The Future of Cardiovascular Imaging

Written by Toni Rizzo

The Multimodality Landscape Looking Forward

Safe and effective visualization of the heart structure and cardiac blood flow for diagnostic evaluation or to guide cardiac procedures is at the heart of medical care. William A. Zoghbi, MD, Weill Cornell Medical College, New York, New York, USA, spoke about the wide application of imaging in cardiovascular disease and new visualization techniques and technologies.

Multimodality imaging runs the gamut from the electrocardiogram to the most advanced trends in echocardiography. Its use is widely applied across all areas of cardiovascular disease, including ventricular function, coronary artery disease, valvular disease, congenital heart disease, and vascular disease. During his presentation, Dr. Zoghbi discussed imaging trends, applications, and implications.

Echocardiography encompasses a family of techniques, including tissue Doppler and speckle tracking modalities. Current trends include the proliferation of 3D imaging, automation, miniaturization, and multimodality integration. Emerging left ventricular applications include twist, torsion, and rotation by 3D wall motion tracking.

The increased accuracy of real-time 3D echocardiography has given it a central role in the assessment of patients prior to valvular surgery. The use of contrast has broadened the indications for transthoracic echocardiography while reducing the number of patients who cannot be screened due to a limited acoustic window.

Assessment of left ventricular structure and function are the most frequent indications for echocardiography. More versatile cardiac magnetic resonance (CMR) imaging is suitable for diagnostic and prognostic applications in valve flow, cardiac mass, stress perfusion, right ventricular dysplasia, myocardial viability, pericardial constriction, aortic disease, and anomalous coronaries.

CMR has provided important diagnostic and prognostic insights into various cardiomyopathies [Park JR et al. *Int J Cardiovasc Imaging* 2011]. Myocardial delayed enhancement after administration of contrast accurately delineates a scar, a powerful marker of poor prognosis in dilated cardiomyopathy. In addition, the quantification of the myocardial parameter T2* on CMR has been validated for accurate quantification of iron myocardial overload and as the strongest predictor for incident heart failure.

New visualization techniques are leading to a future that includes 3D global diastolic function indices based on CMR imaging for aortic disease, anomalous coronaries, valve flow, cardiac mass, stress perfusion, RV dysplasia, myocardial viability, and pericardial constriction.

White et al. [*JACC Cardiovasc Imaging* 2010] assessed the feasibility of providing spatially matched, 3D myocardial scar and coronary imaging for the purpose of fused volumetric image display in patients undergoing cardiac resynchronization therapy (CRT) or coronary artery revascularization (CAR). A total of 55 studies were performed in patients referred for either CRT (n=42) or CAR (n=13). Combined 3D coronary and scar imaging was successful in 49 of them (89%). A quality score ≥2 was obtained for 97% of proximal- and mid-coronary artery and vein segments. The mean quality score of 3D scar imaging was 2.8±1.0 and was scored as ≥2 in 86% of patients with myocardial scar. All patients with a scar quality score ≥2 achieved successful image fusion. Transmural scar was present below ≥1 planned target vessel in 9 patients (39%) planned for CRT and 8 patients (62%) planned for CAR. Physician surveys demonstrated incremental clinical impact in 67% of patients.

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Findings showed that 3D myocardial scar and coronary imaging with fused volumetric display is clinically feasible and may be valuable for the planning of vascular-based interventions when regional myocardial scar is pertinent to therapeutic success.

Future imaging technologies are likely to improve risk stratification and selection of patients for implantable cardioverter defibrillators, resynchronization devices, and other interventions by overcoming remaining problems in stress echocardiography and nuclear stress testing (Table 1). Motivated by the promise to transform preclinical research and clinical care, cardiovascular molecular imaging alone promises great progress via hybrid protocols and the pairing of technology-driven opportunities with those from genomics, proteomics, immunology, and vascular and systems biology [Leuschner F, Nahrendorf M. *Circ Res* 2011].

Table 1. Remaining Problems of Imaging in Evaluation of Coronary Artery Disease.

	Stress Echo	Stress Nuclear
LBBB	Paradox septum	False +
Women	—	Breast attenuation
Inferior wall	Site of false +	Diaphragmatic attenuation
LVH	False – (DSE)	False +
Severe ischemia	—	'Fixed Defect'
3V Disease	Flat EF response	Balanced perfusion
Hypertensive response	Flat EF, False +	—

3V=3 vessel; DSE=dobutamine stress echocardiography; EF=ejection fraction; LBBB=left bundle branch block; LVH=left ventricular hypertrophy.

Among other advances, Dr. Zoghbi foresees high-speed nuclear cardiology cameras with multidetector systems focused on the heart, cadmium zinc telluride semiconductor detectors that decrease the size of the camera head and improve energy resolution by almost 2-fold, improved imaging efficiency and count rate statistics, reduced image degradation by scattered radioactivity, higher spatial resolution, and reduced radiation dose.

The last decade has already seen profound progress, and the future will bring new opportunities to multimodality cardiovascular imaging. These include detection of early disease/cardiovascular phenotype; possible use of imaging for novel drug development and as a surrogate for patient outcome, and the demonstration that novel technologies ultimately have an impact on patient care and outcomes.

Vascular imaging is moving toward the identification of total cardiovascular risk. Dr. Zoghbi predicts more robust quantitation and automation (eg, comparative volumetric 3D flows) in the imaging of valvular regurgitation as well as dynamic mapping of mitral valve strain pre- and post-valve repair. He also expects to see echo-guided interventions for valve repair/replacement, determination of aortic regurgitation post transcatheter aortic valve replacement, noninvasive imaging of plaques, echocardiography and CMR-compatible imaging flow loops, and TAVR patient-specific modeling and 3D heart printing.

Challenges will include the maintenance of innovation in individual modalities, avoidance of layering of multiple testing in individual patients to improve safety and lower costs, and the identification of the best and most cost-effective approaches to disease detection and management.

Noninvasive Assessment of Function and Anatomy Advance Interventional Cardiology

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The ischemic cascade is the sequence of pathophysiological events following cardiac ischemia. Several imaging techniques (eg, single-photon emission computed tomography, stress echocardiography, magnetic resonance imaging [MRI], and positron emission tomography [PET]) scans) have been used to detect myocardial ischemia, while cineangiography and computed tomography angiography (CTA) have been used to evaluate anatomy. However, accurate noninvasive assessment of combined anatomy and function of coronary artery disease (CAD) is challenging. Magdy Rashwan, MD, Alexandria University, Alexandria, Egypt, discussed obstacles and advances in imaging technologies used to guide the management of patients with CAD.

A comprehensive assessment of CAD should include both information on coronary artery anatomy and functional information about the hemodynamic relevance of coronary artery lesions in order to guide revascularization procedures. However, it is common practice for physicians to make decisions regarding revascularization in the cardiac catheterization laboratory based on the results of angiography alone, even though such information does not correlate well with the functional significance of a coronary lesion [Kim JE, Koo BK. *Korean Circ J* 2012].

In patients with stable CAD, these decisions are primarily driven by the severity and extent of luminal stenoses determined by invasive coronary angiography