovascular morbidity and mortality. Cardiac magnetic resonance (CMR) improves on other noninvasive modalities in detection, assessment, and prognostication of ischemic heart disease. The incorporation of CMR in clinical trials allows for smaller patient samples without the sacrifice of power needed to demonstrate clinical efficacy. CMR can accurately quantify infarct acuity, size, and complications; guide therapy; and prognosticate recovery. Timing of revascularization remains the holy grail of ischemic heart disease, and viability assessment using CMR may be the missing link needed to help reduce morbidity and mortality associated with the disease

Cardiovascular Magnetic Resonance in Right Heart and Pulmonary Circulation Disorders 57

Carla Contaldi, Francesco Capuano, Luigia Romano, Brigida Ranieri, Francesco Ferrara, Gaetano Mirto, Salvatore Rega, Rosangela Cocchia, Anna Agnese Stanziola, Ellen Ostenfield, Santo Dellegrottaglie, Eduardo Bossone, and Robert O. Bonow

Right heart and pulmonary circulation disorders are generally caused by right ventricle (RV) pressure overload, volume overload, and cardiomyopathy, and they are associated with distinct clinical courses and therapeutic approaches, although they often may coexist. Cardiac magnetic resonance (CMR) provides a noninvasive accurate and reproducible multiplanar anatomic and functional assessment, tissue characterization, and blood flow evaluation of the right heart and pulmonary circulation. This article reviews the current status of the CMR, the most recent techniques, the new parameters and their clinical utility in diagnosis, prognosis, and therapeutic management in the right heart and pulmonary circulation disorders.

Cardiovascular Magnetic Resonance of Myocardial Fibrosis, Edema, and Infiltrates in *Heart Failure* 77

Kate Liang, Anna Baritussio, Alberto Palazzuoli, Matthew Williams, Estefania De Garate, Iwan Harries, and Chiara Bucciarelli-Ducci

Cardiac magnetic resonance (CMR) imaging is a unique imaging modality, which provides accurate noninvasive tissue characterization. Various CMR sequences can be utilized to identify and quantify patterns of myocardial edema, fibrosis, and infiltrates, which are important determinants for diagnosis and prognostication of heart failure. This article describes available methods of tissue characterization imaging applied in CMR. The presence and patterns of abnormal tissue characterization are related to common etiologies of heart failure and the techniques employed to demonstrate this. CMR provides the opportunity to identify the etiology of heart failure based on the recognition of different patterns of myocardial abnormalities.

Magnetic Resonance-Based Characterization of Myocardial Architecture 85

David E. Sosnovik

Advances in technology have made it possible to image the microstructure of the heart with diffusion-weighted magnetic resonance. The technique provides unique insights into the cellular architecture of the myocardium and how this is perturbed in a range of disease contexts. In this review, the physical basis of diffusion MRI and the challenges of implementing it in the beating heart are discussed. Cutting edge acquisition and analysis techniques, as well as the results of initial clinical studies, are reported.

Cardiovascular Magnetic Resonance in Valvular Heart Disease–Related Heart Failure 103

Seth Uretsky and Steven D. Wolff

Patients with valvular heart disease–related heart failure are unable to pump enough blood to meet the body's needs. Magnetic resonance imaging (MRI) can play an important role by identifying these patients and distinguishing them from patients whose valvular disease is not the cause of their heart failure. Heart failure is a major public health problem, with a prevalence of 5.8 million people in the United States and more than 223 million people worldwide. This article focuses on the diagnostic and prognostic value of MRI patients with valvular causes of heart failure.

Assessment of Pericardial Disease with Cardiovascular MRI 109

Natalie Ho, Gillian Nesbitt, Kate Hanneman, and Paaladinesh Thavendiranathan

Disorders of the pericardium are common and can result in significant morbidity and mortality. Advances in multimodality imaging have enhanced our ability to diagnose and stage pericardial disease and improve our understanding of the pathophysiology of the disease. Cardiovascular MRI (CMR) can be used to define pericardial anatomy, identify the presence and extent of active pericardial inflammation, and assess the hemodynamic consequences of pericardial disease. In this way, CMR can guide the judicial use of antiinflammatory and immune modulatory medications and help with timing of pericardiectomy. CMR can also be used to diagnose congenital disorders of the pericardium. Furthermore, CMR can be used to define pericardial masses and understand their malignant potential.

The Role of Cardiovascular MRI in Cardio-Oncology 121

Wendy Bottinor, Cory R. Trankle, and W. Gregory Hundley

Cardiac imaging is an essential tool in the field of cardio-oncology. Cardiovascular magnetic resonance (CMR) stands out for its accuracy, reproducibility, and ability to provide tissue characterization. These attributes are particularly helpful in screening and diagnosing cardiotoxicity, infiltrative disease, and inflammatory cardiac disease. The ability of CMR to detect subtle changes in cardiac function and tissue composition has made it a useful tool for understanding the pathophysiology of cardiotoxicity. Because of these unique features, CMR is gaining prominence in both the clinical and research aspects of cardio-oncology.

Intracardiac and Vascular Hemodynamics with Cardiovascular Magnetic Resonance in Heart Failure 135

Aakash N. Gupta, Michael Markl, and Mohammed S.M. Elbaz

In heart failure (HF), the impaired heart loses its ability to competently eject blood during systole or fill with blood during diastole, manifesting in multifaceted abnormal intracardiac or intravascular flow dynamics. Conventional imaging techniques are limited in their ability to evaluate multidirectional multidimensional flow alterations in HF. Four-dimensional (4-D) flow magnetic resonance imaging (MRI) has emerged as a promising technique to comprehensively visualize and quantify changes in 3-dimensional blood flow dynamics in complex cardiovascular diseases. This article reviews emerging applications of 4-D flow MRI hemodynamic markers in HF and etiologies at risk of progressing to HF.

Measuring Myocardial Energetics with Cardiovascular Magnetic Resonance Spectroscopy 149

Joevin Sourdon, Sabra C. Lewsey, Michael Schär, and Robert G. Weiss

The heart has the highest energy demands per gram of any organ in the body and energy metabolism fuels normal contractile function. Metabolic inflexibility and impairment of myocardial energetics occur with several common cardiac diseases, including ischemia and heart failure. This review explores several decades of innovations in cardiac magnetic resonance spectroscopy modalities and their use to noninvasively identify and quantify metabolic derangements in the normal, failing, and diseased heart. The implications of this noninvasive modality for predicting significant clinical outcomes and guiding future investigation and therapies to improve patient care are discussed.

Cardiovascular Magnetic Resonance in Congenital Heart Disease: Focus on Heart Failure 157

Vivek Muthurangu

Over the past decade, cardiovascular magnetic resonance (CMR) has become a mainstream noninvasive imaging tool for assessment of adult and pediatric patients with congenital heart disease. It provides comprehensive anatomic and hemodynamic information that echocardiography and catheterization alone do not provide. Extracardiac anatomy can be delineated with high spatial resolution, intracardiac anatomy can be imaged in multiple planes, and functional assessment can be made accurately and with high reproducibility. In patients with heart failure, CMR provides not only reference standard evaluation of ventricular volumes and function but also information about the possible causes of dysfunction.