



Weatherhead P.E.T. Center for Preventing and Reversing Atherosclerosis
The University of Texas Medical School at Houston and Memorial Hermann-Texas Medical Center



A common question we are asked when informing patients about a PET scan is “Will it show the percentage of my artery that is blocked?” This question has triggered the following discussion about the importance of coronary blood flow rather than percent stenosis when

checking on the status of the coronary arteries. The previous issue of PET News introduced readers to Non-invasive imaging of the heart and explained: (1) the differences in anatomic imaging vs. functional imaging of the heart (2) the technical problems with Computed Tomography (CT) and (3) how PET accurately shows a change in blood flow to the heart that is proportionately larger than small unmeasurable anatomic changes in percent stenosis. Since the essential medical problem of coronary heart disease is blood flow in the heart muscle, PET is the best way of identifying or assessing severity of coronary disease and for following progression or regression of coronary artery disease before a coronary emergency.

This article reports further on imaging techniques commonly used in Cardiology practice today and then focuses on new developments in PET imaging for measuring coronary blood flow. Background information is reviewed that is the basis for an ongoing major shift in managing CAD that is starting to develop as evidenced by numerous recent scientific publications.

Published Scientific Studies Demonstrate Accurate Flow Studies Reduce Costs and Complications

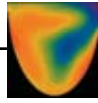
Compelling evidence has demonstrated that invasive procedures such as coronary arteriography, coronary artery bypass grafting and invasive coronary procedures such as balloon angioplasty and stents are over utilized in the United States, contributing to unnecessary health care expenses and patient risks without improved patient outcomes.

Measuring whether the blood flow capacity in an artery is significantly reduced before proceeding with an angioplasty or stent procedure is an important step that is

often skipped in Cardiology Practice today. Two recently published studies demonstrate this point in two different ways. The first study in the New England Journal of Medicine used an invasive technique called FFR (fractional flow reserve) to measure how much blood flow capacity is actually reduced by a blockage, which is often misjudged by its anatomic appearance on the arteriogram. In this study only blockages that demonstrated a significantly reduced flow capacity or FFR were opened with drug eluting stents. Blockages with an FFR of greater than 0.8 (80% of maximum flow capacity) were left alone and treated medically. This selection of patients based on the FFR significantly reduced the number of stent procedures done and also reduced the number of deaths, non-fatal heart attacks, and the need for repeat procedures at one year of follow-up.

Non-invasive stress perfusion studies should help identify the significance of coronary blockages before invasive procedures in the cath lab are considered. However standard nuclear perfusion tests with SPECT cameras have technical limitations. Positron Emission Tomography (PET) imaging improves the diagnostic accuracy without such errors. In a study led by Michael Merhige MD in New York, clinical outcomes, procedure utilization, and costs were evaluated in 2100 patients managed based on PET imaging and were compared to 2 control groups managed according to conventional SPECT imaging. Since PET can accurately identify coronary lesions that are significantly reducing blood flow, unnecessary invasive diagnostic and therapeutic procedures are reduced. The conclusion of the study was that using PET to manage this group of patients with a moderate risk for CAD resulted in greater than 50% reduction in invasive cardiac cath and bypass surgery, a 30% cost savings, and excellent clinical outcomes after one year of follow-up.





Percent Stenosis or Blood Flow in Coronary Artery Disease - A Shift in Cardiology Thinking

Current Cardiology Practice

In cardiology practice today, the standard stress test with ECG monitoring and/or standard radiotracer technology is used to obtain approximate or crude pictures of blood flow in the heart during stress. In people with suggestive symptoms, this standard exercise test using ECG and/or standard radiotracer technology (Thallium, MIBI, or Cardiolite) has an accuracy of only 50% to 75%. In other words, only half to three-quarters of patients tested will be accurately diagnosed. In patients with no symptoms undergoing these tests as a “routine checkup”, the accuracy is worse, only 30% to 50% accurate, with erroneous results in 50% to 70%. This poor accuracy of standard exercise testing is well documented by numerous scientific reports published since 1983 up to the present despite improved equipment. As a result of this well-known limitation in diagnostic accuracy, cardiologists are inclined to proceed to the next diagnostic step, an invasive coronary arteriogram and then usually a balloon dilation or stent regardless of the stress test results or even skipping the stress test entirely. A recent review in the largest medical journal reported that 55% of all elective, non-emergency coronary balloon dilations or stents are done with *NO* prior stress test. The majority of cardiologists in this country are trained for and driven by a viewpoint or concept based on visual estimation of anatomic stenosis severity on an invasive coronary arteriogram.

Problems with Anatomic Percent Stenosis for Guiding Cardiovascular Practice

Based on extensive scientific data, there are two basic problems with this concept of percent stenosis on an arteriogram – the “invasive viewpoint”. The first is that for most people with coronary atherosclerosis, percent stenosis fails to indicate coronary blood flow capacity. The second is that coronary procedures like balloon dilation, stents and bypass surgery do not prevent or reduce heart attacks and deaths caused by coronary heart disease whereas intense medical-lifestyle treatment does reduce heart attacks.

Despite numerous scientific publications over the last 10 years demonstrating the equivalence or superiority of intense medical treatment over expensive invasive procedures or surgery for treating stable coronary artery disease, coronary angioplasty/stent procedures and bypass

surgery continue to be the most common treatments used. The reasons for this dominant “invasive viewpoint” are complex and include the fact that cardiologists spend a long time training in these procedures, are paid to do them and standard stress tests are not adequate for definitively indicating when a stenosis is severe enough that a procedure is necessary. In addition, probably the most important reason is a basic mis-understanding, lack of knowledge or resistance to the importance and clinical value of directly measuring blood flow to the heart muscle as the optimal measure of disease severity.

Cardiologists in this country have been trained to rely on anatomic percent stenosis, “anatomy”, as the basis for their diagnostic and clinical decision-making. This predominantly anatomic viewpoint is associated with the binary yes-no thinking for surgical or mechanical intervention, a thought process that to some extent has not evolved in parallel with cardiovascular science. It continues to focus on an individual stenosis, estimating percent

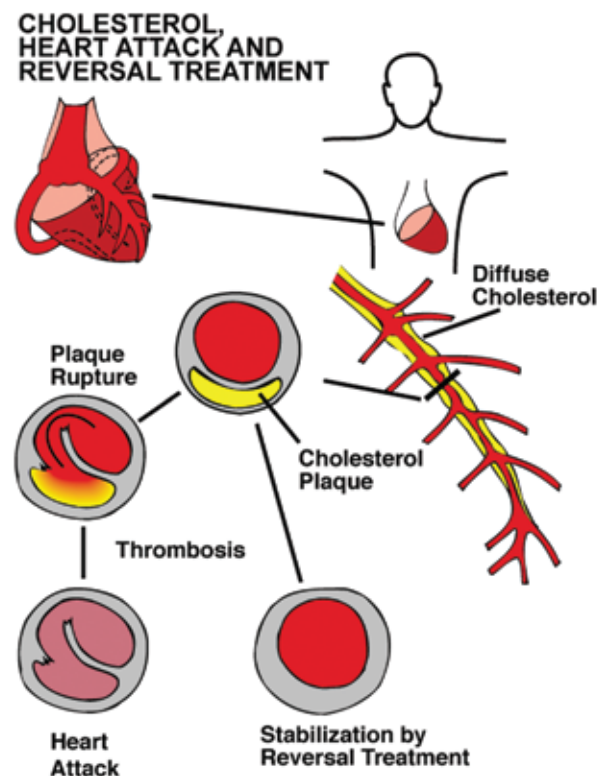
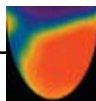


Figure 1.

*Plaque rupture commonly occurs without significant stenosis, causes thrombosis or blood clotting that blocks the artery suddenly with resulting heart attack. Removing the cholesterol from the plaque by intense medical-lifestyle treatment stabilizes it, thereby preventing heart attacks. Reproduced with permission from Gould, *Heal Your Heart*, Rutgers University Press, 1998, New Jersey.*



stenosis as the basis for doing an invasive procedure and the measure of its success. Physicians and their patients have believed that this change in percent stenosis is the most important outcome. This anatomic arteriographic mentality has led to what is referred to as the “oculostenotic reflex”, that is the emotional inclination for the patient and the cardiologist to balloon or stent a stenosis if he sees one during the arteriogram, regardless of whether it is actually reducing blood flow to the heart muscle. In fact from many scientific studies, these elective procedures do not prevent heart attacks or death and at 2 to 3 years after the procedure, chest pain is no different from patients treated medically with no procedure.

Anatomic Percent Stenosis Versus Heart Attacks

Coronary atherosclerosis is principally due to a slow accumulation of cholesterol deposits from the blood into the inner lining of the coronary artery. This cholesterol buildup, called plaque, is usually diffusely distributed along the artery but may be greater in some segments, causing localized more severe narrowings called stenoses. However, a sudden rupture or breaking loose of the plaque at a site that is only mildly or moderately blocked causes the majority of major heart attacks and sudden deaths, illustrated in **Figure 1**. Therefore, focusing on the individual blockages without treating the diffuse disease everywhere else is inadequate. Furthermore, invasive techniques of balloons and stents, carry a significant amount of risk, which in many cases may outweigh the benefit if done without knowing if the stenosis is truly limiting flow capacity in the first place. Thus, heart attacks and sudden death are usually caused by plaque rupture at sites in the coronary arteries where there is no significant narrowing that are not appropriate for stents or bypass surgery.

Even more importantly, in recently published randomized trials of patients with coronary stenosis visually suitable for a balloon or stent, those undergoing the procedure had no benefit on mortality or for preventing heart attacks compared to intense medical management alone, **Figure 2**. At three to five year follow-up, there was also no difference in angina between the procedure group and the medically treated groups. Thus, anatomic measures of coronary stenosis as percent stenosis are poor guides to the management of coronary artery disease from every viewpoint – physiology, technology, clinical management, outcomes, risks and costs – yet percent stenosis remains the central guide to current cardiovascular practice.

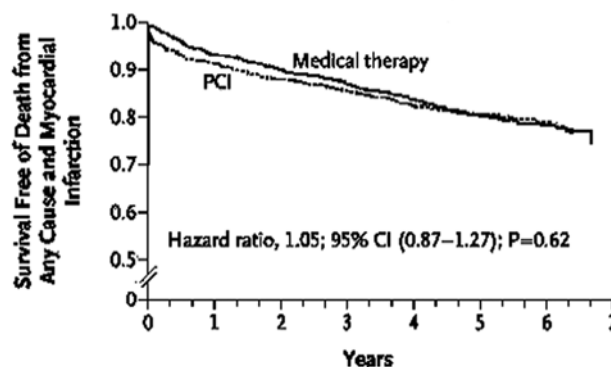
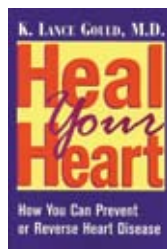


Figure 2.

Comparative survival free of heart attacks in patients undergoing medical treatment or percutaneous intervention (PCI, balloon dilation and/or stents). Reproduced with permission from Boden et al NEJM 2007;356:1503.

Anatomic Percent Stenosis Versus Coronary Blood Flow to the Heart

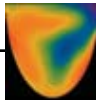
The alternative viewpoint to the “anatomic percent stenosis” mentality is one reflecting the importance of coronary blood flow, i.e., the physiology or function of the coronary arteries. Over 35 years ago, K. Lance Gould M.D. led a team of researchers experimenting with coronary artery blood flow and established the concept of Coronary Flow Reserve (CFR). CFR is a measure of the arteries ability to dilate and increase flow to meet the demands of the heart muscle during stress. In an atherosclerotic, narrowed artery, the CFR is reduced. Although adapted by the cardiology community to set the standards for critical stenosis and guidelines for procedures, the concept of CFR as a marker of the functional status of the artery has not been used to its full potential. As illustrated in **Figure 3**, the % diameter blockage of an artery does not tell how much the flow of blood to the heart muscle is being affected. Many other factors affect coronary blood flow such as the normal size of the artery, other diffuse disease with plaque throughout the entire artery, remodeling enlargement of the artery in response to the



Available through

Rutgers University Press
100 Joyce Kilmer Ave.
Piscataway, NJ 08854

Or call: 800-446-9323



plaque, other blockages in the same artery, the length and absolute diameter in millimeters of the blockage. Percent diameter narrowing is only one factor in this complicated process. The **SINGLE** most important issue is the blood flow to the heart muscle and how much it is restricted due to these complicated multiple characteristics of coronary artery disease. This one measurement, absolute blood flow to the heart muscle in cc/min/gm at rest and after stress with associated Coronary Flow Reserve (CFR) identifies whether the blood flow is reduced enough to require an invasive procedure or surgery or whether intense medical treatment is an option.

Cardiac PET Imaging in Cardiovascular Medicine

With recent improvements in hardware, developments in software, and analysis of thousands of PET scans, absolute CFR of each artery and of the whole heart is measured during every PET scan at the Weatherhead PET Center. This information can help determine when procedures are necessary. However, until cardiologists shift their thinking from an anatomic, binary, quick-fix,

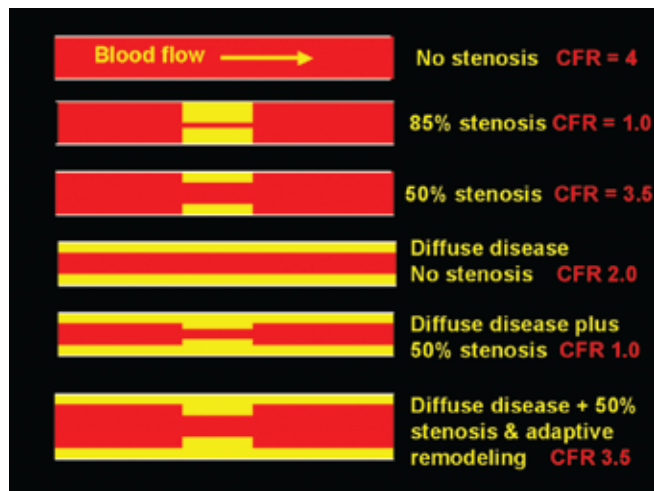


Figure 3.

Schematic of percent stenosis compared to coronary flow reserve (CFR) or the capacity to increase coronary blood flow to the heart muscle. Diffuse disease may severely reduce CFR with no stenosis on the arteriogram. A mild 50% stenosis that alone would only mildly impair CFR causes severe restriction in flow if added to diffuse disease. Commonly, adaptive remodeling of the coronary artery may increase its lumen so that CFR is only mildly reduced.

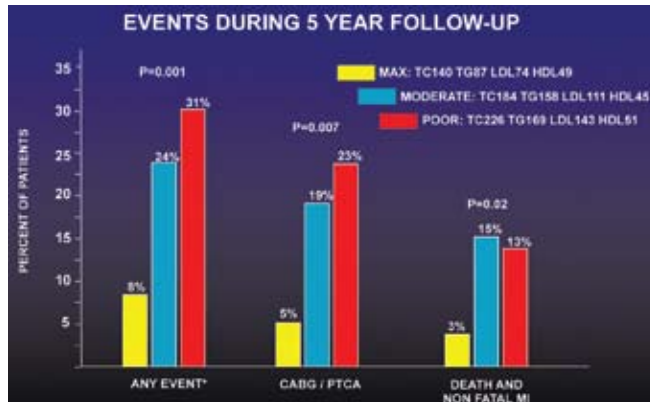
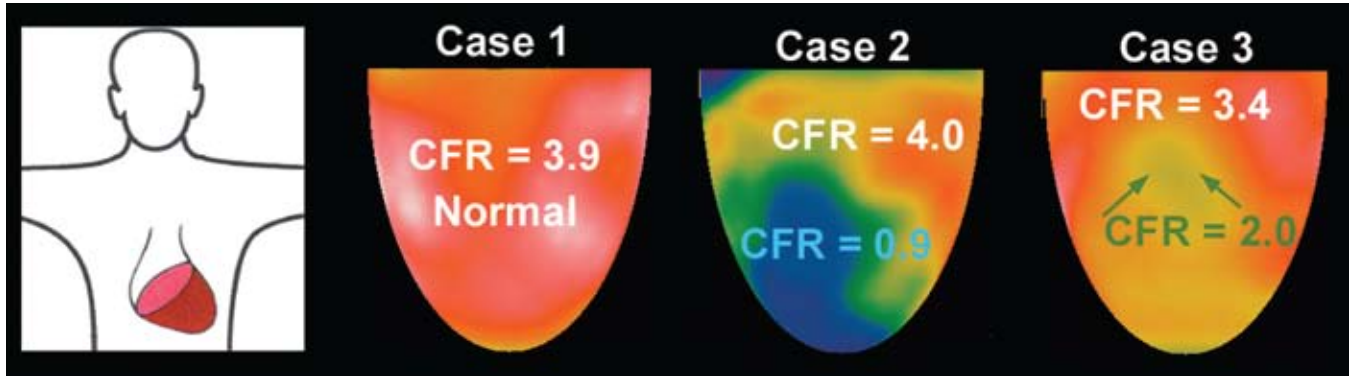
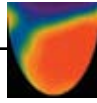


Figure 4.

Reduction in heart attack, death or need for invasive procedures in patients undergoing intense combined medical and lifestyle treatment compared to standard treatment. Reproduced from Sdringola et al JACC 2003;41:263.

procedure oriented viewpoint, to one which recognizes the importance of blood flow of the coronary arteries to the heart, the procedure-driven practices of cardiology will continue with many unnecessary procedures done at high cost with risk of complications and suboptimal outcomes. More emphasis has to be placed on risk factor reduction thru controlling lifestyle and medications. Cardiovascular medicine has new knowledge about coronary atherosclerosis, diffuseness of disease, arterial remodeling, plaque rupture, and stabilization by intense medical therapy but this knowledge has not adequately extended to widespread practice due to predominantly anatomically driven cardiologic procedures.

PET guided management of coronary atherosclerosis integrated with intense lifestyle and vigorous pharmacologic treatment reduce coronary events and invasive procedures by 80% or more over five-year follow-up, **Figure 4**. Serial changes in PET perfusion images show response to treatment, predict outcomes and provide insights into progression or regression of the worst stenosis as well as new narrowing or prevention of new stenosis. The economic impact of PET guided management in clinical practice has also been demonstrated with reduced invasive procedures, lowered overall costs and improved outcomes, compared to standard management without PET. Current economic circumstances particularly demand more efficient treatment of cardiovascular disease in this country, one of the biggest drivers of health care costs. Demonstrating further this approach to cardiovascular medicine will be our focus over the next few years at the Weatherhead Center for Preventing and Reversing Coronary Atherosclerosis.



Blood flow in the heart during stress by PET in three different cases. The body schematic shows the orientation of the heart images in the body. The red, white and yellow colors indicate good blood flow to the heart. Green indicates moderately reduced flow capacity in the heart and blue indicate severely reduced blood flow capacity. The flow capacity or maximum increase in coronary flow with stress is called coronary flow reserve or CFR, expressed as a multiple of baseline resting coronary blood flow. A CFR of 3.0 to 4.0 is good coronary blood flow capacity. CFR of 1.8 to 2.9 is moderately reduced coronary flow capacity and less than 1.8 is severely reduced due to severe stenosis.

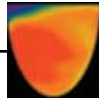
CFR in action - 3 case studies

Case 1 is a 74-year-old female with chest discomfort on lying down or in certain positions, a positive ECG stress test and a coronary arteriogram (cardiac cath) interpreted by her cardiologist as showing severe blockage of the Left Circumflex coronary artery. Due to the location of the blockage, he immediately called in a surgeon who recommended coronary bypass surgery. As second opinion, the patient went to another cardiologist at the University of Texas Medical School who sent her for cardiac positron emission tomography (PET) at the Weatherhead PET Center for Preventing and Reversing Atherosclerosis. The PET scan showed that coronary blood flow during stress increased to 3.9 times baseline resting blood flow, an excellent flow capacity comparable to young healthy volunteer subjects. What was interpreted as a severe blockage on the arteriogram was not severe and caused no limitation in flow and bypass surgery was not needed. Her symptoms improved after ibuprofen consistent with musculoskeletal pain.

Case 2 is 74 year-old vigorous active man with elevated cholesterol (LDL), low good cholesterol (HDL), and high blood pressure, coronary bypass surgery with four bypass grafts done 16 years previously. He had progressively severe chest pain with exertion (angina) leading to the PET scan illustrated as Case 2. The coronary arteriogram confirmed the PET indicating occlusion of the bypass graft to the big artery on the front of the heart (left anterior descending

or LAD) with three other bypass grafts open and normal heart pumping function. CFR in the area of the occluded bypass graft was severely reduced to 0.9 but in the rest of the heart was excellent at 4.0. Repeat bypass surgery or a stent to the LAD artery is appropriate for this case.

Case 3 is a 63 year-old woman with elevated cholesterol, family history of coronary artery disease. She had a small heart attack two months previously with arteriogram interpreted as showing an occluded small diagonal branch and severe disease of all her other coronary arteries for which bypass surgery was recommended. For a second opinion, she came to the Weatherhead PET Center for a cardiac PET scan, that showed a small region of her small heart attack outlined here by the green arrows comprising less than 3% of her heart. The artery to this area is so small that the artery is not suitable for either a stent or bypass surgery. The rest of her heart had good flow capacity with CFR of 3.4 indicating the capacity for increasing coronary blood flow to the heart muscle by 3.4 times resting blood flow levels, nearly as much as young healthy volunteers. Bypass surgery would not improve this good flow capacity any further. Therefore, the PET scan provided information on blood flow to the heart that prevented unnecessary bypass surgery. Intense medical and lifestyle treatment is the best option to prevent further heart attacks which bypass surgery fails to prevent in many scientific studies.



Identifying your Food Habits – The Nighttime Nibbler

One of the first steps to reducing excess weight and achieving a healthy lean body mass is to recognize and identify your food habits. When asked to identify their food intake, many people find it hard to identify where all the calories are coming from until they are asked to fill out a food diary and write down everything they put in their mouth for 3 days. It is then that certain patterns of eating can be identified and addressed. Food habits in some people are fixed and unalterable, whether healthy or not. However, in most people, some aspects of food behavior are surprisingly flexible and adaptable. Some people need three square meals per day. Others want only one meal per day. Still others eat five to eight times per day, a pattern called “grazing.” Some people eat in response to success or in response to stress or depression.

Patricia Mendoza, RD, a nutritionist at Memorial Hermann Hospital in the Clinical Research Center uses some strategies for one of the commonly identified Food Habits-THE NIGHTTIME NIBBLER. The Nighttime Nibbler eats very little during the day, and eats most meals and snacks from dinnertime onward. Since he/she has not eaten anything substantial for 12 to 18 hours (including sleep) they are ravenous at suppertime and continue to eat afterwards.

The goals identified for the Nighttime Nibbler are:

- Spread Calories Evenly throughout the Day**
- Remove Unhealthy Food from the Home**
- Plan One Nightly Snack that Satisfies**
- Reset your Nighttime Routine**



Strategies:

1. Eat more foods during the day, so you approach dinner with less hunger.
2. Each day, plan to eat lunch and a lower-calorie, fiber-rich mid afternoon snack.
3. Once you're eating less at night and feel hungrier

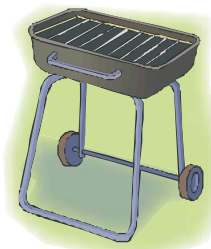
in the morning, add a morning meal to your daily routine.

4. Throw away (and don't buy) high calorie trigger foods (foods that you find difficult to have in small amounts, such as cookies, chips, sweets etc.)
5. Keep high calorie foods out of sight. Put them in opaque containers or in the back of the refrigerator and cabinets.
6. Restock the kitchen with healthy foods.
7. Enjoy a 200-calorie evening snack.
8. Eat mindfully- don't stand in the kitchen eating out of a package. Take time to make your evening snack special by putting it in a real bowl or plate and use silverware.
9. Make your evening snack last at least 15 minutes by eating at a table without distractions like TV.
10. Practice signals of “doneness” after your snack to stop additional evening eating. For example, drink herbal tea, brush your teeth, and turn off the kitchen lights.

Avoiding old habits may require resetting your Nighttime routine, such as finding a new location for typical evening activities such as watching TV in a different room or a different chair. Pick locations that do not trigger your desire to eat. Choose places as far from the kitchen and food as possible. Try new evening activities to take your mind off eating such as taking a walk, practicing deep breathing, listening to relaxing music, taking a bike ride, Practicing a new routine mindfully for 3 weeks turns it into a habit.

Healthy Summer Cook-out

Here is an idea for a Healthy Summer Cook-out. Jennie-O All Natural Turkey Burgers made with Lean white meat. 1/3 lb. individually wrapped burgers that you can take directly from the freezer to the grill. They are lightly seasoned and taste great. Each burger has only 5 gms of fat, 30 gms protein and only 160 calories.



PET News is published for the patients and friends of the Weatherhead PET Imaging Center for the Prevention and Reversal of Heart Disease. We welcome your story ideas, comments, and suggestions.

Mary P. Haynie R.N., MBA
Editor, PET News
6431 Fannin, Suite 4.256
Houston, TX 77030

e-mail- Mary.P.Haynie@uth.tmc.edu