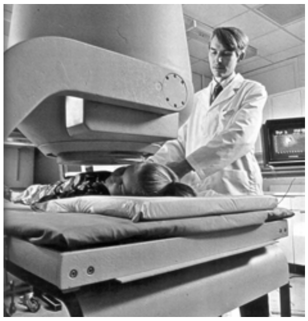
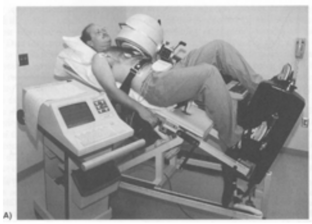
Radionuclide Imaging
Chapter 22

- **Measures Ventricular function**
- **Myocardial Perfusion**



Ventricular Function



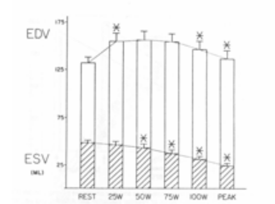
A)

The Radiocardiogram

- **1948, Prinzmetal et al.**
- **Geiger counter in front of the chest**
- **Inject a patient with a radioactive tracer**
  - **sodium chloride, 24-Na**
  - **iodine 131-labeled albumin**
- **Measures of ventricular function:**
  - **transit time**
  - **EDV, ESV, EF**

Normal Ventricular Response to Upright Exercise

- **Decrease in ESV**
- **Mild increase or no change in EDV**
- **Increase in EF**
  - **60 to 85%**



Ischemic Ventricular Response to Upright Exercise

- **Patients with ischemic heart disease**
  - **larger increase in EDV**
  - **increase in ESV**
  - **failure of EF to increase by at least 5%**
  - **regional changes in EF**
  - **wall motion abnormalities**

Advantages of Nucleotide Methods to assess Ventricular Function

- **Measurements are independent of geometric assumptions (volume is calculated from radioactive counts)**
- **Measurements can be obtained during exercise**
- **Sensitivity and specificity for CAD are not great, but add with other tests:**
  - wall motion, 60% sensitivity, 85% specificity
  - EF fall of 5%, 77% sensitivity, 58% specificity

Nuclear Imaging for Ventricular Function

- **First pass imaging (injection of a radionucleotide bolus with fast imaging as it passes through the heart)**
- **Multi-gated acquisition (MUGA) blood pooling imaging (blood is labeled to monitor several cardiac cycles) "equilibrium method"**

First Pass Imaging

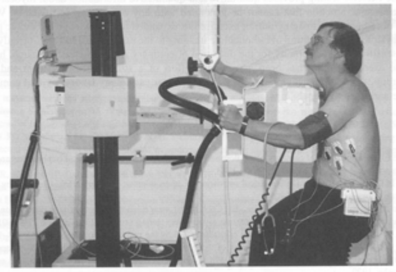


Figure 9 Gamma cameras designed specifically for first-pass radionuclide imaging have been configured for

First Pass Image

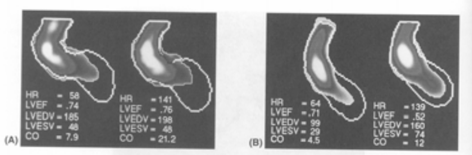


Figure 6 The first-pass radionuclide angiogram allows display of one ventricle at a time, in this case the left ventricle along with the ascending aorta. The end-diastolic perimeter and the end-systolic volume are displayed at rest and during exercise in a normal subject (A) and in a subject with coronary artery disease (B). Note the much larger increase in end-diastolic volume (EDV), the increase in end-systolic volume (ESV), the drop in ejection fraction (LVEF), and the smaller increase in cardiac output (CO) in the subject with the ischemic response.

Rest exercise rest exercise

NORMAL CAD

First Pass ventricular volume curves

Systole *Ventricular filling*

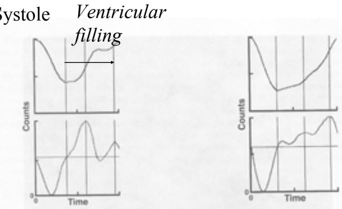


Figure 7 A normal left ventricular volume curve (upper left) and its first derivative (lower left) are compared with those of a subject with abnormal left ventricular diastolic function (right). The vertical lines indicate end-systole, the peak of rapid filling, and the peak rate of atrial filling. Notice the markedly delayed and decreased early diastolic filling in the abnormal case and the concomitant increase in the relative contribution of the atrium to ventricular filling.

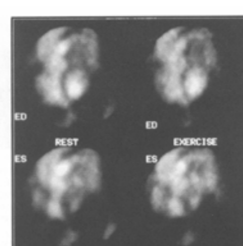
NORMAL ABNORMAL VENTRICULAR FN

Multi-Gated Blood Pool Imaging (MUGA)

- **Anger gamma cameras (1967)--high speed images to "catch' the cardiac cycle**
- **Radiotracers, fast decay time allowing multiple injections**
  - **Technetium-99m-labeled pharmaceuticals**

MUGA Images

Normal subject



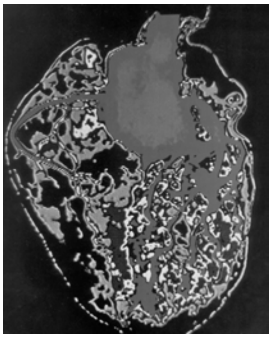
Wall motion sensitivity, 73%
Specificity, 91%

EF fall > 5%
sensitivity, 76%
specificity, 80%

Figure 5 Gated equilibrium imaging may be performed during exercise. The left anterior oblique view must be acquired during exercise so that the LVEF may be calculated. The end-diastolic images (top) and end-systolic images (bottom) at rest and at peak exercise are shown in this figure for a normal subject.

Measures ventricular function:
cardiac volumes (count based)
wall motion abnormalities (cine analysis)

Ventricular Perfusion



Nuclear Imaging for coronary perfusion

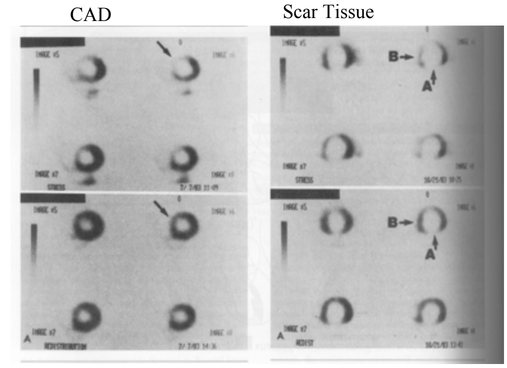
- **Injection of tracers taken up by the myocardial tissue**
  - **Potassium-43 (1973)**
  - **Thallium-201 (1975)** **(73 hr half life)**
  - **Tc-sestamibi, Tc-teboroxime (1980s)**
    - **shorter half lives (6 hrs)**
    - **higher doses allow clearer images**

Thallium-201 testing

- **Images during peak exercise**
  - **dark areas reveal CAD or scar tissue**
- **Images during recovery (redistribution)**
  - **ischemic areas now show perfusion**
  - **scar tissue still dark**

Exercise Thallium Images

CAD — Scar Tissue



Top = immediately post-exercise
Bottom = 4 hours post-exercise

Tc-99m Sestamibi

- **Obtain resting images 30-60 min after injection of Tc-99m**
- **Second injection during exercise and images taken 30-60 min later**
  - **No redistribution. Images after exercise represent perfusion at time of ejection (e.g., at peak exercise, during ischemia)**
- **Compare rest to post-exercise images**
  - **increased perfusion with exercise?**
  - **Vasodilatory reserve?**

Tomography

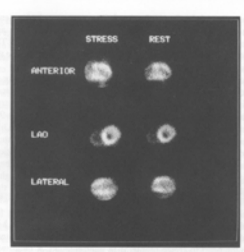


Figure 1 Planar perfusion imaging is typically performed in three or four views, here displayed as anterior, left anterior oblique (LAO) or best septal, and lateral views. The resting images must be acquired using the same patient positioning and camera angles as those of the stress study in order to be able to directly compare the two sets of images.

Planar--3 planes

Planar Images

Single slice views in standardized planes.

Each plane contains regions perfused by specific coronary arteries

Used for persons too large to fit into a SPECT “gantry”

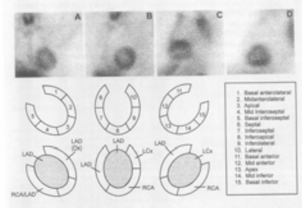
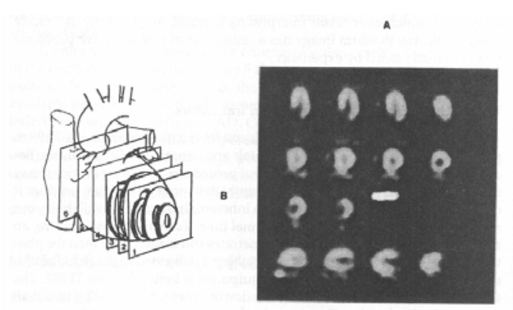


FIGURE 22-4. Planar thallium images in a 550-pound man who could not fit into the gantry for SPECT images. The best LAO view perpendicular to the septal plane, *B*, provides a guide for the anterior view, *A*, in which the camera head is rotated 45 degrees counterclockwise from the LAO position, followed by the left lateral view, *C*. In image *C*, the inferobasilar wall is attenuated by soft tissue. Since the patient could not fit under the camera for a right lateral decubitus view, the patient was imaged by having him lie in the right lateral decubitus position on a mattress placed on the floor, and lowering the camera to obtain the image in *D*. This shows the inferobasilar wall has normal activity. Beneath the images are diagrams of the wall segments as well as the coronary supply to them. (Diagrams after Wackers, 1992, by permission from the author and the publisher.)

Single Photon Emission Computed Tomography (SPECT)

- **1982, tomography added to Tc imaging analysis (planar, SPECT)**
- **a large number of static images are acquired as the camera rotates around the subject**
- **a 3-D reconstruction can more precisely locate ischemic regions and wall abnormalities**

SPECT



Positron Emission Tomograpy (PET)

- **Imaging is combined with a labeled metabolic tracer, (carbon-11, nitrogen-13, oxygen-15)**
  - **e.g., labeled glucose to measure glucose utilization**
  - **used to assess “viability” of the myocardium, not just perfusion**
  - **identifies “hibernating myocardium” (viable but loss of function)**

Conclusions

- **Cardiac Nuclear Imaging Techniques can be used to detect:**
  - Ventricular dysfunction
  - Perfusion abnormalities
- **Images are acquired while stress is applied by:**
  - exercise (cycle, handgrip)
  - drugs (adenosine, dipyridinamole, nitrates, dobutamine)
  - other stressors (cold pressor test)

Conclusions

- **Images can be analyzed by**
  - first pass methods
  - multiple gated equilibrium (MUGA)
  - planar or SPECT tomography methods
  - uptake or washout of perfusion tracers (thallium, Tc-sestamibi)
- **Specific metabolic functions can be assessed by PET scanning**