MAYO CLINIC

CARDIOVASCULAR UPDATE

CLINICAL CARDIOLOGY AND CARDIOVASCULAR SURGERY NEWS

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New Developments in Nuclear Cardiology—The Heart-Breast Scan

Screening for Breast Cancer in Patients Undergoing Myocardial Perfusion Imaging

Todd D. Miller, MD, Michael K. O'Connor, PhD, J. Wells Askew, MD

Introduction

One in 3 American women dies of heart disease. In 2007, almost twice as many women died of cardiovascular disease (both heart disease and stroke) than of all cancers combined. Approximately 1 in 7 women will get breast cancer during her lifetime, and women are at their highest risk during their sixth and seventh decades of life. The diagnosis of coronary artery disease and the detection of breast cancer are normally accomplished by different imaging technologies. However, in nuclear medicine, these 2 different disease processes are connected through the fortuitous biological behavior of the radiopharmaceutical Tc-99m sestamibi. "This radiopharmaceutical was originally developed in the 1980s for myocardial perfusion imaging and has become the standard radiopharmaceutical used in the United States for nuclear cardiology stress testing," according to Michael K. O'Connor, PhD, a radiation physicist in the Nuclear Cardiology Laboratory at Mayo Clinic in Rochester, Minnesota. In the late 1980s, it was noticed that this compound also localized in various cancers and showed strong uptake in breast cancer. This finding led to the development of a technique known as scintimammography. Technical limitations reduced the sensitivity of the technique for the detection of small breast tumors, and the technology never gained widespread clinical use. Over the past 6 years, a new breast imaging technique called molecular breast imaging (MBI), which uses small, ultra-high-resolution gamma cameras, has been under development at Mayo Clinic. "This new technology has a high sensitivity for the detection of breast cancer, and a recent large screening study at Mayo found that it was 3 times more sensitive at early detection of breast cancer than screening mammography," according to Todd D. Miller, MD, director of the Nuclear Cardiology Laboratory.

Limitations of Conventional Breast Imaging

Several large-scale studies have demonstrated a clear benefit to mammographic screening for breast cancer, particularly in women older than 50 years; yet despite its success, mammography is recognized as a less-than-perfect screening method. The limitations of mammography are particularly evident in women with mammographically dense breasts, where the sensitivity of mammography can be less than 50%. The reduced sensitivity of mammography in these women is compounded by the fact that increased density is a serious risk factor for breast cancer, a factor that greatly diminishes the value of mammography in the screening of younger women who have a high familial risk of breast cancer.

Given the limited efficacy of mammography there has been considerable attention focused on imaging techniques such as ultrasound and magnetic resonance imaging (MRI) as alternatives or adjuncts to screening mammography. Results from several recent studies comparing mammography, ultrasound, and MRI have consistently shown both mammography and ultrasound to have a low sensitivity in women at increased risk, while indicating a sensitivity of between 75% and 100% for MRI in the same patients. However, MRI has variable specificity and high cost (10 to 15 times that of mammography).

Figure 1. A patient during MBI. The MBI system comprises dual semiconductor-based gamma cameras mounted on a modified mammography unit. The breast is lightly compressed between the 2 detectors to acquire views analogous to those obtained during mammography.

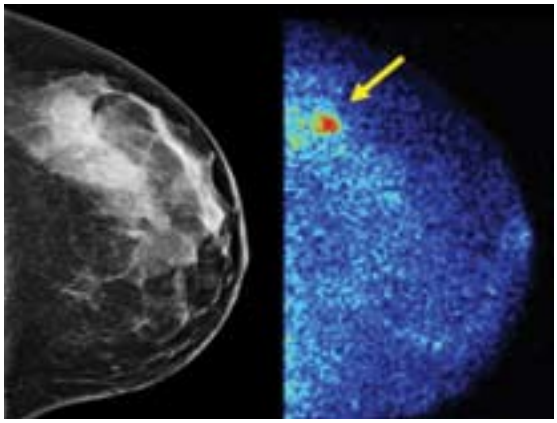

Figure 2. The digital screening mammogram and screening MBI images from an asymptomatic patient with increased risk for breast cancer and extremely dense breasts on mammography. The digital mammogram (left) was interpreted as negative, but the MBI (right) detected a 13-mm invasive lobular cancer (arrow) that was occult on mammography due to breast density.

"The limitations of the above technologies are part of the reason for the development of MBI," says J. Wells Askew, MD, a nuclear cardiologist at Mayo Clinic. "This technology uses small, ultra-high-resolution gamma cameras configured in a dual-head design in order to overcome previous limitations of the technology." With scintimammography, the 2 main technical problems that prevented the detection of small cancers were 1) the large cameras designed for whole-body imaging did not allow close positioning to the breast and 2) the low resolution of the scintillating crystal technology.

The compact design of the MBI detectors allows the breast to be positioned directly between 2 gamma cameras (Figure 1) in positions analogous to those used in mammography. The detector is also made up of small elements of a semiconductor called cadmium zinc telluride, which gives superior spatial and energy resolution compared with conventional technology and greatly improves image quality and the ability to detect small cancers (Figures 2 and 3). "MBI has a high sensitivity of more than 93% for the detection of lesions measuring 5 to 10 mm. A recent large screening study at Mayo Clinic found that in women at increased risk of breast cancer, MBI was 3 times more sensitive at early detection of breast cancer than screening mammography, while demonstrating better specificity," says Dr Miller.

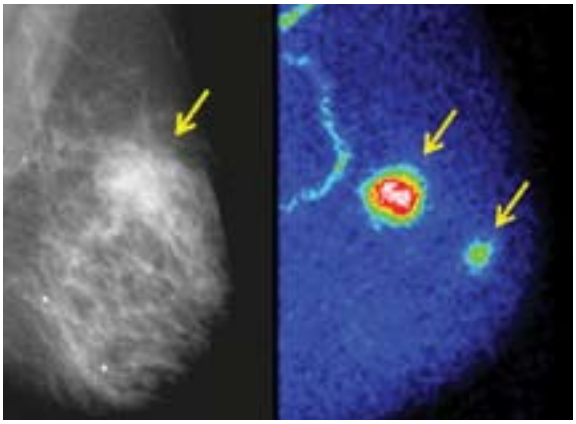

Figure 3. The mammogram and MBI images from a patient with a known 20-mm breast cancer detected by mammography (left, arrow). MBI (right) detected this cancer (upper arrow), and an additional 10-mm cancer (lower arrow) not detected on the mammogram. This patient had mildly dense breasts on mammography and no apparent risk factors for breast cancer, other than advanced age.

Combined Heart-Breast Scan

The Mayo Clinic Nuclear Cardiology Laboratory offers a combined heart-breast scan to any woman coming to the laboratory for a myocardial perfusion scan. The MBI scan is painless (only light breast compression is required) and can be performed during the waiting period between the stress study and cardiac imaging. Thus, it is possible to complete both the myocardial perfusion scan and the MBI study with no additional radiation burden and no extension of the time needed to complete the cardiac procedure.

As part of an ongoing research protocol, the MBI procedure is available at no additional charge to all female patients undergoing myocardial perfusion imaging in the Nuclear Cardiology Laboratory. On entry into the laboratory women are offered the opportunity to have the MBI study while they wait for their stress myocardial perfusion scan. Patients are asked to complete a short questionnaire on their breast status to assist in the determination of their hormonal status and risk of breast cancer. The only requirement is that patients have not undergone breast biopsies, surgery, or radiation within the past year and have a mammogram on record at Mayo, so that any findings on the MBI study can be correlated with a prior mammogram.

Patients are required to indicate on the consent form their preference for communicating any unexpected findings on the MBI study. If the patient elects to proceed with follow-up at Mayo, the patient will be seen at the Mayo Clinic Breast Center and will likely follow the standard of care that is already established at Mayo for the MBI screening program.

"MBI was developed at Mayo Clinic in Rochester, and currently no other medical institution offers this combined heart-breast procedure," says Dr Askew. "It has the potential to enhance the clinical value of myocardial perfusion imaging for female patients by providing additional information on breast function that could only otherwise be obtained with expensive procedures such as contrast-enhanced MRI."

For additional information or to refer a patient, please contact Dr Askew, Miller, or O'Connor at 507-284-4269.

Valve-Sparing Root Repair in Marfan Syndrome

Thoralf M. Sundt III, MD, Heidi M. Connolly, MD

Cardiovascular disease is the principal cause of mortality and morbidity among patients with Marfan syndrome. Fortunately, considerable progress has been made in the prevention and treatment of the complications of this disease. "Thanks to earlier diagnosis of Marfan syndrome, the identification of patients at risk for vascular catastrophe, pharmacologic interventions to reduce the progression of aortic aneurysmal disease, and the continued refinement of surgical techniques for safe repair and replacement of the diseased aorta, the life expectancy of patients with Marfan syndrome approaches that of the normal population," according to Thoralf M. Sundt III, MD, a cardiovascular surgeon at Mayo Clinic in Rochester, Minnesota.

Among the most exciting developments in the surgical treatment of Marfan syndrome in recent years has been the refinement of techniques for valve-sparing root replacement. Aneurysmal dilation of the aortic root is the most common cardiovascular complication of Marfan syndrome and places individuals at risk of catastrophic aortic rupture or dissection in addition to the more insidious effects of aortic valvular insufficiency. In 1968, Bentall and De Bono described a technique for complete replacement of the ascending aorta, which has become the standard of care in the treatment of patients with Marfan syndrome and root aneurysms. Their technique was modified by Kouchoukos, and today composite root replacement (Figure 1) has become a standard part of the surgical armamentarium. The operative mortality rate for the procedure performed in high-volume centers under elective circumstances is in the low single digits. Conversely, the mortality rate associated with acute aortic dissection approaches 25% among those patients who make it to the hospital. The long-term results associated with composite root replacement are excellent; current prosthetic mechanical valves have almost unlimited durability. The price to be paid, however, is long-term anticoagulation with warfarin. Reoperations following this procedure principally occur for the treatment of subsequent aneurysms of the remaining native aorta. The lifetime risk of reoperation on the prosthesis itself is approximately 5%; reoperation is indicated for infection or for valve obstruction caused by pannus formation (scar tissue obstructing the orifice of the valve or impeding leaflet motion).

Many patients with Marfan syndrome undergoing root surgery are young and, for women, of childbearing age, and there has been an unmet need for a satisfactory biological approach that would free patients of the requirement for chronic anticoagulation. Bioprosthetic valves have limited durability, and the complexity of a repeat operation in the setting of root replacement discourages the use of these valves in young patients. Beginning in the late 1970s, however, Yacoub developed a "valve-sparing root reconstruction" procedure in which the diseased sinuses of Valsalva and ascending aorta were replaced with Dacron grafts while the native valve leaflets themselves were left intact. The results were excellent, with the anatomy on postoperative echocardiography being almost indistinguishable from normal. Unfortunately, patients with Marfan syndrome appear to be at considerable risk of late aortic insufficiency, probably because of progressive dilation of the aortic anulus. David and Feindel developed an alternative "reimplantation" valve-sparing operation, first described in 1992. This procedure involves resuspending the aortic valve apparatus within the Dacron graft (Figure 2). It has become widely accepted as the preferred approach to valve-sparing procedures and has become the technique of choice at Mayo Clinic.

Results of this valve-sparing approach have been so encouraging that the National Marfan Foundation (NMF) has sponsored a multicenter trial to compare the results of the valve-sparing procedure with that of the standard of care,

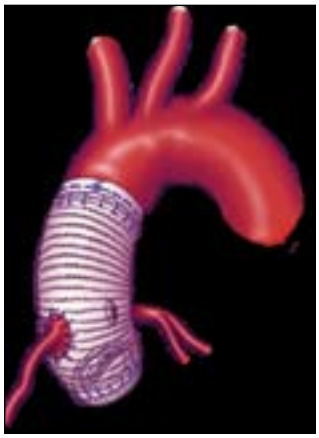

Figure 1. Composite aortic root repair.

Figure 2. Valve-sparing aortic root repair.

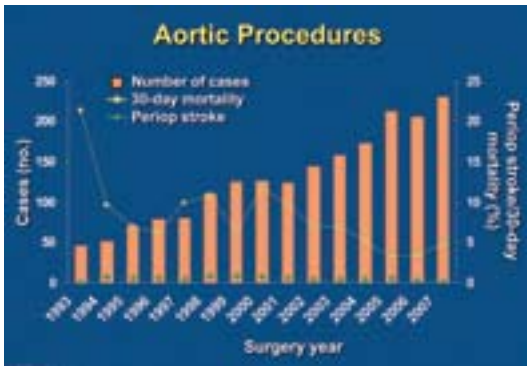

Figure 3. Mortality and perioperative stroke morbidity of aortic root repair procedures at Mayo Clinic in Rochester, Minnesota, 1993-2007.

Figure 4. Repair of aortic aneurysms at Mayo Clinic in Rochester, Minnesota, 1993-2008.

Figure 5. Valve-sparing and composite root reconstruction performed at Mayo Clinic in Rochester, Minnesota, 1993-2008.

composite root replacement. Enrollment in the NMF study began in March 2005, the target is 250 patients, and Mayo Clinic has been the leader in enrollment. Patients are being enrolled from 20 study sites, with data collection rigorously controlled with core laboratories in clinical genetics (Johns Hopkins) to ensure uniform diagnostic criteria as well as core echocardiography at Mayo Clinic to assure uniform evaluation of valve performance. As of the June 2008 analysis (which included 202 patients enrolled, 32 from Mayo Clinic), 70% of patients had undergone a valve-sparing procedure with the vast majority being a David-type reimplantation. Of the remaining patients, most (85%) had replacement with a mechanical composite graft. "In this study to date, no early mortalities have occurred," according to Dr Sundt. There have been only 3 instances of valve dysfunction, 2 of which were secondary to failed valve-sparing procedures corrected intraoperatively. No late failures of the valve-sparing procedure have occurred thus far, although follow-up has been brief and is ongoing. Postoperative morbidity, including hospital stay, has been similar for both procedures, although the valve-sparing operation is more complex and requires a longer cross-clamp time.

Cardiovascular surgeons at Mayo Clinic have a long history of aortic repair with excellent morbidity and mortality rates (Figures 3 and 4). They have performed valve-sparing procedures since 1993, with numbers increasing over recent years as confidence in the long-term durability of the procedure has built. The valve-sparing operation has become the preferred procedure in the setting of Marfan syndrome, and currently 80% to 90% of native valves are spared in patients who have favorable anatomic characteristics (Figure 5). This group includes patients with Marfan syndrome as well as other causes of aortic root enlargement, such as familial thoracic aortic aneurysmal disease and bicuspid aortic valve disease. As such valve-sparing surgery has become an important part of the program in aortic surgery at Mayo Clinic.

UNDER THE STETHOSCOPE

by Clarence Shub, MD

Clinical Features of Marfan Syndrome

- Abnormal skeletal features such as pectus carinatum or excavatum, scoliosis, arm span exceeding height, joint hypermobility, high arched palate, and flat feet often raise the initial suspicion of Marfan syndrome. Identification of these features should prompt careful clinical review and aortic imaging—which may be life saving in affected individuals.
- Additional noncardiac features that raise the suspicion of Marfan syndrome during clinical evaluation include striae not related to weight gain or pregnancy and recurrent abdominal or incisional hernias. Patients may also present with recurrent pneumothoraces or visual symptoms caused by ectopia lentis (lens dislocation).
- The most important cardiovascular feature of Marfan syndrome is dilation of the ascending aorta at the level of the sinuses of Valsalva. This may cause the diastolic murmur of associated aortic valve regurgitation. Aortic enlargement predisposes the patient to aortic dissection, the most dreaded and lethal complication of Marfan syndrome, which can occur as the initial presenting feature. Consider Marfan syndrome when there is aortic dissection in a young patient without hypertension.
- Bileaflet mitral prolapse and less commonly tricuspid valve prolapse may occur, and the associated systolic murmurs and clicks can be heard. Consider Marfan syndrome when the combination of mitral valve prolapse and dilated aortic sinuses is found during cardiac imaging.

Sports Cardiology Clinic: Keeping Athletes Active

Thomas G. Allison, PhD, MPH

Athletic performance often places extreme demands on the heart. Ensuring that the heart is healthy and fit enough for high-level training and competition is of paramount importance. Although relatively rare, sports-related symptoms and concerns do occur in adolescent and young adult athletes. "Athletic training and competition now commonly extend into the fifth decade of life and beyond—when the possibility of cardiac disorders has greatly increased. So thorough and thoughtful evaluation of the cardiovascular system of older athletes has become an important aspect of adult cardiology," says Todd D. Miller, MD, medical director of the Sports Cardiology Clinic at Mayo Clinic in Rochester, Minnesota.

In the Sports Cardiology Clinic, a team of physicians and allied health personnel evaluate and treat cardiac symptoms with a priority of keeping athletes active in sports. "Mayo's sports cardiologists have extensive experience diagnosing and treating cardiac conditions in athletes; many also have personal athletic experience and so understand the importance of sports participation in an individual's life," according to Thomas G. Allison, PhD, MPH, program director of the Sports Cardiology Clinic. "This means they will attempt to offer treatment to allow athletes to continue to be active in sports when possible." While the primary aim of the sports cardiology evaluation is to identify potentially serious cardiovascular disorders that could ultimately prove to be harmful if left unrecognized and untreated, guidelines for training and performance improvement are also provided.

Program Components

The sports cardiology evaluation includes tests appropriate to an individual's situation, as such:

- A thorough review of medical history
- Review of athletic history
- A cardiovascular examination
- Evaluation of symptoms
- Electrocardiography
- Appropriate laboratory testing
- Cardiopulmonary exercise test
- Other diagnostic cardiac tests when indicated
- Training advice to improve athletic performance
- Optional sports nutrition consultation
- Optional sports medicine evaluation and consultation for musculoskeletal and orthopedic concerns
- Physical therapy as indicated
- Referrals to other specialists if the health issue cannot be resolved by cardiologists

Potential Patients

Patients who are appropriate for the Sports Cardiology Clinic include adult athletes who compete at any level from recreational to high-level competition. Adolescent athletes at least 15 years of age may also be evaluated in the Sports Cardiology Clinic. Patients may be self-referred or referred by their local physician. Reasons for coming to the Sports Cardiology Clinic might include any of the following:

- Clearance to resume sports participation after cardiovascular surgery or a cardiac event
- Evaluation of symptoms like chest pain, palpitations, or shortness of breath that occur during training or competition
- Unexplained deterioration in performance
- Concern over family history of cardiovascular disease
- Athletic performance impaired by previously prescribed medical treatment
- Advice on controlling cardiovascular risk factors
- Comprehensive cardiovascular screening

Appointments

Patients may be referred by their primary physicians, or they may make appointments on their own. To set up an initial evaluation with the Sports Cardiology Clinic, please call 507-284-3994, Monday through Friday, 8 AM to 5 PM Central time. For additional information, please see the Cardiovascular Health Clinic Web site at http://www.mayoclinic.org/cardiovascular-rst/cardioheartclinic.html.

Cardiovascular Innovations

Noncardiac Arrhythmias — Different Locations, Similar Solutions

Mapping and Ablation in the Central Nervous System for Seizures via the Venous Drainage of the Brain

Paul A. Friedman, MD, Samuel J. Asirvatham, MD, Charles J. Bruce, MD, David R. Holmes Jr, MD

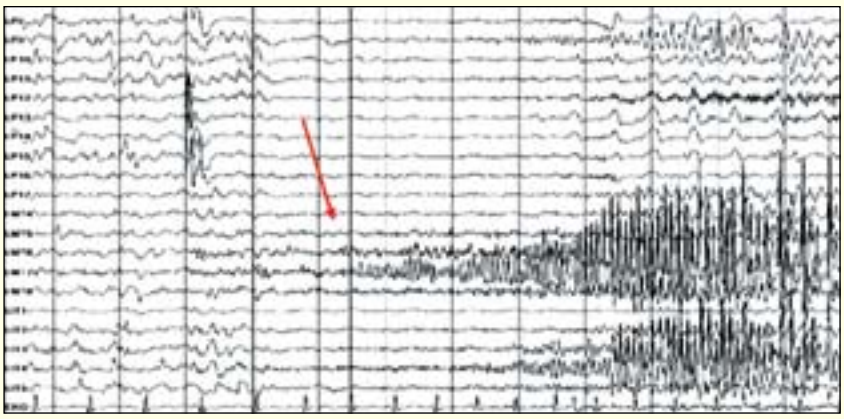

Figure 1. Seizures often present as an area of abnormal electrical activity (arrow) that precedes global abnormalities and can be targeted for focal energy delivery.

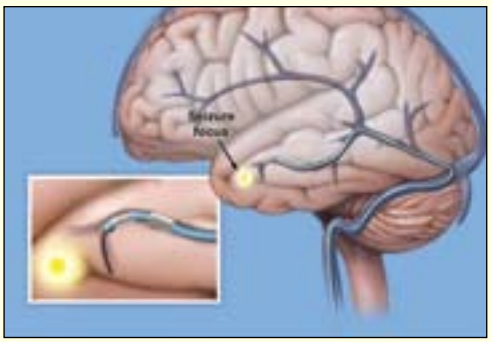

Figure 2. Illustration of the principle of accessing the jugular vein and cerebral venous system in this instance, with an over-the-wire mapping and ablation catheter moved toward the focus of seizure activity.

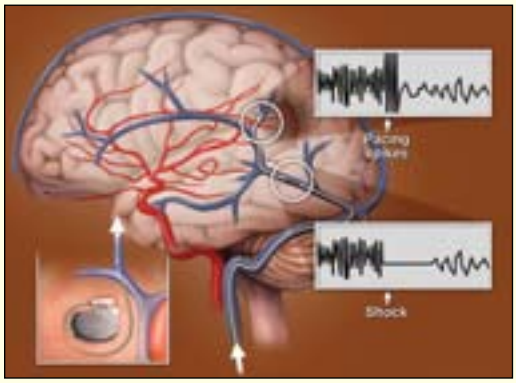

Figure 3. Illustration showing various potential applications including indwelling catheters, stimulators, and suppression devices that can be placed via the brain's venous system.

Background

When drug therapy for epilepsy fails and patients have intractable and life-altering symptoms, surgical removal of the epileptogenic cortex is attempted. Although highly successful in eliminating the seizure focus, the procedure is highly invasive and associated with severe morbidity. As a result, surgical management of seizures is uncommon. Adequate localization of the epileptogenic cortex and distinguishing this abnormal tissue from neighboring healthy cortical tissue involves intracortical, craniotomy-based mapping.

The evolution of the treatment of cardiac arrhythmias from open heart surgery to percutaneous catheter ablation provides insights to the potential for endovascular diagnosis and treatment of seizure disorders (Figure 1).

The Invention

Electrophysiologists Samuel J. Asirvatham, MD, and Paul A. Friedman, MD, invasive cardiologist David R. Holmes Jr, MD, and echocardiographer Charles J. Bruce, MD, all from the Division of Cardiovascular Diseases at Mayo Clinic in Rochester, Minnesota, have developed a system of specifically designed mapping and ablation catheters for accessing cortical brain tissue via the venous network of the central nervous system (CNS) (Figure 2). Animal studies have demonstrated the feasibility of this approach. In vivo experiments have confirmed successful mapping and placement of confirmed ablative lesions in the swine cerebral cortex.

If validated, the venous and other vascular approach to the CNS may become the preferred route for placement of deep brain–stimulating electrodes to treat various CNS disorders and to place sensors to allow early detection and intervention for stroke (Figure 3).

IN THE NEWS

Mayo Brothers Inducted Into Health Care Hall of Fame

William J. "Will" Mayo, MD, and Charles H. "Charlie" Mayo, MD, founders of Mayo Clinic, were inducted into the Health Care Hall of Fame on March 22, 2009, in conjunction with the American College of Healthcare Executives' 2009 Congress on Healthcare Leadership. The annual honors program is sponsored by ***Modern Healthcare*** magazine, and inductees are determined by a panel of judges selected from the industry.

"The Mayo brothers pioneered the group practice of medicine—an innovative way to organize and deliver care to patients. Today, we are determined to build upon their legacy by bringing patient-centered health care reform to this country," says Denis Cortese, MD, president and CEO of Mayo Clinic.

Perspective on the Mayo brothers' pioneering work in health care was provided by Donald M. Berwick, MD, president and CEO of the Institute for Healthcare Improvement and a leading national authority on health care quality and improvement issues. According to Dr Berwick, "Drs Will and Charlie combined visionary ideals with practical skills. That same integrated approach, which puts the needs of the patient first, is still in place at the Mayo Clinic today. As we look at national health care reform efforts, the Mayo model of care also provides a real-life example of the best forms of teamwork to deliver high-value care."

QUALITY

Pulmonary Vein Isolation

Pulmonary vein isolation (PVI) procedures have become a treatment option for many patients with atrial fibrillation. Electrophysiologists at Mayo Clinic in Rochester, Minnesota, have performed almost 1,500 PVIs over the past decade (70% of patients have been younger than 65 years). The mean hospital stay is 2.3 days, and the major complication rate is less than 2%. At 12 months, atrial fibrillation is either eliminated or easily controlled with medication in 82% of patients who have undergone PVI at Mayo Clinic.

Do You Know?

Patients with urgent cardiovascular conditions are seen within 48 hours at Mayo Clinic in Rochester in divisions of cardiology, pediatric cardiology, and cardiovascular surgery.

Upcoming Courses

Continuing Medical Education, Mayo Clinic

To request additional information or to register, unless noted otherwise, please call 800-323-2688, e-mail cme@mayo.edu, or visit www.mayo.edu/cme.

Success With Failure: New Strategies for the Evaluation and Treatment of Congestive Heart Failure
Aug 9-12, 2009, Whistler, BC
Phone: 800-283-6296; e-mail: cvcme@mayo.edu

23rd Annual Echocardiographic Symposium at Vail: New Technologies, Live Scanning, and Clinical Decision Making
Aug 9-13, 2009, Vail, CO

Mayo Echocardiography Review Course for Boards and Recertification
Aug 22-25, 2009, Rochester, MN

Pulmonary Hypertension Update 2009
Aug 29, 2009, Jacksonville, FL
Phone: 800-462-9633; e-mail: cme-jax@mayo.edu

Mayo Clinic Stroke and Cerebrovascular Disease Review Course
Sep 11-13, 2009, Amelia Island, FL
Phone: 800-462-9633; e-mail: cme-jax@mayo.edu

Echocardiography for the Sonographer
Sep 20-22, 2009, Rochester, MN

9th Annual Mayo Clinic Nutrition and Wellness in Health and Disease
Sep 24-25, 2009, Minneapolis, MN

Mayo Cardiovascular Review Course for Cardiology Boards and Recertification
Oct 3-8, 2009, Rochester, MN

Echo Focus Session, Mayo Cardiovascular Review Course
Oct 2-3, 2009, Rochester, MN

Interventional Cardiology Subspecialty Board Review Course
Oct 2-4, 2009, Rochester, MN

Electrophysiology Subspecialty Board Review Course
Oct 8-10, 2009, Rochester, MN

RECOGNITION

Mayo Clinic's Division of Cardiovascular Surgery announces the appointment of Lyle Joyce, MD, PhD, to the Mayo Clinic staff. Dr Joyce has practiced cardiac, thoracic, and vascular surgery in the Twin Cities area for more than 25 years. His addition to the team complements the existing services offered, which include off-pump coronary artery bypass surgery, robotic and minimally invasive surgery, mitral valve repair and replacement, aortic aneurysm and root repair, ventricular assist device implantation, and cardiac transplantation.

Douglas L. Packer, MD (center), was the program chair of the scientific sessions committee for the 2009 Heart Rhythm Society annual meeting in Boston, Massachusetts. Win-Kuang Shen, MD (left), and Traci L. Buescher, RN (right), also served on the committee.

25th Annual Echocardiography in Pediatric and Adult Congenital Heart Disease
Oct 11-14, 2009, Rochester, MN

Coronary Artery Disease: Prevention, Detection and Treatment
Oct 19-21, 2009, Las Vegas, NV

Continuing Medical Education, Cosponsored With American Society of Echocardiography

To request additional information or to register, unless noted otherwise, please phone 507-266-6703 or e-mail echocme@mayo.edu.

Dynamic Echocardiography: A Road to Comprehensive Quantification
Aug 21-22, 2009, Chicago, IL
Phone: 507-252-9069

17th Annual Echocardiography for the Sonographer 2009
Sep 20-22, 2009, Rochester, MN
Phone: 507-266-0677; e-mail: cvcme@mayo.edu

4th Annual The Beat Goes On
Oct 1-4, 2009, Orlando, FL
Phone: 336-716-4505; e-mail: cmu@wfubmc.edu

19th Annual Cases in Echocardiography: TEE, Doppler and Stress—Interpretation and Clinical Decision Making for the Advanced Echocardiographer
Oct 28-31, 2009, Napa, CA
Phone: 507-266-0677; e-mail: cvcme@mayo.edu

Other Education Opportunities

25th Annual National Conference on Marfan Syndrome and Related Disorders
Aug 6-9, 2009, Rochester, MN
Phone: 800-8-MARFAN; e-mail: marfan2009@mayo.edu; Web: www.marfan.org

Mayo Clinic Cardiovascular Update

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