Technically suboptimal first-pass radionuclide angiographic studies

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Abstract. First-pass radionuclide angiography (FPRNA) has proven to correctly assess left ventricular function, however, technical difficulties do occur. One hundred and thirty one patients had contrast angiography and resting radionuclide angiography within 24 h. Of the 131 patients, 86 (66%) had adequate studies and 45 (34%) were technically suboptimal studies. In the latter group, low counts affected the quality of the images but did not change the left ventricular ejection fraction (LVEF) or regional wall motion (RWM) scores. Patients with high background activity showed overestimation of LVEF, however, by using a formula that was derived from the linear regression the LVEF could be calculated accurately in most cases. Multiple technical problems were noted in 14 patients in whom the best correlation was between contrast LVEF and background uncorrected LVEF from FPRNA (r = 0.87). In the latter group, FPRNA showed overestimation of RWM in 8 patients (57%), mainly in the inferior wall. We conclude that for most technically compromised first-pass radionuclide angiographic data, accurate LVEF values can be achieved but errors in regional wall motion interpretation will occur, especially when multiple technical problems exist.

Key words: Radionuclide angiography – Blood-pool imaging – Left ventricular function


Introduction

Radionuclide angiography (RNA) is a non invasive method for assessment of left ventricular (LV) function. Results of both first-pass (FP) and equilibrium methods have been shown to correlate well with contrast angiography (CA) (Bodenheimer 1978; Hecht 1978; Papapietro 1981; Schelbert 1974). Until recently, two major disadvantages of the FP method precluded its universal application: 1. the need for a multicrystal gamma camera that could reliably provide the high count rates required for FP imaging and 2. the greater potential for technical problems during acquisition and processing of FP studies. The need for a multicrystal gamma camera has recently been overcome using the latest generation of digital single crystal cameras (Gal 1986a, b). However, technical problems still compromise processing of first-pass data.

In this study, we retrospectively analyzed all resting first-pass radionuclide angiographic (FPRNA) studies that were carried out in the catheterization laboratory in which any technical difficulties had occurred. Using contrast angiographic data for comparison, we evaluated how effectively useful clinical data could be salvaged from compromised FPRNA studies, specifically with regard to left ventricular ejection fraction (EF) and regional wall motion (RWM) analysis.

Material and methods

Patients. One hundred and thirty eight patients had resting FPRNA in the catheterization laboratory followed by CA. There were 86 studies (62%) judged to be technically satisfactory. Of the other 52, five had inadequate CA and 2 were excluded because part of the LV was out of the field of view in the FPRNA. In the remaining 45 studies of which there were 12 females and 33 males with an average age of 61 years, there were a variety of technical problems (including combinations). The limit of normal was calculated as at least two standard deviations of the average in the optimal studies. A low count rate (<125000 counts/s in the RV phase) was noted in 17 cases. High background activity (HBA) during the LV phase was observed in 23 instances. Delayed (FWHM > 1.5 s in the superior vena cava) or split bolus without HBA was seen in 3 patients. Patient motion and a large left atrium were noted in one and two patients, respectively. Arrhythmias were detected in 11 patients.

Radionuclide studies. The hardware and software for acquisition and processing of these first-pass studies have pre-
viously been described in detail (Gal 1986a). In brief, the gamma camera was a small field of view, portable, single crystal camera (apo 215, Elscint). Three types of collimators were used: 1. the commercially provided low-energy, ultra-high-sensitivity collimator (15 cases) 2. a collimator specially designed by one of the authors, (23 cases) and 3. a medium sensitivity high resolution collimator (7 cases).

A 1 inch, 20 gauge teflon cannula was inserted into the external jugular vein or, a 2 inch, 18-gauge cannula was inserted into the antecubital vein. The cannula was connected to a 3-way stopcock, an extension tube and a syringe of 20 ml saline. The detector was then positioned in the RAO 20°-30° view. The energy window was 140 kev ±15% (119-161 kev). A dose of 27±2 mCi 99mTc-DTPA was then injected. Data were acquired in frame mode (0.03 s/frame) on a 32 x 32 matrix for 30 s. Data from the 86 patients with technically good studies were collected on the hard disk and stored on a floppy disk for later processing.

Processing. A time-activity curve from a manually drawn LV region of interest (ROI) was used by the computer to identify end-diastolic (ED) and end-systolic (ES) frames according to the highest and lowest counts respectively during the LV phase. The user could override the system and select or edit each ED or ES frame according to the image, the number of counts in the LV ROI or for other technical reasons. A representative cycle using the user’s beat selection criteria was then created by a beat alignment process. A number of frames of the pulmonary phase, identical to the number of beats in the representative cycle were subtracted from each frame of the representative cycle after multiplication by a washout factor that was determined by the slope of the disappearance of tracer from the lungs. A final LV ROI was then drawn by tracing the perimeter of a phase image derived from the initial representative cycle. The new LV ROI was then used to repeat the entire process of generating a representative cycle. The EF was calculated as:

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\text{Background corrected ES counts - Background corrected ED counts} \quad (1)
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The final background (BKG) corrected representative cycle was smoothed using median and temporal filters. That representative cycle was later reviewed in cine mode to evaluate regional wall motion (RWM). The RWM analysis was based on a ten point scoring of three regions: anterior, apical and inferior. In each region, zero meant normal, one–three hypokinesia (according to extent), four–six akinesia, and seven–nine dyskinesia.

Contrast angiography: After measurement of left ventricular pressures, contrast left ventriculography was performed in the RAO 20°–30° view using 30–50 ml meglumine diatrizoate (Renografin 76®) injected in the left ventricle. The cine angiogram was shot at 30 frames/s on 35 mm film using a 9 in. image intensifier. Selective coronary angiography was performed in multiple views. Angiographic left ventricular ejection fraction was determined for each patient using the Kennedy modification of the single plane area-length method of Sandler et al. (Kennedy et al. 1966). The interpretation of contrast angiograms was performed by two experienced cardiologists who were unaware of the results of RNA studies. The same wall motion scoring method described for the FPRNA analysis was used.

Statistics. Paired observations of ejection fractions were analyzed using the student’s t-test and least squares fit for determination of the regression equation. A Spearman rank correlation was used to compare the contrast angiographic wall motion scores to those from FPRNA. A significance of differences was determined at the P<0.05 level.

Results

Technically good studies

The results from the 86 patients with technically good studies revealed a correlation coefficient between CA EF and background uncorrected RNA EF of 0.91. The SEE of the background uncorrected FPRNA was 4.1%. After background correction, the correlation coefficient increased to 0.96 while the SEE was minimally increased to 4.3%. Spearman rank correlation coefficients between CA and FPRNA wall motion scores were 0.82, 0.80 and 0.83 for the anterior, apical, and inferior walls respectively.

All technically compromised studies

In Fig. 1A the FPRNA ejection fractions are plotted against the CA ejection fractions of these patients. The correlation between the background uncorrected RNA EF and the CA EF yielded an r = 0.92 and a SEE of 4.2% (Fig. 1B). After background correction, the correlation coefficient was similar (0.91) and the SEE was 6.7%. The average background corrected RNA EF was not statistically different (p=0.36) from CA EF: 59.6% (19%-82%) vs 59.2% (14%-88%). The Spearman rank correlation coefficients between CA wall motion scores and background corrected FPRNA scores were 0.70, 0.70 and 0.53 for the anterior, apical, and inferior walls respectively.

Studies with low count rates

There were 17 patients with <125000 counts/s in the whole field of view during the RV phase. They range from 54000 to 124000 counts/s. Ten of the 17 patients had no other technical problems besides the low count rate. Of those 10, seven had CA EF <80%, and RNA EF results were very similar to CA EF (P=NS). In 3 women, CA EF was higher than 80%, and RNA EF was lower 10%. Wall motion analysis (difference >1 point score between CA and FPRNA) showed no significant difference in 29/30 segments.

Studies with high lung-background activity during LV-phase

This was the problem in 23 patients, 5 of whom had delayed or split bolus. A classic time-activity curve is shown in Fig. 2B. RNA EF was an average of 5.2% higher than CA EF (61.4% vs 56.2%). Of the 69 segments, 1 was underestimated and 12 were overestimated by the RNA RWN scores.