Introduction

The following abstracts were selected from those presented at the conference on Multimodality Cardiovascular Imaging for the Clinician: Update in Echocardiography, Nuclear, CT and CMR held in Houston, Texas, October 2–3, 2010 under the direction of Dr. William Zoghbi and co-chaired by Drs. Miguel Quiñones, John Mahmarian, and Dipan Shah.

This conference was designed to address the conundrum of clinicians in choosing the best imaging procedure from the many now available choices for a particular clinical problem thus avoiding the time and expense of multiple imaging procedures.

CT Coronary Angiography: When Should It Be Performed?

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Over the past decade, technological advances in multidetector computed tomography (CT) with submillimeter spatial resolution and almost heart-freezing temporal resolution have enabled the accurate noninvasive assessment of coronary arteries. Multiple studies have shown that CT coronary angiography (CTCA) has a high sensitivity, good specificity and, in particular, an extremely high negative predictive value, making it an attractive imaging modality to rule out the presence of coronary artery disease (CAD). Furthermore, CTCA depicts the presence of nonobstructive coronary plaques and has been used for prognosticating future coronary events. CTCA is now considered by many as a noninvasive imaging modality of choice that supplants invasive angiography for assessing obstructive CAD in selected patient populations. It is also now recognized as an "appropriate" procedure in several selected clinical scenarios, including: 1) evaluation of chest pain syndrome with uninterpretable or equivocal stress test; 2) evaluation of chest pain syndrome in patients with intermediate pre-test probability of CAD; and 3) acute chest pain with intermediate pre-test probability of CAD, no ECG changes, and negative serial enzymes. Other applications of CTCA include the diagnosis of coronary anomalies. Despite its many advantages and promising clinical results, many concerns related to inappropriate use have been raised due to radiation exposure and use of iodinated contrast material. It is considered inappropriate to use CTCA as a screening tool in asymptomatic patients. In addition, it is recommended that CTCA use be avoided in patients who have chronic kidney disease, a severe reaction to contrast material, and a rapid or irregular heart rate.

Live 3-D Imaging Facilitates Percutaneous Paravalvular Repair

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Overview: Our initial experience using live three-dimensional transesophageal echocardiography (3-D TEE) during percutaneous paravalvular repair (PPVR) is described. We report that 3-D TEE enables real-time catheter visualization and facilitates occluder device placement across regurgitant mitral paravalvular defects (PD).

Purpose: 3-D TEE (Philips, USA) was employed during four consecutive PPVR procedures. Image guidance by 2-D TEE and 3-D TEE was qualitatively compared for 1) assessment of the structural defect location and geometry, 2) continuous catheter visualization, and 3) evaluation of closure device position and function.

Methods: Five occluder devices (Amplatzer PDA, USA) were successfully positioned across large PDs in three patients. Patient 1 — single occluder deployed for mechanical mitral PD; patient 2 — 2 occluders deployed for mechanical mitral PD, a third adjacent occluder deployed 5 months later (Figure 1); patient 3 — single occluder deployed for bioprosthetic mitral PD. Compared to 2-D TEE, supplemental imaging by 3-D TEE was of immediate value. Live 3-D/color Doppler imaging clearly identified the size, location, and crescent-like geometry of significant mitral paravalvular

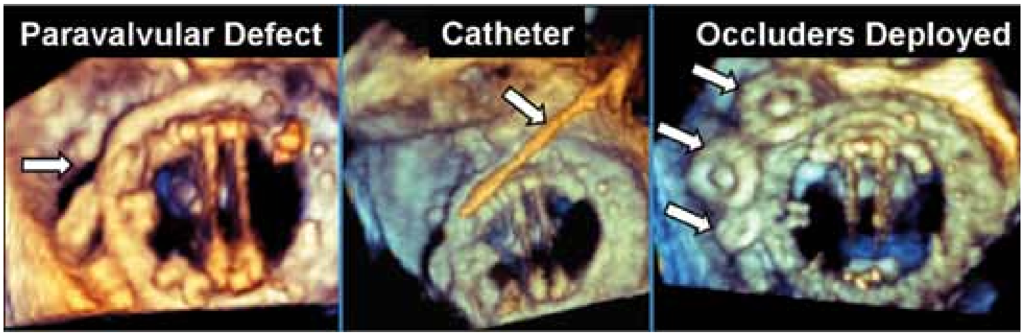

Figure 1. 3-D TEE imaging assists in deploying and visualizing occluders used for repairing mitral paravalvular defects.

defects. Useful display modes were: 1) Live 3-D Zoom during transeptal puncture and to identify dynamic catheter position relative to en-face views of the valve; and 2) Live 2-D biplane display (of 3-D data) to identify and track the guide wire tip during positioning across the PD. After device deployment, 3-D/color Doppler imaging provided immediate evaluation of occluder position and procedure success.

Conclusion: Live 3-D TEE during PPVR provides important additive value regarding structural defect geometry, device delivery guidance, and immediate assessment of procedural success.

Role of Cardiac Imaging in CRT

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Congestive heart failure (CHF) carries a high mortality and is the leading cause of hospitalizations in the United States. Despite optimal medical therapy, many patients with CHF — due to a depressed EF — remain symptomatic. In these patients who also have a prolonged QRS duration, CRT has shown favorable effects on LV function along with a significant reduction in adverse clinical events. However, around 30% of patients who receive CRT do not show clinical or functional improvement. Cardiac imaging can help identify patients who are more likely to benefit from CRT. This includes the assessment of the presence, severity and extent of mechanical dyssynchrony. At the present time, echocardiography is the most practical modality for this purpose due to its high temporal resolution. Several techniques have been evaluated including: M-mode, 3-D, tissue Doppler, and speckle tracking. In addition, it is possible to identify the site with latest mechanical activation, and the presence or absence of contractile reserve. Using echocardiography and cardiac magnetic resonance, it is possible to study the presence and distribution of scar tissue, which is one of the important factors that can predict the occurrence of reverse remodeling after CRT.

The Role of Cardiovascular Magnetic Resonance in Detecting Coronary Artery Disease

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With recent technical and clinical advances, cardiovascular magnetic resonance (CMR) has evolved from a promising research tool to an everyday clinical tool that is considered a competitive first-line test for common indications, such as detection of coronary artery disease (CAD). In fact, a 2006 consensus panel from the American College of Cardiology Foundation deemed the following indications as appropriate uses of stress perfusion CMR: evaluating chest pain syndromes in patients who have an intermediate probability of CAD with uninterpretable resting ECG or the inability to exercise; evaluating suspected coronary anomalies; and ascertaining the physiologic significance of indeterminate coronary artery lesions detected on coronary angiography (catheterization or CT). Currently, there are several CMR approaches for detecting coronary artery disease, including coronary magnetic resonance angiography (MRA), pharmacologic stress CMR with dobutamine (to assess contractile reserve and inducible wall motion abnormalities), and pharmacologic stress CMR with adenosine (to assess myocardial perfusion).

Coronary MRA may be used to directly visualize coronary anatomy and morphology, but it is technically demanding. The coronary arteries are small (3–5 mm) and tortuous compared with other vascular beds that are imaged by MRA, and there is nearly constant motion during the respiratory and cardiac cycles. To counter these difficulties, several technical advancements have been made in recent years, including the advent of ultrafast steady-state free precession sequences that offer superior signal-to-noise ratio in combination with whole-heart approaches analogous to multidetector CT. These sequences typically can be run with submillimeter in-plane spatial resolution (0.8–1.0 mm) and slice thickness slightly more than 1 mm, and they generally require 10 minutes to perform. While this spatial resolution is insufficient to routinely assess for native vessel coronary stenosis, it is sufficient for identifying anomalous coronary arteries or coronary artery aneurysms.

Stress testing with imaging of myocardial contraction can provide information concerning the presence and functional significance of coronary lesions. Dobutamine stress CMR to detect ischemia-induced wall motion abnormalities is an established technique for diagnosing coronary disease and is performed in a manner analogous to dobutamine echocardiography. It has been shown to yield higher diagnostic accuracy than dobutamine echocardiography[1] and can be effective in patients not suited for echocardiography because of poor acoustic windows. Logistic issues regarding patient safety and adequate monitoring are nontrivial matters that require thorough planning and experienced personnel.

Stress perfusion CMR with adenosine has existed for nearly two decades with numerous clinical validation studies demonstrating average sensitivity and specificity of 84% and 80% respectively for detection of coronary stenosis in comparison to X-ray coronary angiography.[2] These studies used various imaging protocols, and many used a quantitative approach for diagnostic assessment. Although a quantitative approach has the potential advantage of allowing absolute blood flow to be measured or parametric maps of perfusion to be generated, the approach is laborious and requires extensive interactive post-processing; this makes it unfeasible for everyday clinical use.

Recently we have published a multicomponent approach to CMR stress testing that can generally be performed in less than one hour and includes the following: 1) cine CMR for assessing cardiac morphology and regional and global systolic function at baseline, 2) stress perfusion CMR to visualize regions of myocardial hypoperfusion during vasodilation (e.g., with adenosine infusion), 3) rest perfusion CMR to aid in distinguishing true perfusion defects from image artifacts, and 4) DE-CMR for determining myocardial infarction.[3] We demonstrated that the determination of CAD using the multicomponent CMR stress test significantly improved diagnostic performance, yielding a sensitivity rate of 89%, a specificity rate of 87%, and a diagnostic accurac rate of 88%.

In conclusion, CMR is a useful imaging modality for detection of CAD. Coronary MRA approaches have demonstrated utility in assessment of coronary artery anomalies or aneurysms. Pharmacologic stress CMR (either of myocardial contraction or perfusion) is useful for detecting CAD or for determining the physiologic implication of stenosis of unclear significance detected on coronary angiography. CMR approaches offer several advantages over competing modalities in that they can generally be performed in less than an hour and do not require administration of ionizing radiation.

References

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Appropriate Use Criteria (AUC) for Cardiovascular Imaging

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Cardiovascular (CV) imaging use has increased substantially over the last 10 years. The reasons remain complex and partially defined. In 2005, the American College of Cardiology Foundation (ACCF) began a systematic process for determining imaging "appropriateness criteria," now known as the "appropriate use criteria" (AUC). For each major CV imaging modality, the modified Delphi Method was employed for determining AUC.[1] AUC were constructed using a three-step approach: 1) an expert writing group establishes a set of imaging and patient-specific "assumptions" along with a set of clinical scenarios (indications) for common anticipated uses; 2) external reviewers (other experts and stakeholders) critique the indications and suggest revisions; and 3) a diverse technical panel rates the clinical indications as appropriate (A), uncertain (U) or inappropriate (I) based on available published data and expert opinion. To date, initial and updated or in-progress AUC have been produced for cardiac radionuclide imaging (2005, 2009); echocardiography (2007, 2008, 2010); cardiac computed tomography and MRI (2006, 2010 CT); peripheral vascular ultrasound (2011); and multimodality imaging (2011). The published AUC are currently in an implementation phase. Updated AUC documents reflect advances in the clinical knowledge base and more carefully refined indications. Desirable outcomes include more rational cost-effective use. AUC implementation tools may allow users and payers to determine areas of over- and underutilization and target areas where further clinical research is needed ("uncertain" indications).

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Peripheral Arterial Disease: CTA or MRA?

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Peripheral arterial disease (PAD) affects approximately 8 million Americans, and its prevalence is expected to rise significantly with the aging population. While intra-arterial digital subtraction angiography (DSA) is regarded as the reference standard, less-invasive imaging modalities, including computed tomography angiography (CTA) and magnetic resonance angiography (MRA), are increasingly used to establish the diagnosis, delineate disease severity, and plan for revascularization interventions. Recent advances in multidetector CTA have allowed for improved spatial resolution, larger coverage area, shorter scanning time, and use of lower amounts of contrast. Relative to two-dimensional time-of-flight imaging, three-dimensional contrast-enhanced MRA has further improved diagnostic accuracy by markedly reducing imaging time and enlarging the coverage area. Compared to DSA, both MRA and CTA are highly sensitive and specific in identifying hemodynamically significant stenoses and in differentiating occlusions and nonoccluded segments in all regions of the lower-extremity arteries. Factors that need to be considered when choosing an imaging test are local availability, staff experience, and patient characteristics. MRA does not require iodinated contrast or radiation exposure and is therefore more favorable for patients with contrast allergy and in younger patients who need repeat testing. However, MRA uses gadolinium-based contrast agents, which can be associated with nephrogenic systemic fibrosis in patients with coexisting renal insufficiency. Another advantage of MRA is its ability for flow quantification. CTA, on the other hand, may be preferred in individuals with pacemakers, metal implants, and significant claustrophobia and in critically ill/less-cooperative patients due to its very fast data acquisition. In addition, there is more experience using CTA in follow-up after stent placement.