The Role of Radionuclide Imaging in the Diagnosis of Coronary Bypass Graft Failure

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Noninvasive diagnostic methods are particularly attractive to monitor success or failure of surgical revascularization. Using radionuclide imaging, three well-established approaches are considered here: (a) assessment of global or regional left ventricular function, (b) assessment of acute myocardial tissue damage, and (c) assessment of myocardial perfusion.

Assessment of Cardiac Function

Cardiac function can be assessed noninvasively either by first-pass radionuclide angiocardiography (FPRNA) or by equilibrium radionuclide angiocardiography (ERNA). FPRNA requires specialized gamma cameras with high-count sensitivity. The advantage of this technique is that it allows determination of left ventricular ejection fraction during the short time period, 15–30 s, when a rapidly injected radioactive bolus travels through the central circulation [1]. Although this method has been well validated, the required optimal equipment is not widely available. Therefore this specific method is not discussed further.

Widely available, is the regular gamma camera used to perform ERNA [2]. This technique is commonly also referred to as gated blood-pool imaging or radionuclide ventriculography. For this method the patient’s own red blood cells are labeled with radioactive technetium-99m [3]. Because of the relatively stable binding of $^{99m}$Tc within the red cells, radioactivity is contained within the vascular space. Externally measured changes in radioactivity are proportional to changes in blood volume. In order to determine cardiac function the gamma camera is positioned over the patient’s chest, and data are acquired synchronized with the R wave of the QRS complex of the electrocardiogram [4]. ERNA data are recorded throughout the cardiac cycle (R-R interval) and stored separately in computer memory depending upon the relationship to each R wave. Imaging is continued for 5–8 min, accumulating data over several hundred cardiac cycles. Since radioactivity is in equilibrium within the blood pool, imaging can be performed over an extended period of time. For complete analysis of all cardiac chambers, images are acquired in multiple projections. Usually three views are ob-
tained: the anterior, left anterior oblique, and left lateral views. For interpretation these images are displayed on computer screen as an endless loop movie. Each cardiac chamber can then be analyzed in terms of relative size and global and regional contraction pattern [5].

Left ventricular ejection fraction (LVEF) is calculated from the left anterior oblique view. In this projection radioactivity from the right ventricle is well separated from that of the left ventricle. By choosing a variable region of interest over the left ventricle, a time-activity curve corresponding to volume changes in the left ventricle can be generated [7]. LVEF is calculated from background-corrected enddiastolic (ED) and endsystolic (ES) counts as follows: (ED - ES)/ED. Most computers now have automated or semiautomated software to rapidly calculate LVEF, regional ejection fraction, and diastolic filling parameters. Right ventricular ejection fraction (RVEF) cannot be determined reliably from an ERNA study because of unavoidable overlap of radioactivity of the right atrium and left ventricles [6]. The technique of choice for the assessment of RVEF is ECG-gated list-mode FPRNA, which can be performed using regular gamma cameras. The lower limit of normal LVEF is 50%, whereas the lower limit of normal for RVEF is 40%.

A major advantage of radionuclide assessment of RVEF and LVEF is the relative ease of acquisition. These measurements can be obtained either in the outpatient laboratory or at the bedside of critically ill patients. Moreover, it is feasible to obtain diagnostic quality ERNA studies in virtually all patients. A most important aspect of ERNA is the excellent reproducibility of calculating ejection fraction [7]. In our laboratory calculation of LVEF is reproducible within 3% (ejection fraction units), whereas RVEF has slightly greater variability and is accurate within 6% (ejection fraction units).

ERNA allows detailed analysis of the chambers of the heart and adjacent structures. We usually report on the size of right and left atria, the size and contraction pattern of right and left ventricle, the presence of left ventricular hypertrophy, and the size and configuration of the pulmonary artery and ascending aorta [5].

Because of the excellent reproducibility of assessment of global and regional LVEF, ERNA is ideally suited for following patients after bypass surgery. In many patients improvement in regional and global left ventricular function is observed after successful revascularization. When perioperative infarction is suspected, deterioration of regional wall motion and a decrease in global LVEF is strong evidence of perioperative or postoperative graft failure and infarction (Fig. 1).

Although ERNA has been used extensively in the past in conjunction with supine bicycle exercise, at the present time this methodology is employed less often. It has become evident that an abnormal response of LVEF during exercise (failure to increase >5%) may be nonspecific and is not necessarily evidence of exercise-induced myocardial ischemia.