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Vanderbilt Heart is on the move – both literally and figuratively. In November 2005, Vanderbilt Heart Institute physically relocated into a stunning new outpatient facility located on the fifth floor of Medical Center East and offers a full range of diagnostic and consultative services. This outpatient and administrative unit is linked via a crossbridge to our state-of-the-art inpatient cardiovascular intensive care units that opened earlier in 2005. The new Vanderbilt Heart Institute is far more than an updated physical plant – it reflects significant clinical innovation and integration at every level.

The new Heart Institute houses the Division of Cardiovascular Medicine, Department of Cardiac Surgery, and Division of Vascular Surgery under one roof and with one purpose: to provide optimal patient care through clinical and service line integration. We want you to know about dramatic initiatives underway in our programs, from novel imaging techniques to unique innovations in cardiac revascularization to advances in electrophysiology to treatment of cardiac dysfunction. Vanderbilt Heart will periodically deliver concise clinically relevant reviews of these advances from the Heart Institute that will help enhance your practice.

We hope you will join our readership and let Vanderbilt Heart provide a vision of the future of cardiovascular care at Vanderbilt Heart Institute today.

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Robert N. Piana, MD
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Director, Vanderbilt Cardiovascular Network
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Vanderbilt Heart Institute was established to provide state-of-the-art, compassionate, evidence-based care for our patients with cardiovascular disease. It also serves as the largest training program for cardiovascular specialists in Tennessee and is one of the largest cardiovascular research programs in the nation. Recently, Vanderbilt Heart Institute has reorganized to coordinate the combined efforts of Vanderbilt University Medical Center’s Division of Cardiovascular Medicine and Department of Cardiac Surgery. This merger of adult cardiovascular medicine and cardiac surgery is an exceptional initiative reflecting this institution’s values and vision, and creating a coordinated and synergistic unit for delivery of cardiovascular care. Treatment of adults with heart disease is changing rapidly. Nationwide, the number of coronary bypass operations is decreasing, while percutaneous coronary interventions are growing in frequency. Our team offers the best of both worlds, giving our patients the option of combined surgical and percutaneous revascularization.

Our recently opened, cutting-edge cardiac catheterization laboratory, combined with a fully equipped cardiac operating room, helps achieve this goal. This facility, the first of its kind in the country, allows delivery of combined interventional and cardiac surgical procedures in one room. Care is coordinated by a complementary team of interventional cardiologists and cardiac surgeons. Using this platform, Vanderbilt is poised to redefine standard of care for cardiac surgery.

Other important technological innovations are changing the way we diagnose and treat heart disease. Recent remarkable advances in cardiac imaging will have a huge impact on the practice of cardiology. Vanderbilt Heart Institute installed and opened a dedicated cardiac magnetic resonance imaging (MRI) facility in June to provide state-of-the-art imaging for our patients with cardiovascular disease. This modality allows us to generate detailed pictures of the heart and vasculature without radiation. Concurrently, with our colleagues in the Department of Radiology, we have developed a team to provide multislice computed tomography scans, which many experts feel has potential to accurately and noninvasively reveal the presence and severity of coronary artery disease.

In fall 2005, we also opened a new outpatient facility in Medical Center East, providing new and expanded services and resources for patients with cardiovascular disease.

These examples highlight our investment in Vanderbilt Heart Institute and our commitment to providing patients with the most advanced technologies and care. So, while our facilities grow and our programs expand, our motivation is unchanged – providing state-of-the-art, compassionate, and evidence-based care for our patients with cardiovascular disease “One Heart at a Time.”
“SIGHTED” CARDIOVASCULAR SURGERY AND HYBRID PROCEDURES

John G. Byrne, MD
Chairman, Department of Cardiac Surgery
William S. Stoney Professor of Surgery

“Sighted” or image-guided cardiac surgery allows visual confirmation of accuracy and precision of coronary artery bypass grafting (CABG) and valve procedures.

In nearly every reconstructive procedure, success is largely measured by “before” and “after” images. CABG is a glaring exception. Orthopedic surgeons obtain X-rays before leaving the operating room (OR) to document satisfactory fracture reduction. In orthopedics, a few millimeters of inaccuracy is perhaps acceptable. Yet in CABG, cardiac surgeons sew 1 mm vessels to other 1 mm vessels using 400% magnification. In this setting, minimal inaccuracies can dramatically alter outcomes, yet surgeons have not traditionally imaged reconstruction quality.

General surgeons perform completion cholangiograms after cholecystectomy to confirm the common bile duct has no residual gallstones, where the consequence of retained stones is needed for endoscopic retrograde cholangiopancreatography. Vascular surgeons consider completion angiography routine after femoral–tibial bypass, where the great toe is at stake, yet we do not image the left internal mammary artery (LIMA) anastomosis to the left anterior descending artery (LAD), one of few life-prolonging reconstructions in all of medicine. Even for the simplest procedures, such as lines and drains, completion images are considered standard, such as for insertion of a central line, a Swan-Ganz catheter, or a chest or endotracheal tube. Failure to obtain such images would be considered below standard of care.

(Continued on following page)
Valve surgery is an area in cardiac surgery revolutionized by before and after photographs. Evaluating mitral valve repair outcomes with intraoperative transesophageal echocardiography (TEE) is accepted as standard. Few cardiac surgeons today would feel comfortable performing mitral valve repair without intraoperative TEE. Indeed, for all valve replacement procedures, intraoperative TEE is deemed mandatory to confirm proper valve seating and function and document safe evacuation of intracardiac air. Thus, imaging has raised standard of care for valve surgery.

At Vanderbilt University Medical Center, we applied this conviction to CABG. On April 4, 2005, we performed the first CABG surgery with immediate intraoperative completion angiograms (Figure 1). We took the traditional paradigm of a separate OR and imaging/percutaneous coronary intervention (PCI)-catheterization lab and created a combined Vanderbilt “hybrid” lab where we can perform coronary surgery and catheter-based interventions in one location. As patients referred for CABG become more complex, imaging becomes more critical, particularly in populations such as patients with diabetes, who have more diffuse coronary disease and who reap potential survival benefits with LIMA-LAD.

The hybrid approach requires cooperation between surgeon and cardiologist to cross traditional boundaries and provide optimum care for patients. In the Vanderbilt hybrid OR, patients can have “one-stop” care. Examples are LIMA-LAD with a stent to non-LAD vessels and valve repair through a small incision with a stent for coronary blockage. Thus, instead of valve/CABG, we perform valve/PCI in one setting.

We believe “sighted” ORs will be to cardiac surgery what airbags and child safety seats are to cars. Imaging will raise standard of care, and in time, we will not be able to imagine a world without it.

Vanderbilt has created a new model for treating patients with the opening of the Hybrid OR suite, a “one-stop shop.”
Clinical Utility of Cardiovascular MRI in Contemporary Practice

Mark A. Lawson, MD
Assistant Professor of Medicine and Radiology

Magnetic resonance imaging (MRI) of the heart and vasculature has substantially improved over the past decade and is entering mainstream diagnostic cardiovascular imaging. Advances in MRI technology have resulted in faster imaging times, making MRI ideally suited for imaging the cardiovascular system with excellent spatial and temporal resolution. Images are acquired in the absence of ionizing radiation in any tomographic plane and without interference from surrounding bone and soft tissue.

The role of cardiovascular MRI is to provide clinically relevant and reliable diagnostic and prognostic information in patients with cardiac and vascular diseases. This goal is accomplished with high-quality detailed images of cardiac and vascular anatomy, flow, and function; all in one patient visit. MRI image analysis is quantitative and highly accurate and reproducible, making MRI ideal for serial measurements over time.

MRI is simple and easy for patients. Other than screening for metal within the body, no special patient preparation is required prior to scanning. MRI is safe, noninvasive, and avoids exposure to ionizing radiation. Coronary artery stents, surgical clips, wires, and most prosthetic heart valves are MRI compatible. Most scans for cardiac anatomy and ventricular function can be performed without administration of intravenous contrast, since intrinsic contrast exists between flowing blood and static soft tissues. However, when contrast agent injection is necessary, it is administered intravenously through an antecubital vein with a low incidence of side effects. Consequently, patients require no aftercare and can resume normal daily activities.

For years, indications for performing cardiovascular MRI seemed limited to a handful of “boutique” applications, such as detection of constrictive pericarditis, arrhythmogenic right ventricular dysplasia, cardiac masses, and aortic disease. Long examination times and limited access to MRI kept it from becoming the imaging method of choice. With recent improvements in system hardware and software, MRI can achieve its legendary diagnostic ability with shorter imaging times.
Aside from evaluating randomly moving objects (such as thrombi or vegetations) or small structures (such as a patent foramen ovale), the flexibility of MRI to study morphology, flow, and function drives this modality further upstream in the diagnostic pathway.

**NEW CONCEPTS IN CHARACTERIZING MYOCARDIAL VIABILITY**

In clinical practice, patients presenting with heart failure are classified as having either an ischemic or nonischemic etiology. This differentiation is important, as patients with ischemic cardiomyopathy have a worse prognosis but may benefit substantially from coronary revascularization. In patients with severely impaired left ventricular (LV) dysfunction from myocardial infarction (MI), it is important to have an easy, precise, accurate, and reliable method for assessing myocardial viability, since the amount of viable myocardium will determine whether pharmacological therapy alone, bypass surgery, or heart transplantation should be considered.

In recent years, MRI techniques have emerged as powerful tools for characterizing ischemic heart disease. Late (also referred to as delayed or equilibrium phase) gadolinium enhancement is a technique to visualize transmural and nontransmural MI. When injected ≥10 minutes prior to imaging, MRI contrast agents enhance differences between normal and infarcted myocardium during the equilibrium distribution of the contrast agent. These late enhancing zones represent infarcted nonviable myocardium. Infarcts whose transmural extent involves >50% of wall thickness are less likely to improve segmental wall motion following revascularization.

**LEFT VENTRICULAR END-SYSTOLIC VOLUME:**

Single Most Important Prognostic Indicator

Patients with advanced LV remodeling (defined as large end-systolic volumes) after MI do not experience improvement of systolic function following revascularization, despite documenting myocardial viability of revascularized segments. Similarly, end-systolic volume is the best predictor of postoperative mortality and LV function after aortic valve replacement in patients with severe aortic stenosis and congestive heart failure.

While ventricular function can be qualitatively assessed by reviewing dynamic images in a continuous loop of ventricular contraction and relaxation, MRI quantitatively measures LV volumes by applying Simpson’s Rule to a stack of LV short axis images.
ASSESSMENT OF VALVULAR HEART DISEASE: Flow Quantification

In cine MRI, turbulent blood flow creates an area of low signal due to loss of phase coherence with an appearance similar to images seen on color flow echocardiography. After a radiofrequency pulse is delivered to the chest, the received signal from the body has both amplitude and phase. A velocity sensitive MRI technique, known as phase velocity mapping (or phase contrast imaging), can determine flow through a given imaging plane at velocities up to 5 m/s. By determining the cross-sectioned area and flow through a region of interest (e.g., the aortic root) and measuring blood flow through the region, it is possible to determine the total forward and reverse flow through the region.

MRI SAFETY: Screening for Metal

MRI is a safe, low-risk procedure. There are no known harmful biologic effects from exposure to the strong magnetic field. Nevertheless, the magnetic field creates several potential hazards. It is important to question patients about any metallic objects in their bodies. Metallic objects in the body may move within tissues, induce electrical currents, or cause excessive heating. Fortunately, most metal objects do not pose a safety hazard, but can degrade image quality of adjacent structures by warping the magnetic field.

Gadolinium-based MRI contrast agents are extremely safe. The reported incidence of minor adverse reactions, such as nausea, is about 3%, while the rate of serious or life-threatening reactions is 1 in 400,000. The agent is not nephrotoxic and can safely be used in patients with chronic renal insufficiency. (Continued on following page)
CARDIOVASCULAR MRI AT VANDERBILT

The Siemens Avanto MRI system was installed in June 2005 on the first floor of The Vanderbilt Clinic. This high-performance MRI system operates at speeds sufficient to acquire images of the beating heart and flowing blood.

Cardiac and vascular anatomy is complex, and structures have different appearances depending on the imaging plane, MRI pulse sequence, and MRI parameter selection. At Vanderbilt, rigid imaging protocols are avoided. Rather, a well-devised patient imaging session is tailored to accommodate individual variations caused by disease. An experienced MRI cardiologist is present during the examination to address unexpected adaptations of the imaging protocol.

To optimize each patient’s imaging session, a detailed medical history, description of the study indication, and clinical relevance is requested. Patient data is crucial for appropriate choice of MRI techniques, localization to the target anatomy, and optimizing imaging time in the scanner.

Vanderbilt’s Cardiovascular MRI laboratory waiting room faces an outdoor courtyard, and four private dressing rooms are provided for the comfort of patients and their families. Studies are scheduled for 1 hour, although many scans are completed in 30 minutes. A CD containing MRI images and a viewer is sent to each referring physician for easy reference.

VIRTUAL VANDERBILT:
CD containing patient images and viewer sent to referring doctors

IF YOU BELIEVE YOUR PATIENT WOULD BENEFIT FROM CARDIAC OR VASCULAR MRI SCANS, PLEASE CALL (615) 936-8000. PLEASE FAX ORDERS AND PATIENT INFORMATION TO (615) 936-8558.
CARDIOLOGY CONFERENCE:

Vanderbilt Heart was pleased to host its 4th annual conference Cardiology 2006: Advances in Science and Practice, February 17-18, 2006, at Loews Vanderbilt Plaza Hotel in Nashville. Course Director and Cardiovascular Medicine’s Associate Chief Rob Piana, MD, and the 2006 program committee – Chief of Cardiovascular Medicine Doug Vaughan, MD, Vanderbilt Heart Institute Medical Director Tom Di Salvo, MD, and past Course Director Keith Churchwell, MD, assembled an agenda and collection of speakers that provided pertinent and cutting-edge information. Topics included:

Cardiovascular Implications of the Obesity Epidemic
   » Douglas E. Vaughan, MD

Hybrid “Sighted” Surgery
   » John G. Byrne, MD

Clinical Application of the MRI
   » Mark A. Lawson, MD

Coronary CT Angiography
   » Javed Butler, MD, MPH

This year’s keynote lecture, Cardiac Regeneration: State of the Art in Clinical Application, was presented by Professor of Medicine and Biomedical Engineering and Director of the Cardiovascular Section for The Johns Hopkins Institute for Cell Engineering Josh Hare, MD.
In 2006, coronary artery disease (CAD) is the leading cause of morbidity and mortality in the United States. Invasive coronary angiography, with its spatial resolution of 0.2 mm, is the gold standard for assessment of CAD. However, approximately one third of patients undergoing coronary angiography have anatomy that does not require a percutaneous or surgical revascularization procedure. Coronary angiography also is associated with rare but significant side effects. Thus, it is desirable to have a noninvasive method for reliable assessment of CAD, particularly for exclusion of flow-limiting coronary stenoses. At present, coronary computed tomographic (CT) angiography is a promising technique for noninvasive imaging of coronary arteries.

CT scanning and CT angiography (CTA) have been in clinical use for the past 2 decades. The challenges of imaging the beating heart have only been overcome in the past few years. Advances in CT technology, in particular acceleration of rotation speed and improvements in detector technology, now enable imaging of coronary arteries with achievable breath-hold times. Multidetector CT devices, especially 40- and 64-slice scanners, allow imaging of the coronary bed in a single breath-hold of ≤15 seconds. Images with a spatial resolution of <1 mm enable imaging of virtually the entire coronary tree. The majority of published clinical validation studies were performed with 16-slice scanners. Overall sensitivity and specificity for detection of CAD ranged from 66% to 90% and 70% to 99%, respectively. However, 16-slice scanners could not visualize up to 30% of RCA.

Moore distal Circ. No O.M’s 6
Slab MIP of a patient with a stent in the proximal left circumflex coronary artery and tandem moderate stenoses in the mid circumflex artery (arrows).
coronary bed segments. It is anticipated that these values will improve with the latest generation of multidetector scanners.

By acquiring coronary CTA images under electrocardiographic gating, data can be reconstructed on a graphics workstation to display coronary arteries during diastole, a time when cardiac motion is minimized. Volume-rendered images provide a visual display of the coronary vasculature. Additionally, images can be interactively displayed as a single slice, which allows precise tracing of the lumen despite tortuosity of coronary arteries.

Vanderbilt University Medical Center now has two 64-slice multidetector CT scanners in clinical operation. Coronary CTA studies are performed collaboratively between the Department of Radiology and the Division of Cardiovascular Medicine. Participants include Murray J. Mazer, MD, associate professor of radiology, Ron C. Arildsen, MD, associate professor of radiology, and David M. Kerins, associate professor of medicine.

Experience at Vanderbilt and elsewhere has enabled assessment of anomalous coronary arteries and detection of stenoses in native coronary arteries and bypass grafts. Experience in assessment of segments within coronary artery stents is growing, but many published studies validating coronary CTA against the gold standard of invasive coronary angiography have excluded patients with bypass grafts or stents.

Limitations of CTA include the need to maximize the duration of diastole (heart rates of <70 bpm), the administration of approximately 100 mL of iodinated contrast, the challenges of assessing highly calcified segments, and the unknown potential of long-term radiation exposure. Recent advances, including electrocardiogram-controlled dose modulation, reduce X-ray exposure during systole (a time when coronary artery motion limits the quality of vessel imaging).

Coronary CTA has a promising future for noninvasive assessment of coronary artery anatomy. It may play a central role in exclusion of flow-limiting stenoses in patients who would otherwise require invasive coronary angiography, and also may play a role in planning percutaneous coronary interventions. Although it has taken 2 decades for CT to advance to the stage of imaging coronary arteries, the achievements of the past 5 years are remarkable, suggesting an exciting future for this rapidly evolving technology.

Volume rendering image demonstrating motion free coronary arteries in a left anterior oblique projection.