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A PHYSICIAN NEWSLETTER OF THE ZENA AND MICHAEL A. WIENER CARDIOVASCULAR INSTITUTE
AND THE MARIE-JOSÉE AND HENRY R. KRAVIS CENTER FOR CARDIOVASCULAR HEALTH



Drs. Jonathan L. Halperin, Valentin Fuster, and Samin K. Sharma

Message from the Directors

As the sawdust clears from the air, plastic partitions come down, and the noise of hammers and power tools fades away, the new face of the Zena and Michael A. Wiener Cardiovascular Institute and the Marie-Josée and Henry R. Kravis Center for Cardiovascular Health is beginning to emerge. This spring brings the opening of a host of new facilities that bring Mount Sinai ever closer to the pinnacle of cardiovascular care. Our new suite of offices adjacent to the west lobby of the New Guggenheim Pavilion at the main entrance on Fifth Avenue provides expanded clinical consultation and examination space—often the point of initial contact for patients with faculty physicians in cardiology and cardiothoracic surgery. The area also houses new laboratories for diagnostic echocardiography and stress testing, a home for the Executive Health program and expanded administrative offices. Concurrently, on the fifth floor, the expansion of the invasive cardiac laboratories is reaching completion, bringing additional facilities for cardiac catheterization, interventional angiography and electrophysiology replete with greatly expanded areas for patient preparation and recovery and accommodations for friends and families.

These changes, and others like them, signal the evolution of Mount Sinai toward a unified

continued on page 2

Mechanisms of Atherothrombosis in Diabetic Patients

Pedro R. Moreno, M.D., Valentin Fuster, M.D., Ph.D.

Diabetes mellitus affects close to 20 million people in the United States and 150 million worldwide. Atherosclerosis accounts for up to 80% of all deaths among diabetic patients in North America. All told, the economic burden imposed by diabetes amounts to nearly \$100 billion annually in the US alone. This review focuses on the pathophysiology of diabetic atherosclerosis, from the metabolic syndrome to advanced disease, including the mechanisms responsible for plaque rupture and acute coronary thrombosis, with insights into novel experimental therapies. The authors have recently published a more comprehensive review that is recommended for interested readers.

The Metabolic Syndrome

Formerly known as the pre-diabetic state, the metabolic syndrome is characterized by two or more of the following: abdominal obesity, insulin resistance (elevated fasting glucose), hypertension, dyslipidemia (elevated triglyceride and decreased HDL cholesterol levels), and microalbuminuria. This syndrome affects almost one-fourth of the U.S. population and almost half of those over 60 years old — some 47 million people — correlating with the increase in obesity.

In diabetics with the metabolic syndrome, the prevalence of coronary disease reaches almost 20%, in contrast to the lower prevalence in diabetics without the metabolic syndrome, which is similar to that in non-diabetics (less than 10%). Immunity and inflammation are important in the development of insulin resistance, and circulating markers of inflammation, acute-phase reactants, or interleukin are strong predictors of the development of type 2 diabetes. These associations underlie the theory that insulin resistance, the metabolic syndrome, and atherosclerotic cardiovascular events may share a common basis in inflammation.

Early and Advanced Stages of Diabetic Atherosclerosis

Several molecular mechanisms have been implicated in hyperglycemia-induced endothelial damage, each associated with overproduction of superoxide by mitochondria. Reactive oxygen species lead to endothelial dysfunction that promotes formation of atherosclerotic plaque. Endothelial dysfunction is evident in asymptomatic diabetic children in the form of decreased flow-mediated brachial artery dilation, and an association with early atherosclerosis is reflected in increased carotid intimal-medial thickness. Diabetes-induced microvascular permeability is responsible for the expression of vascular endothelial growth factor (VEGF), the main promoter of angiogenesis and neovascularization responsible for diabetic microangiopathy.

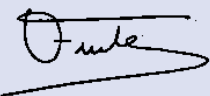
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Directors Message

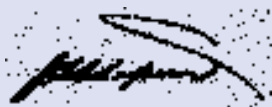
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specialty hospital covering all aspects of medical and surgical care for patients with cardiovascular disease. Next on the horizon are renovations in the Joseph H. Hazen Ambulatory Care Center, expansion of nuclear cardiology capacity in the Phyllis and Lee Coffey Noninvasive Laboratories and outfitting of vast new basic science laboratories in the Atran Research Building. Unchanged is our emphasis upon prevention, rehabilitation and education, and expansive investment in research to attract the most productive scientists, with all that promises for the treatments of tomorrow.

The months ahead will draw Mount Sinai more closely into the public eye as newly charged programs in coronary, valvular, and aortic disease emerge along with enhanced services in cardiac failure, transplantation, electrophysiology and diagnostic imaging take center stage in rapid succession. Through it all, however, it's important to bear in mind that the essence of cardiovascular care at Mount Sinai is its people — the superior physicians, scientists, nurses, technicians, administrative and support personnel who are the faces, minds, hearts and spirit we bring to our work every day. And in this context, the evolution unfolding before us should be a source of great pride to us all.



Valentin Fuster, M.D., Ph.D.



Jonathan L. Halperin, M.D.



Samin K. Sharma, M.D.

Mechanisms of Atherothrombosis

continued from page 1

Insulin resistance is associated with increased macrophage uptake of oxidized LDL and expression of matrix metalloproteinase (MMP) in fibroblasts. Macrophage infiltration and thrombus formation are greater in the coronary plaques of diabetic patients with unstable angina compared with those from non-diabetic hearts.

Adventitial inflammation and neovascularization of the vasa vasorum leads to intra-plaque hemorrhage and expansion of the lipid core associated with high-risk atherosclerotic lesions. Silent plaque rupture occurs in 22% of hypertensive or diabetic populations, compared with 9% of the general population. Microvascular density in lesions with inflammation correlates with plaque instability, and the changes in plaque composition associated with diabetes and the metabolic syndrome are thus associated with an increased risk of acute coronary events.

Therapeutic Implications

In addition to the success of aggressive lipid-lowering therapy, high-density lipoprotein (HDL) therapies and the peroxisomal proliferator-activated receptors are under active investigation in patients with atherosclerosis and diabetes. High-density lipoproteins remove free cholesterol from the blood, and low levels of HDL are frequent in patients with insulin resistance. Measures associated with elevation of HDL for as brief a period as 5 weeks are associated with lesion regression as documented by various methods of plaque imaging in patients with coronary artery disease, suggesting a potential role for this type of therapy in achieving plaque stabilization.

Peroxisomal proliferator-activated receptors (PPAR) act as transcription factors that control the expression of genes regulating an array of cellular functions. Several of these are expressed in endothelial cells, smooth muscle cells, lymphocytes, and macrophages and play a role in adipogene-

sis and lipid metabolism. These PPAR activators inhibit expression of adhesion molecules and cytokines, reduce production of MMP and reduce plaque inflammation. In addition to decreasing thrombogenicity and enhancing fibrinolysis, PPAR-activators reduce the lipid content of plaques by enhancing reverse cholesterol transport and facilitating efflux of free cholesterol from the plaque to the liver.

Conclusions

The pathophysiology of atherosclerosis involves all three layers of the vessel wall, with rupture of the internal elastic lamina, and plaque proliferation in the media and neovascularization of the adventitial vasa-vasorum. The microangiopathic process in diabetes mellitus is associated with inflammation, intra-plaque hemorrhage and plaque rupture that underlie many cases of coronary thrombosis. These events, which are mediated by systemic procoagulant factors, are up-regulated in diabetics with poor glycemic control. Novel therapies including HDL and peroxisomal proliferator-activated receptor agonists hold promise for the future treatment of diabetic atherosclerosis.

References available on request.

Milestones

Born: February 16, 2005, to Cardiology Administrator **Katherine Gandolfo** and Christopher Fix, a daughter, Katherine Judith Fix (Katie), their second child.

Appointments: **Dr. Donald A. Smith** was elected Treasurer of the Northeast Chapter of the National Lipid Association.

Awards: **Dr. David B. Bharucha** was awarded the "Mount Sinai School of Medicine Excellence in Teaching Award" in 2004

Dr. Jonathan L. Halperin received the Heart of New York Award from the American Heart Association on February 8, 2005

Computed Tomographic Angiography of the Coronary Arteries

Andrew J. Einstein, M.D., Ph.D., Sanjay Rajagopalan, M.D.

The first computed tomography (CT) scan of a human by Godfrey Hounsfield in 1972 ushered in a new era of medical imaging. While early scanners lacked the temporal resolution to acquire motion-free images of a beating heart, several improvements in CT technology have since facilitated using CT angiography (CTA) as a diagnostic modality in cardiovascular disease. These include continuous helical scanning, faster gantry rotation times, improved detector design, and retrospective EKG gating.

With multi-detector CT (MDCT) scanners, images are obtained by placing a patient on a table inside a large circular structure called a gantry. The gantry houses an x-ray point source and a detector array, placed opposite the source. In general, the total number of detector elements determines the number of possible slices for a given scanner. Improvements such as alternating or “flying” focal spots (the location of the x-ray source rapidly alternating between two locations), make it possible to utilize the existing arrays more efficiently, doubling the number of effective detector elements (slices).

With current-generation scanners, the table moves through the gantry as the gantry rotates around the patient, with the source emitting a fan-shaped beam of x-rays. This results in a helical trajectory of x-rays (hence spiral or helical MDCT). Data are acquired continuously and images are reconstructed mathematically to coincide with a specific phase of the cardiac cycle, most typically in diastole, when coronary motion is minimized.

Potential advantages of CTA compared to traditional approaches include non-invasiveness, superb spatial resolution, ability to visualize vessel wall as well as lumen, short scan time and high level of patient comfort. Disadvantages include the requirement of iodinated contrast, exposure to ionizing radiation, susceptibility to motion artifacts, and lack of luminal visualization in areas of vessel wall calcification.

The quality of the images obtained is dependent on a number of factors. These include intrinsic properties of the scanning system, including tube current and voltage (which affect spatial resolution), the gantry rotation speed (which affects temporal resolution), and the reconstruction algorithm used, as well as patient-specific gating and tissue characteristics, such as heart rate and the presence of coronary calcium.

Electron beam CT, an alternative CT approach that replaces the rotating x-ray tube with an electron beam that is deflected electromagnetically, requires a separate scanner. Such units are used, at present, primarily for coronary calcium scoring; they have higher temporal resolution but lower spatial resolution than MDCT scanners.

A 16-slice MDCT of the heart has been available at Mount Sinai for 2 years and we will be transitioning to a more advanced 64-slice scanner this summer. Several studies have compared 16-slice CTA with invasive coronary angiography for the diagnosis of coronary stenoses. Results have varied from study to study. The percentage of coronary segments inadequately visualized in these studies has gradually decreased as the temporal resolution of scanners has improved. Studies with the 64-slice CTA are currently underway and these investigations will define further its role in the management of patients with suspected and established coronary disease.

The table below addresses the common cardiovascular indications for MDCT, as well as frequently asked questions.

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Frequently Asked Questions

What are indications for coronary CT angiography?

1. Diagnostic evaluation in a patient with chest pain syndrome. Depending on the clinical presentation, MDCT may precede a perfusion stress test, or may be used to clarify a perfusion stress test that is equivocal, non-diagnostic, or simply inadequate in explaining the patient's symptoms.
2. Facilitation of the management decision of a symptomatic patient with known coronary artery disease. (eg., post-stent, post CABG) when the results of the MDCT may guide the decision for repeat intervention.
3. Assessment of congenital anomalies of the coronary circulation or great vessels.

What are some noncoronary uses of CT in cardiology?

1. Assessment of aortic dissection.
2. Delineation of pulmonary vein anatomy.
3. Evaluation of pericardium and intra- and extra-cardiac masses.

What limitations exist on patient size?

The scanner supports patient weighing up to 450 pounds. The gantry bore is 70 cm in diameter (approximately 86 inches in circumference), although only the middle 50 cm can be used for scanning; the patient and patient's heart must fit within these constraints.

How much contrast will my patient receive?

Typically 80 cc of iodinated contrast.

Is breath holding required?

Yes, the scans are all breath-hold sequences (12 seconds is required for calcium scoring, and approximately 18 seconds for angiography).

What is the radiation dose to the patient?

Radiation dosage of CT is typically quantified in terms of effective dose and measured in units of millisieverts (mSv; 1 Sievert = 100 rem = 1 joule/kg). Average sized male patients scanned on a 16

continued on page 4

Reaching Out

The Cardiovascular Institute has a growing list of on-site services at other hospitals in the New York metropolitan area—an expansion that is improving access to high-quality cardiac care in other communities, broadening the skills of the medical staff at the affiliate institutions, and strengthening Mount Sinai itself.

North General Hospital

A prime example involves Manhattan's North General Hospital, where Cardiology represents the largest program to emerge from the broad clinical and academic partnership announced with Mount Sinai last February. The centerpiece of the new collaboration is a diagnostic cardiac catheterization laboratory, slated to open at North General in July 2005.

The new facility will be an immediate boon to patients served by North General, which is located on the border of East and Central Harlem. "This is the first time we will be able to offer on-site cardiac catheterization services," comments North General's Medical Director

Valentine Burroughs, M.D., M.B.A., "Given the particularly high prevalence of heart disease in our community, the need is certainly there! Ultimately, of course, we hope there will come a time when we have acquired enough experience to assume responsibility for running the facility on our own, referring only highly specialized procedures we can't handle to Mount Sinai. But that is most probably five years out."

Mount Sinai's Facilities Management department has been overseeing the design and construction of the North General cardiac catheterization laboratory, a one-procedure-room suite with four recovery beds. At the same time, a major program expansion is underway at Mount Sinai itself, involving two new electrophysiology labs and an additional catheterization laboratory with an eight-bed intake capacity and a 20-bed recovery unit. That project is slated for completion in the summer of 2005.

Heading the program at both North General and Mount Sinai is Samin

Sharma, MD, Director of Mount Sinai's Interventional Cardiology and the Cardiac Catheterization Laboratory, and also Co-Director of the Cardiovascular Institute and the Center for Cardiovascular Health. Dr. Sharma, whose group has perfected rotational atherectomy for particularly tough blockage problems, leads New York State in angioplasty safety.

Mount Sinai and North General have also begun conducting joint cardiovascular screening programs at Harlem health fairs and street festivals. In light of the enthusiastic response to the initiative, funding is being sought to expand its reach.

Elmhurst and Queens Hospital Centers

For the past three and a half years, Mount Sinai's David B. Bharucha, MD, PhD, has been building cardiac arrhythmia and electrophysiology programs at two long-time affiliates of the Medical Center, Elmhurst and Queens Hospital Centers. Dr. Bharucha, who spends two days a week on-site at the sister institutions and serves as a telephone resource 24/7,

Frequently Asked Questions

continued from page 3

detector scanner typically receive an estimated effective dose of about 2 mSv for calcium scoring, and an additional 6-8 mSv for angiography for CT angiography if tube current modulation by ECG gating is employed. For females, the effective dose is typically 30% higher due to the higher organ dose to the breast. Radiation doses may be up to 50% higher for 64 detector scanners. We attempt to abide by the ALARA ("as low as reasonably achievable") principle to minimize radiation dose while maintaining diagnostic image quality.

How does this compare to radiation exposure from other sources?

Average annual effective dose from background radiation in the United States is 3.6 mSv. Effective dose from a stress test with 40 mCi of Tc-99m Sestamibi has been estimated at 7 to 12 mSv. Effective dose in cardiac catheterization averages about 1 mSv per minute of fluoroscopy time; typically this is 3 to 5 mSv.

What prescan testing is required?

All patients need a serum BUN and creatinine within three weeks of the study.

How much does the study cost?

About \$1000. Insurance coverage varies by payor and is rapidly evolving.

How long does a study take?

From registration to leaving the hospital is typically less than one hour. The actual scanning time is under five minutes.

What factors affect study quality?

Heart rate: It should be less than 70 bpm, and patients are typically beta blocked to obtain an appropriate heart rate.

Heart rhythm: Irregular rhythms worsen gating and image quality.

Coronary calcium: The more likely that the involved segment of the coronary artery is "non-evaluable" in terms of luminal stenosis and soft plaque.

Habitus: Study quality is worse in more obese patients.

Breath holding: Without breath holding, respiratory motion severely degrades image quality.

Patient motion: Patients must lie still and in a supine position during the study.

has established and run on-site arrhythmia and pacemaker clinics, while also providing inpatient consults.

Also central to his work are the training programs for Elmhurst- and Queens-based residents, fellows, and nurse practitioners — an effort that is creating a multiplier effect by widening the safety net for patients and keeping the programs running smoothly when Dr. Bharucha cannot be there himself.

Dr. Bharucha values the collaborative ties with colleagues at the affiliate institutions that result from this bridge-building. “The more you’re there, the more readily they think of you,” he says, “not just for cases that are obviously complex, but also for those that on the surface seem routine. In cardiology, seemingly small issues are often only the tip of the iceberg, so it’s very beneficial to be present to help with all types of cases.”

Another benefit is the opportunity Dr. Bharucha now has to follow more closely the patients he treats at Mount Sinai. “I can get to know my patients and their families better before the procedures performed in Manhattan,” he says, “and also keep in touch with them afterwards, more as an ongoing physician. That is important to me, as well as to them.”

Today, these growing bonds are being formalized still further: Elmhurst has built its own Electrophysiology and Device Implantation Laboratory, which Dr. Bharucha is directing. He anticipates that the volume of complex procedures referred to Mount Sinai from Elmhurst and Queens Hospital Centers—now numbering some 250 a year—will continue to rise, as well.

“The more you do, the more you do,” he concludes.

Cabrini Medical Center

In March 2004, Mount Sinai and Cabrini Medical Center began a collaborative cardiology initiative, facilitated by Michael Poon, MD, Director of the Cardiovascular

Medicine and Integrated Imaging Program at Cabrini.

The initiative gives Cabrini clinicians access to state-of-the-art diagnostic techniques, extending the high-level cardiac care available to Cabrini patients in their local community, while also giving those in need of more extensive services, such as cardiac catheterization or cardiothoracic surgery, better coordinated access to Mount Sinai’s expertise in those areas.

Pediatric Cardiology

Younger patients at other hospitals are also benefiting from such outreach efforts. The Mount Sinai Children’s Heart Center has clinical and academic affiliations with St. Joseph’s Hospital (Paterson, New Jersey), Maimonides Medical Center (Brooklyn), and Elmhurst and Queens Hospital Centers (Queens).

Initiated in 1997, the collaborative Pediatric Cardiothoracic Surgical Program with St. Joseph’s is overseen by Khanh Nguyen, MD, Director of Mount Sinai’s Pediatric and Congenital Heart Surgery Program, and Ira A. Parness, MD, Mount Sinai’s Chief of Pediatric Cardiology. Uncomplicated heart repairs are performed on-site at St. Joseph’s, in collaboration with a multidisciplinary local team, while complex cases requiring more advanced care are performed at Mount Sinai.

Maimonides Medical Center and its new Children’s Hospital serve as an ancillary training site for Mount Sinai Pediatric Cardiology Fellows. Young heart patients are cared for by a team of pediatric cardiologists who hold joint appointments at Mount Sinai. Pediatric patients are transferred for tertiary cardiac interventions to Mount Sinai, but return immediately thereafter to the expert care of their local physicians. The same is true at Elmhurst and Queens Hospital Centers, where collaboration on pediatric heart disease extends to both the patient-care and research arenas.

Highlights from the Controversies in Cardiology Conference Series— New Alternatives in Heart Failure Therapy

Riple Hansalia, M.D.

On February 28, Mount Sinai hosted visiting professor Dr. Lynne Warner-Stevenson, Professor of Medicine, Harvard Medical School, Co-Director, Cardiomyopathy & Heart Failure Program, Brigham & Women’s Hospital.

Moderator:

Sean Pinney, MD

Panelist:

Lynne Warner-Stevenson, MD

Alan Gass, MD

Elias Zias, MD

Davendra Mehta, MD

Riple Hansalia, MD

Farzan Filsoufi, MD

Although the last 20 years have seen dramatic improvements in congestive heart failure treatment—beta-blockers, ACE inhibitors, aldosterone antagonists, and resynchronization—heart failure still accounts directly for 40,000 to 45,000 deaths per year, contributes to another 200,000 deaths, and is the leading reason for hospitalization in patients over 65 years of age.

What is more, even with treatment advances, heart failure remains a progressive disease. Patients still survive only a median of 1.5 years after first hospitalization for heart failure. Those with New York Heart Association (NYHA) class IV symptoms have a 30-50% one-year mortality.

Coronary Revascularization in Ischemic Cardiomyopathy

Perhaps one of the most exciting areas in ischemic cardiomyopathy is surgical revascularization. In 2002, Allman *et al.* performed a meta-analysis of patients with coronary artery disease and left ventricular dysfunction. In all, the study included 3,088 patients (24 studies) with a mean LVEF (left ventricular ejection fraction) of 32% who were followed for months. Prior to revascularization,

all the patients had myocardial viability testing, either by single photon emission computed tomography (SPECT), F-18 fluorodeoxyglucose positron emission tomography, or dobutamine/atropine stress echocardiography. The primary endpoint in the study was mortality.

Patients revascularized with a significant amount of viable myocardium had a mortality rate per year of 3.2% vs 16.0% in the medical-therapy-only group ($p < 0.0001$). However, those patients without viable myocardium receiving only medical therapy trended toward a lower mortality rate of 6.2% compared to that of the surgical arm of 7.7% ($p = 0.23$). Bouchart and colleagues found two-year survival in a similar population to be 84% without preoperative myocardial viability assessment.

Nonetheless, standard practice today usually dictates some type of myocardial viability assessment prior to surgical revascularization in patients with severe left ventricular dysfunction. The ongoing Surgical Treatment for Ischemic Heart Failure (STICH) trial will report in approximately 5 years.

Mitral Valve Surgery in Systolic Dysfunction

Patients who develop end-stage cardiomyopathy often develop significant mitral regurgitation from dilatation of the mitral annulus, deformed ventricular geometry, and papillary muscle dysfunction. Bolling and colleagues dominate the literature with their experience of mitral valve reconstruction in heart failure.

One of the first reports by this group at the University of Michigan followed 167 patients after mitral valve repair with mean preoperative LVEF of 14% and class III or IV NYHA failure. The population had actuarial survival rates of 82%, 71%, and 52% at 1, 2, and 5 years respectively after an operative mortality of 5%. At seven years, all patients reported NYHA class I or II symptoms; the group's mean ejection fraction was 26% and mean transmitral gradient was 3 mmHg. However, their most recent article (JACC 2005, February 1; 45(3):388-90) concluded that there was no demonstrable mortality

benefit conferred by mitral repair for significant mitral regurgitation with severe LV dysfunction.

Dor Left Ventricular Aneurysm Repair

In 1985, Vincent Dor reported on endoventricular patch plasty (EVPP), similar in principle to partial left ventriculectomy, to remodel the ischemic left ventricle with simultaneous surgical revascularization. Dor postulated that removal of akinetic and dyskinetic segments of the left ventricle would help reduce ventricular size and improve function. The operation essentially excludes the non-contractile segment(s) with an intraventricular patch. Early results reported by Dor quoted survival at 8 years of 69% in a group of 100 patients with ejection fraction $< 30\%$.

Athanasuleas and colleagues conducted the Surgical Anterior Ventricular Endocardial Restoration (SAVER) trial in a multicenter setting using Dor's principles. The authors followed 439 patients who underwent ventricular endocardial restoration, as well as coronary artery bypass grafting (89%), mitral valve repair (22%), or mitral valve replacement (4%) for 18 months. The group observed a hospital mortality of 6.6%. Postoperatively, ejection fraction increased from 29% to 39%, left ventricular systolic volume index fell from 109 ml/m² to 42 ml/m². Overall at eighteen months, the group reported 84% patient survival and 85% freedom from heart failure admission. At five years, a larger cohort ($n = 1,198$) reported 78% freedom from hospital admission for CHF and a survival of 68.6%.

Discussion

Although currently, the backbone of heart failure management remains medical therapy, there is now growing evidence that many NYHA class III and IV patients would benefit from aggressive surgical approaches to heart failure.

Assuming that medical therapy has been maximized, those patients with greater than three hospitalizations for heart failure within six months are candidates for further testing. Specifically, this cohort should undergo evaluation for valvular abnormalities, as well as for myocardial viability. Based upon results, those with viable myocardium should be considered for revascularization, those with substantial valvular abnormalities should be considered for surgical correction, and those with large akinetic/dyskinetic segments should be considered for the Dor procedure (or a modification thereof).

Furthermore, all patients without improvement should be considered for heart transplant and be evaluated prior to transplant for advanced approaches such as mechanical bridge therapy, continuous inotropic infusion, and experimental techniques. Non-transplant patients also have multiple options available to them: destination mechanical support, long term inotropic therapy (home and/or inpatient), and experimental protocols.

In all, heart failure treatment has advanced dramatically, although many questions remain to be answered, including cost, mortality benefit, applicability beyond the academic center, and quality of life.



In a rare public musical performance, Dr. Valentin Fuster (center) joins in song with renowned entertainer Julio Iglesias (left) and famed designer Oscar de la Renta at the Heart of New York benefit gala for the American Heart Association. (Photo courtesy of AHA)

24-Hour Ambulatory Blood Pressure Monitor (ABPM)

Clive Rosendorff, M.D., Ph.D.

Though often associated with the diagnosis of white coat hypertension, ABPM has far broader usefulness. The information gathered may aid in the evaluation and management of patients with borderline hypertension, refractory hypertension, reverse white coat hypertension, some types of secondary hypertension, sleep apnea syndrome, unexplained syncope or paroxysmal headache. ABPM is also sometimes indicated in patients with labile hypertension in whom office or clinic BP measurements are sometimes normal and at other times elevated. Furthermore, 24-hour measurements of BP levels can help establish optimal dosing schedules for antihypertensive medication in individual patients, to ensure consistent control over the whole 24 hours.

Interpreting ABPM Results

• Diurnal Blood Pressure Variation and Patterns of Hypertension

There is remarkably little agreement about one of the most basic physiological functions, the normal pattern of blood pressure during sleep. The average nocturnal pressure, however, should be $\geq 10\%$ below the average daytime value, a physiological phenomenon known as “dipping” (Table I). Failure of the BP to decline during sleep, or its increase above daytime values (“non-dipper” pattern), is associated with a risk of cardiac events, stroke, and progression of hypertensive nephropathy.

The non-dipper pattern can occur in essential hypertension and in some forms of secondary hypertension (e.g., chronic renal disease, primary aldosteronism, pheochromocytoma, Cushing’s syndrome), in patients with autonomic dysfunction, diabetes mellitus, or obstructive sleep apnea, and in heart transplant recipients. However, patterns of BP fluctuation on ABPM have a low sensitivity and specificity for these conditions.

Some patients show a substantial increase in BP immediately before and after awakening, a prominent “morning surge”, compared with pre-sleep awake values. This morning surge is associated with an elevated risk of coronary events. We do not yet know whether there is any outcome benefit of preventing the morning surge.

• White Coat Phenomena

White Coat Hypertension is the term used to describe elevated office or clinic BP levels with normal measurements on ABPM in patients not taking antihypertensive medication. ABPM is the “gold standard” for this diagnosis. Prospective studies have demonstrated that average BP levels during ABPM better predict cardiovascular outcomes than in-office readings do, and that white coat hypertension is probably associated with a low-risk of cardiovascular disease.

White Coat Effect refers to patients on antihypertensive medication with elevated BP levels in the office or clinic (BP ≥ 140 mmHg systolic or ≥ 90 mmHg diastolic, or both) but normal readings at other times, as documented by ABPM. Such patients may have refractory or resistant hypertension based upon office measurements, and ABPM may help determine whether BP control is adequate throughout the day and night, (“pseudorefractory hypertension”) or not (“truly refractory hypertension”). Pseudorefractory hypertension does not appear to predict increased cardiovascular morbidity or mortality.

Reverse White Coat Hypertension: Some patients have normal office or clinic BP readings but elevated BP levels at other times, as determined by ABPM. These individuals are more likely than normotensive ones to develop left ventricular hypertrophy or carotid arterial wall thickening.

Reimbursement for ABPM

The Centers for Medicare and Medicaid Services (CMS) currently recognize suspected white coat hypertension as the only indication for reimbursement for ABPM. Specific criteria for reimbursement include that the patient should (1) not be receiving antihypertensive medication at the time of recording, (2) have elevated BP readings documented in the office or clinic, and (3) have observed normal self-monitored BP levels at home. Other third-party carriers vary with respect to reimbursement policies for ABPM.

For more information

To find out more, or to refer a patient for ABPM or hypertension consultation, contact the Joseph H. Hazen Ambulatory Cardiac Care Center (Telephone 212- 241-5586).

Table I. Normal Diurnal Blood Pressure Values (mmHg)

Period	Normal	High Normal	Hypertension
24 Hour	$\leq 130/80$	131-134/80-85	$\geq 135/85$
Daytime	$\leq 135/85$	136-139/86-89	$\geq 140/90^*$
Night-time	$\leq 120/70$	121-124/71-74	$\geq 125/-75$
Awake/Sleep Ratio: ≥ 1.10 = “Dipper” pattern (normal); < 1.10 = “Non-dipper” pattern			

BP measurements are in mmHg.

* or $> 25\%$ of all daytime BP readings ≥ 140 mmHg systolic.

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www.mssm.edu/cvi/cmail

CME Calendar of Events

Continuing medical education is a priority at the Cardiovascular Institute, and these sessions provide an opportunity for faculty and fellows to interact with visiting cardiologists. The institute sponsors nearly 50 lectures, conferences and academic rounds every month, and we invite you to share in these special educational events as often as you can. For information about conference locations or an updated schedule, please contact Ms. Imelda Samson at 212-241-7784 (imelda.samson@mountsinai.org).

Visiting Professors

June 20, 2005

Dr. Bernard J. Gersh
Mayo Clinic

October 24, 2005

Dr. Ramon Brugada
St. Joseph's Hospital
Health Center

November 21, 2005

Dr. Patrick O'Gara
Brigham & Women's

December 19, 2005

Dr. Mark A. Pfeffer
Brigham & Women's

January 23, 2006

Dr. Ray Gibbons
Mayo Clinic

February 27, 2006

Dr. Hasan Garan
Columbia University

March 27, 2006

Dr. Mark Creager
Brigham & Women's

April 24, 2006

Dr. Christine Seidman
Harvard Medical School

June 19, 2006

Dr. Pamela Douglas
Duke University
Medical Center