What You Do After A Positive Treadmill: Thallium and The Rest of The Story∝

With the advances made in radiological diagnostic medicine, one might expect that following a positive treadmill there might be some sort of exam that might be minimally invasive to use as a follow-up to either rule in or rule out the results from the treadmill exam. There is: a thallium scan.

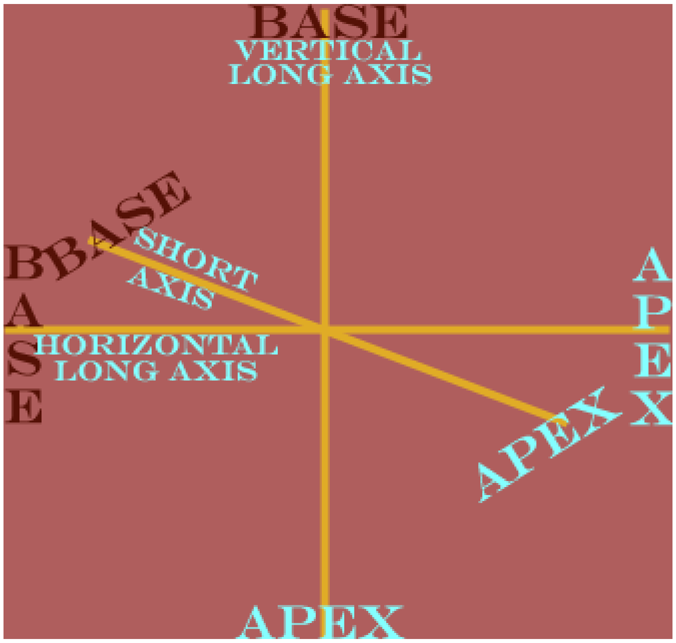
In a nutshell,

> "*During exercise, healthy coronary arteries dilate (develop a more open channel) more than an artery that has a blockage. This unequal dilation causes more blood to be delivered to heart muscle supplied by the normal artery. In contrast, narrowed arteries end up supplying reduced flow to its area of distribution. This reduced flow causes the involved muscle to "starve" during exercise. The "starvation" may produce symptoms (like chest discomfort or inappropriate shortness of breath), and EKG abnormalities. When a "perfusion tracer" (a nuclear isotope that travels to heart muscle with blood flow) is injected intravenously, it is extracted by the heart muscle in proportion to the flow of blood.*
>
> *The amount of tracer uptake helps differentiate normal muscle (which receives more of the tracer) from the reduced uptake demonstrated by muscle that is supplied by a narrowed coronary artery. In other words, areas of the heart that have adequate blood flow quickly picks up the tracer material. In contrast, muscle with reduced blood flow pick up the tracer slowly or not at all. Analysis of the images of the heart (taken by a scanning camera) can help identify the location, severity and extent of reduced blood flow to the heart. The reduced blood flow is known as ischemia (pronounced is-keem-ya)*." [1]
>
> "*Thallium is a metallic element in group IIIA of the periodic table, with biologic properties similar, but not identical, to potassium. The ionic radii of these 2 elements are close to each other, and as with potassium, the distribution of the thallous ion following intravenous administration is primarily intracellular. Transport of thallium across the cell membrane has been reported to occur partly via an ouabain inhibitable mechanism, presumed to be the sodium-potassium ATPase pump*." [2]

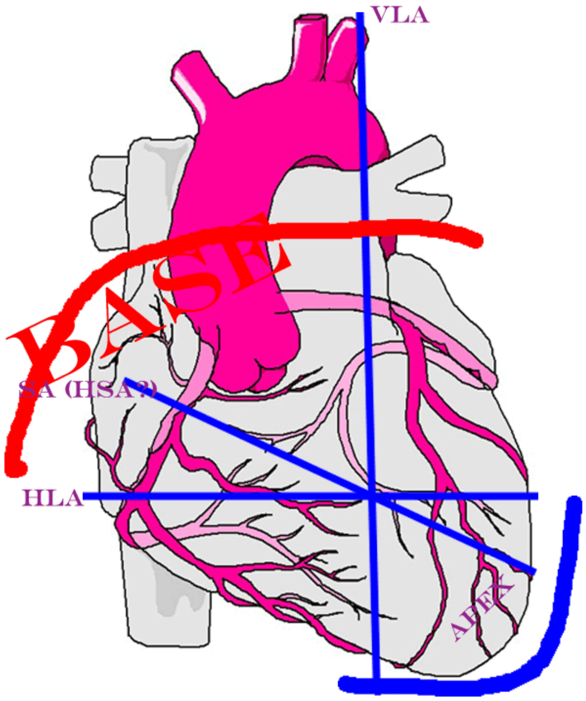
In addition,

> "*thallium, an isotope that behaves like potassium, is taken up by perfused, viable myocardium when injected at maximum exercise*." [3]

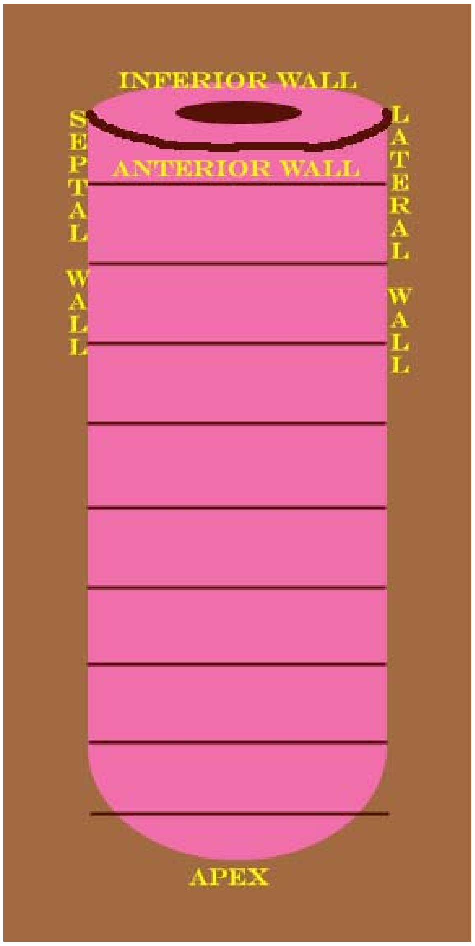
A special "camera" is used to "take pictures of" the myocardium once the isotope has been taken into the cells. This "camera" slices the heart into sections based on orienting the heart about three (3) axes: the short axis, vertical long axis and the horizontal long axis. The image, below, illustrates these three axes:



The “Base” is the base region of the heart and the “Apex” is the apical region of the heart. Here is the same idea overlaid on a heart image:



How do we apply this? If we use the short axis (the “Z” axis in the image, above) to get a handle on this, we can use a simple analogy to get the idea. The analogy is a tube with a rounded end on it. The tube represents the left ventricle and the rounded end represents the apical end of the left ventricle:

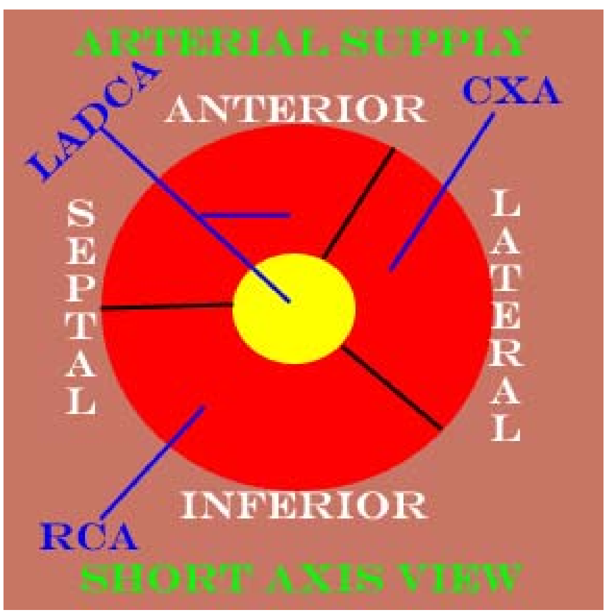


As the labels indicate, the anterior wall is in front of the graphic and the inferior wall is in the back of the graphic. An exceptional graphic that will, perhaps, make this a bit clearer is found at the following med school website: http://brighamrad.harvard.edu/education/online/Cardiac/anatomic-orient.html. This web page is a part of an atlas of SPECT images (Single photon emission tomography images) from the Department of Radiology, Brigham and Women's Hospital, Harvard Medical School, Boston, MA [4], and is quite remarkable and spectacular in its organization, presentation and graphic arts' designs.

In the image at left, each brown line perpendicular to the tube represents where a slice made by the computer to examine an individual "piece" of the left ventricle. In this graphic, there are 10 slices starting from the apical end of the left ventricle "tube".

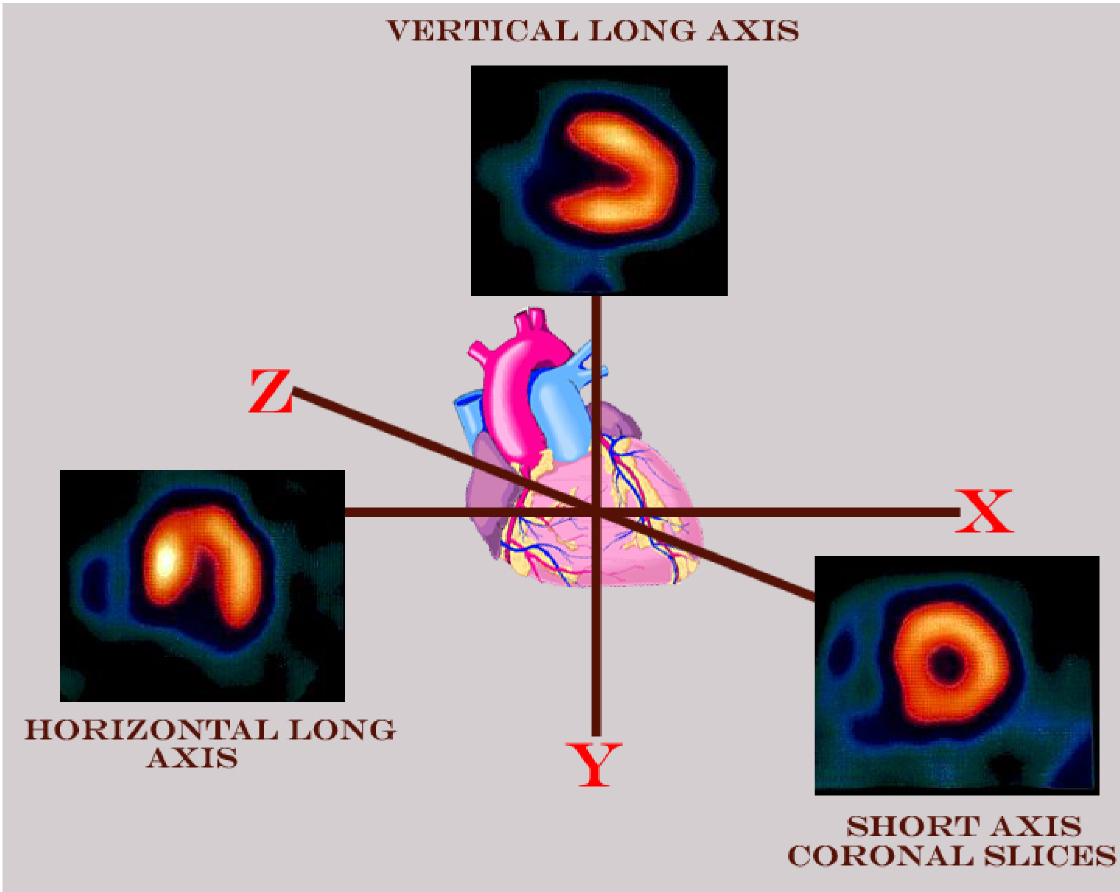
The blood supply is as you'd expect: LADCA (left anterior descending coronary artery) to the anterior and apical region; CXA (circumflex artery) to the lateral wall and the RCA (right coronary artery) provides blood supply to the inferoseptal region of the left ventricle.

The image, below, illustrates on a short axis slice the blood supply to the myocardium via the coronary arteries:

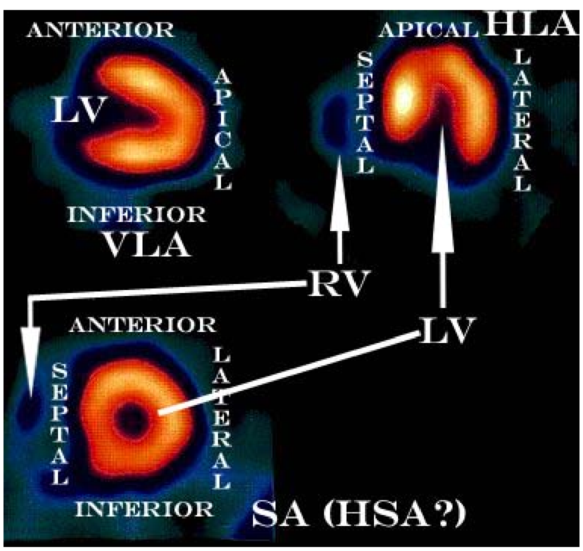


The yellow region in the graphic represents the apical region – remember that the LADCA provides blood supply all the way down to the tip of the apex. The black lines divide the regions of the left ventricular wall into "zones" fed by the coronary arteries on an individual basis (these are marked in/with blue lines). Can you align the two images (tube and slice) in such a way in your head that you can "see" the blood supply to and around the tube image of the left ventricle? The image immediately left is oriented as you will find the sections/slices on an actual thallium scan.

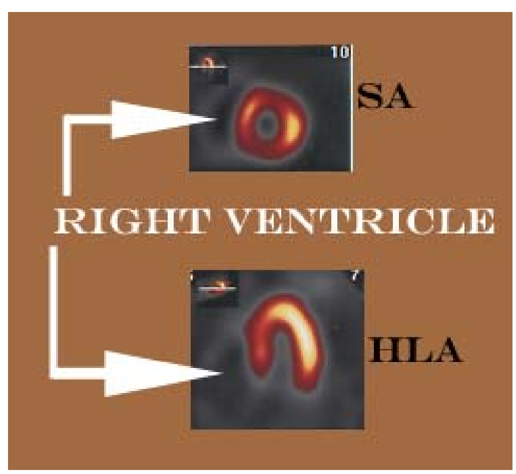
If we combine the axis ideas with the tube idea, we get the following graphic that shows the alignment of the slices as viewed on thallium scan:

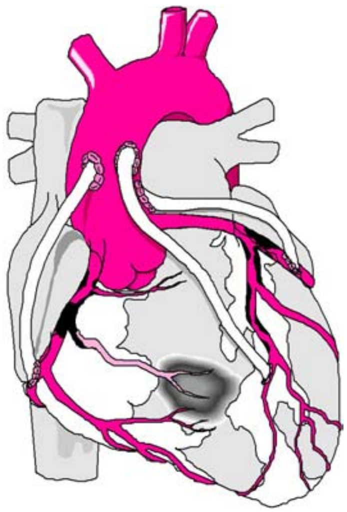


The orientation of these slices is illustrated below:

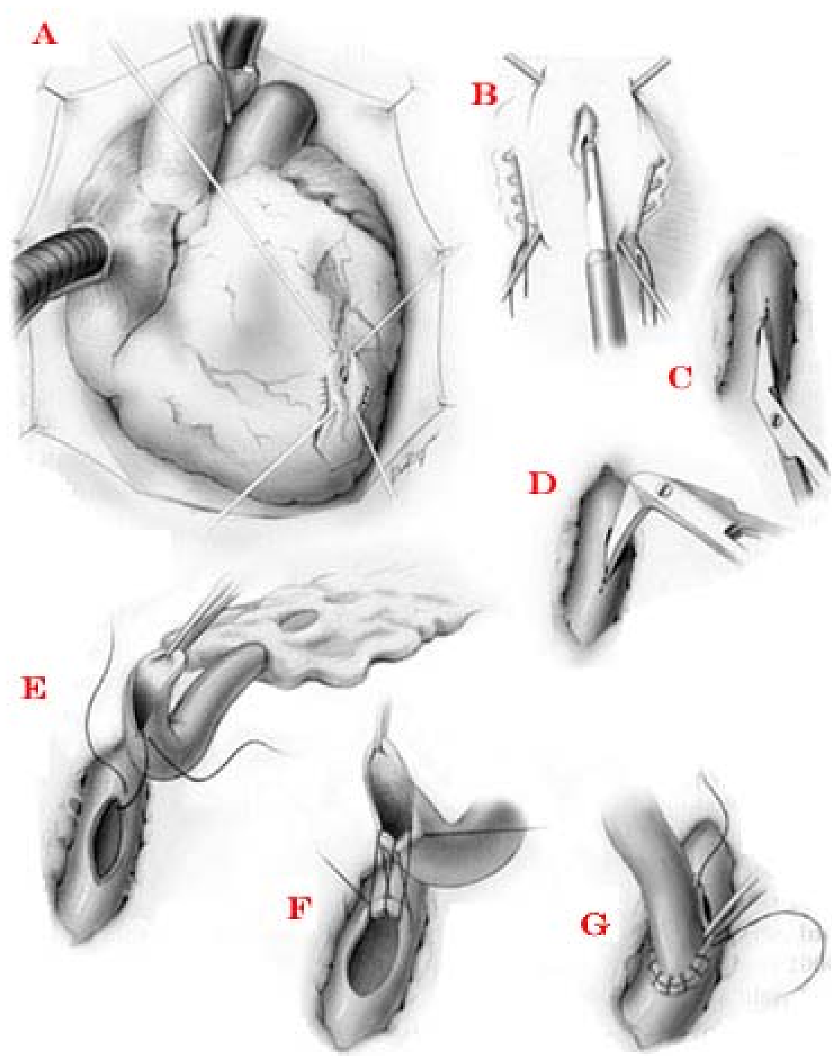


LV = left ventricle; RV = right ventricle; SA = short axis; HSA = horizontal short axis; VLA = vertical long axis. Note that you only see the right ventricle on the SA and HLA slices (pick a graphic):

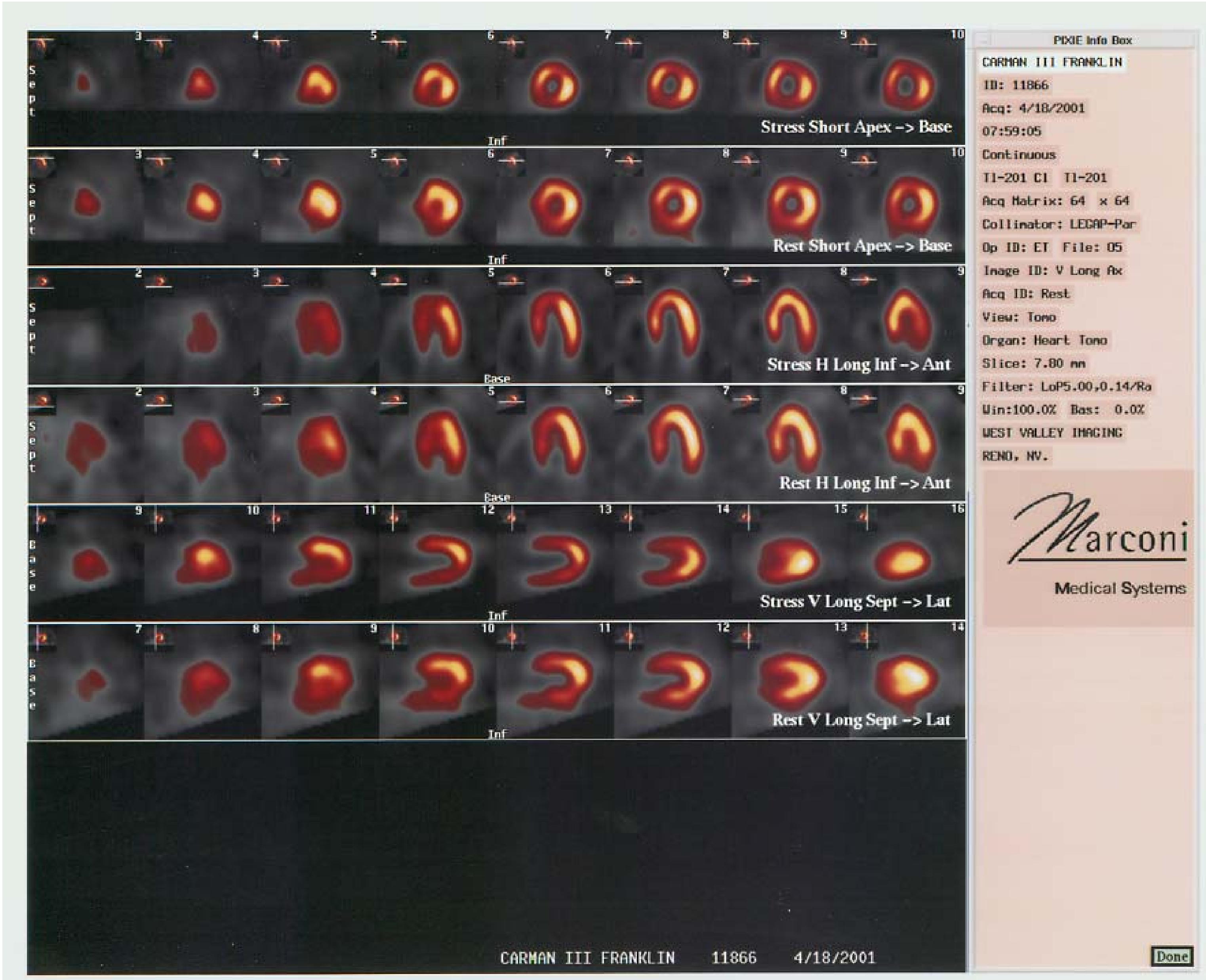


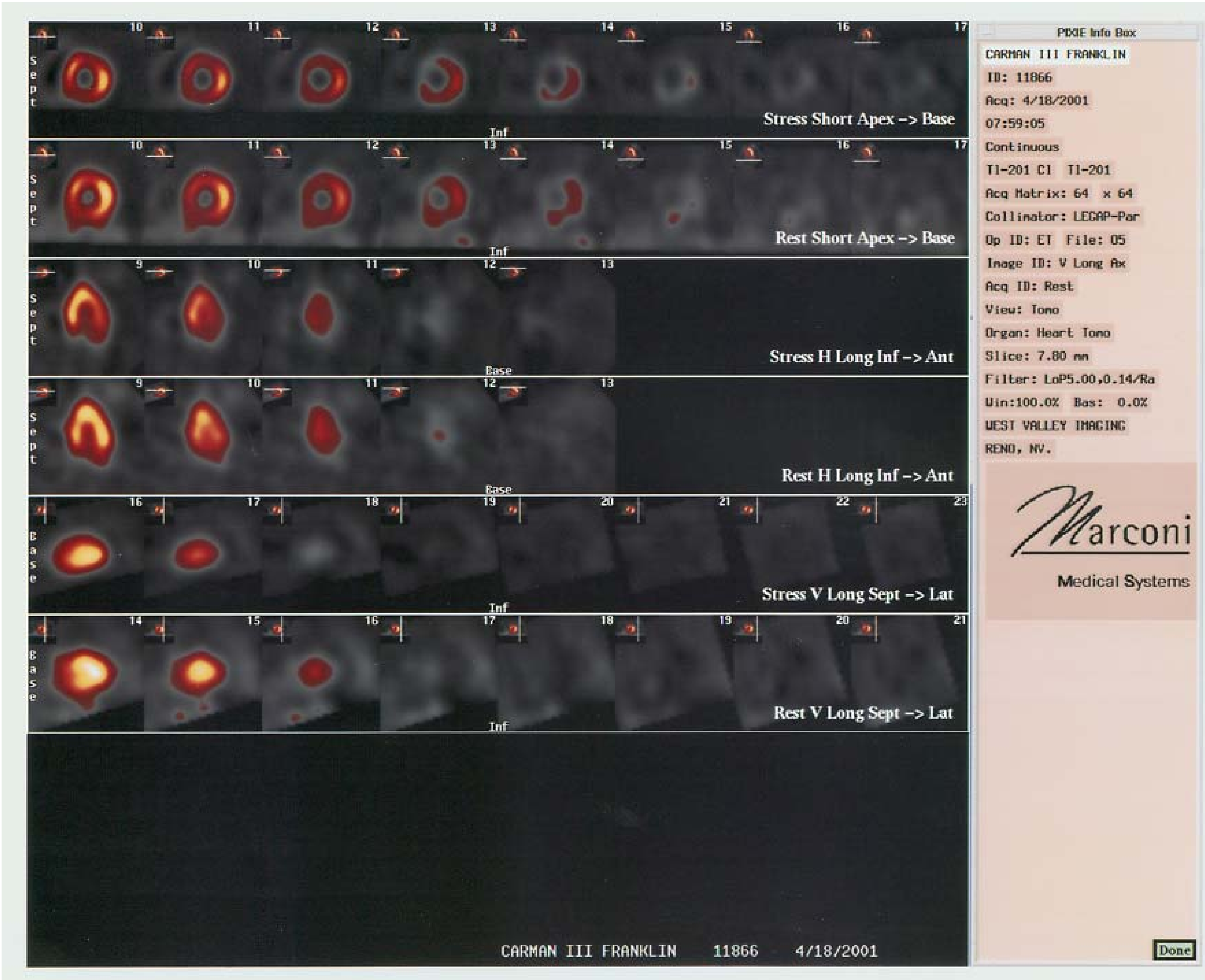


Among the obvious reasons to obtain an isotope scan of a person's heart is a positive stress test (treadmill test). When one learns the test is positive and that that might mean coronary artery occlusion, no matter how minimal or complete, it behooves that person for their quality of life to go the next diagnostic step. The graphic, left, illustrates coronary artery blockages and correction via CABG. The red/fuschia represents aorta, high, and coronary arteries – right and left. The black regions in the vessels illustrate blockage. The white vessels from the ascending aorta below the occlusions on the RCA, LADCA and CXA represent the CABG. While CABG's are quite technically remarkable and extend life – both in quality and quantity – the idea is almost as simple as fixing a radiator hose with duct tape (steps A-G, below):



Below are two pages of the thallium scan images taken following my positive treadmill test:




Stress Short Apex -> Base
Rest Short Apex -> Base
Stress H Long Inf -> Ant
Rest H Long Inf -> Ant
Stress V Long Sept -> Lat
Rest V Long Sept -> Lat
PIXIE Info Box
CARMAN III FRANKLIN
ID: 11866
Acq: 4/18/2001
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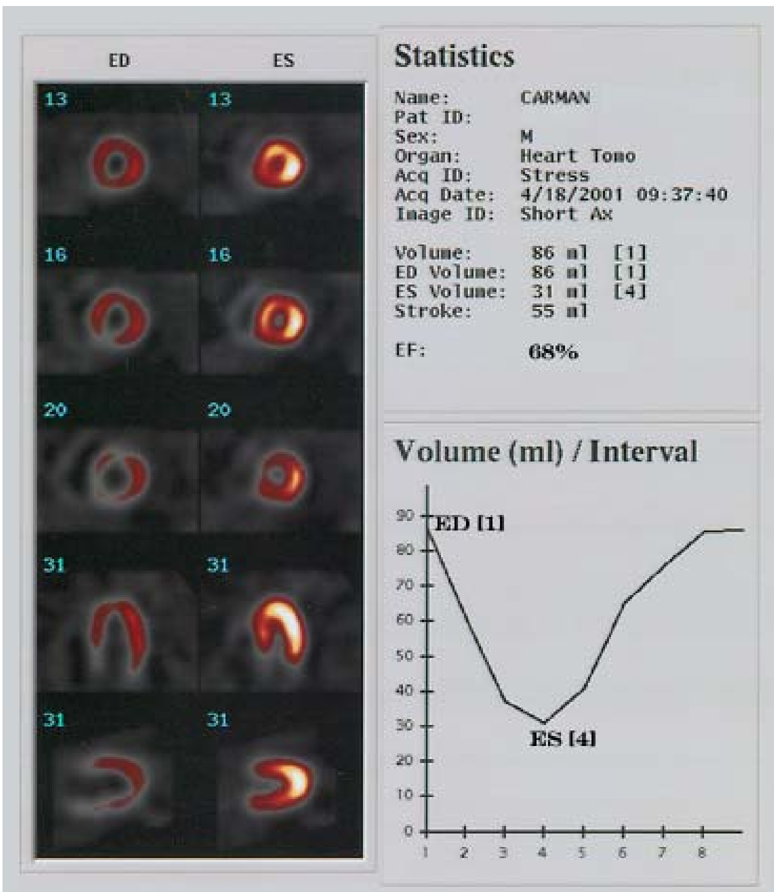
Acq Matrix: 64 x 64
Collimator: LEGAP-Par
Op ID: ET File: 05
Image ID: V Long Ax
Acq ID: Rest
View: Tomo
Organ: Heart Tomo
Slice: 7.80 mm
Filter: LoP5.00,0.14/Ra
Win:100.0% Bas: 0.0%
WEST VALLEY IMAGING
RENO, NV.
Marconi
Medical Systems
Done
CARMAN III FRANKLIN 11866 4/18/2001

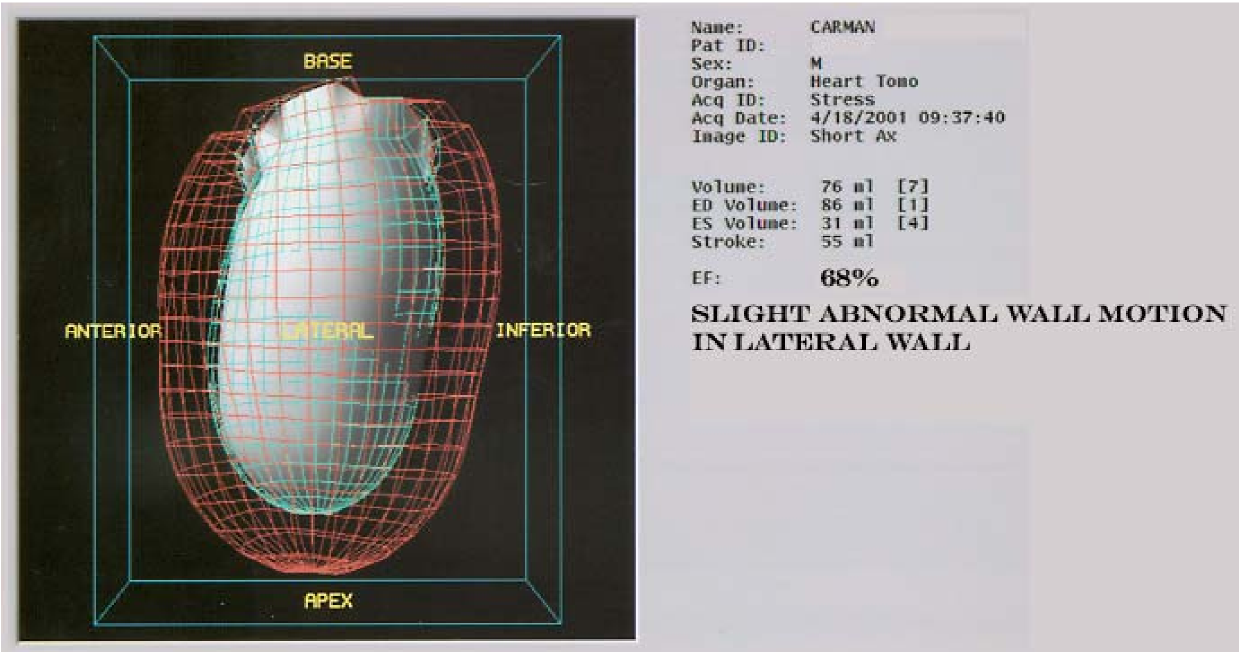
Note that the stress images for each axis slice are immediately above the resting images. This is a normal thallium scan. The coronary arteries are providing comparable flow to the myocardium during exercise relative to resting. The more yellow the images, the more flow – red indicates a lesser flow, albeit relative to rest – just like there is no textbook EKG or MI, there is no textbook thallium scan – one must be able to compare images in order to differentiate normal from pathology. Note that in both SA and HLA slices that my right ventricle is fairly prominent. Although it appears as silvery-grey, that is also isotopic thallium uptake – as pointed out by the reading/interpreting radiologist, this is "prominent right ventricular uptake". This is not surprising when one takes into account that I was hiking, backpacking and working out considerably at the time this was obtained and it follows that my right ventricle had to put forth extra effort to eject blood to my lungs for oxygenation, acid-base balance and carbon dioxide removal – be it at 4,000 feet in elevation or 11,000 feet in elevation. That wasn't surprising.

Based on thallium scan information, my ejection fraction (the ejection fraction is a measure of the per cent of blood in the LEFT ventricle that is ejected per beat) was also calculated. Here are the images that the computer used to determine how much blood was being ejected every time my left ventricle contracted:



My end diastolic volume (ED Volume) is 86 mL; my end systolic volume (ES Volume) is 31 mL. My stroke volume is 55 mL – in NV, that amounts to almost 2 shots and my ejection fraction (EF) is 68%. Do you see the difference in the volumes of my left ventricle during end diastole and end systole in the slices?

The last little thing that was obtained was a "caged" image of my left ventricle. The software for this was developed by a cardiologist by the name of Berman. He has written a great number of articles dealing with computerizing tomography as it applies to the heart, of which one is a very nice, clearly written "monograph" on thallium scans [5]. The software that was used to explore my left ventricle in 3 dimensions gave this image:



In this view, there is a "break-out" of the teal and orange cage that was "set" inside my left ventricle against the lateral wall. Interestingly enough, this just happens to be in the region where I have the clinically significant ST segment depression. At first glance, this sort of "break-out" is suggestive of endocardial wall weakness indicative of a subendocardial infarct. This sort of infarct, also known as a non-Q wave infarct (as there are no pathological Q waves accompanying the ST segment and T wave changes) is inconsistent with the results of this thallium scan [6]. A very nice, succinct article written for MedScape walks practitioners and students, alike, through EKG changes following cardiac episodes [7]. Keep in mind, too, that the left ventricle is the most easily compromised ventricle as it has to eject blood to meet the far reaches of the body – hence, some ischemia is to be expected on exercise. This lateral wall weakness, BTW, is just that – weakness – regular exercise will assist with that.

∝This phrase is blatantly plagiarized without permission from Paul Harvey.

References in Order of Citation in Text

[1] http://www.heartsite.com/html/isotope_stress.html

[2] http://www.medscape.com/viewarticle/416431

[3] http://216.185.102.50/Scientific/statements/1995/029530.html

[4] http://brighamrad.harvard.edu/education/online/Cardiac/Contents.html

[5] http://www.cardiolite.com/hcp/education/workbook/chapt4.pdf

[6] http://www.medscape.com/viewarticle/404383_5

[7] http://www.medscape.com/viewarticle/404383_1