Gated ^{99m}Tc-Tetrofosmin and ^{18}F-FDG Studies: A Comparison of Single-Acquisition and Separate-Acquisition Protocols

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^{18}F-FDG is a well-established tracer for evaluating myocardial viability, as is ^{99m}Tc-tetrofosmin (TET) for evaluating myocardial perfusion. Dual-isotope single-acquisition (DISA) studies using a ^{99m}Tc perfusion agent and ^{18}F-FDG have been performed to evaluate myocardial viability. The purpose of this investigation was to determine whether there is a difference in the results of gated SPECT DISA, compared with gated SPECT DIDA (dual-isotope dual-acquisition) studies using ^{99m}Tc-TET/^{18}F-FDG and a high-energy collimated dual-head SPECT system.

Methods: We prospectively studied 13 patients with depressed left ventricular function using both acquisition protocols. Summed rest scores were calculated for both ^{99m}Tc and ^{18}F-FDG studies using a 12-segment model and a 5-grade severity score. Images were evaluated by a single reader who did not know whether the images were acquired separately or simultaneously.

Results: The concordance of DISA and DIDA protocols for ^{99m}Tc-TET when allowing no difference in the SRS was 57%, or 89 of 156 segments. The concordance of DISA and DIDA protocols for ^{18}F-FDG was 86%, or 134 of 156 segments. The concordance of segments determined to be viable versus nonviable was 92%, or 143 of 156 segments. Ejection fraction measurements obtained by gated ^{99m}Tc-TET studies correlated strongly with those obtained by gated ^{18}F-FDG studies.

Conclusion: A high concordance for ^{18}F-FDG studies was shown between gated DISA and gated DIDA. A lower concordance was shown between gated DISA and gated DIDA studies using ^{99m}Tc-TET, most likely because of downscatter from ^{18}F into the ^{99m}Tc window. An excellent concordance was demonstrated between the 2 techniques for viability assessment. The gated ^{99m}Tc-TET/^{18}F-FDG DISA protocol can be both a reliable and an efficient way to evaluate myocardial function, perfusion, and viability.

Key Words: dual-isotope single acquisition; downscatter; ^{18}F-FDG

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The most commonly used single-photon tracer for the evaluation of myocardial viability is ^{201}Tl. However, several investigators have reported that SPECT using ^{18}F-FDG, when compared with other commonly used tracers for determining myocardial viability, identifies additional viable tissue (*1–3*). These findings have made ^{18}F-FDG the imaging gold standard for assessment of myocardial viability. The widespread use of ^{18}F-FDG has been limited in the past by several factors but primarily by tracer availability and the high cost of dedicated PET scanners. Recent advances in technology have allowed the imaging of positron-emitting radionuclides, such as ^{18}F, on scintillation cameras using ultra-high-energy parallel-hole collimators. For cardiac applications, the camera–collimator combination has acceptable spatial resolution and sensitivity for ^{99m}Tc and ^{18}F single-acquisition SPECT imaging studies (*4*). The available data show that ^{18}F-FDG SPECT provides comparable information to ^{18}F-FDG PET concerning myocardial viability in patients with chronic coronary artery disease and depressed left ventricular function (*5*). For these viability studies, it is important to compare the ^{18}F-FDG distribution to the distribution of myocardial perfusion. The ability to perform perfusion and viability imaging simultaneously would be economically and logistically attractive. As noted by Sandler et al. (*6*), several important technical issues may interfere with the widespread application of this technology. The purpose of this study was to compare dual-isotope single-acquisition (DISA) studies with dual-isotope dual-acquisition (DIDA) studies and to evaluate the potential advantages and disadvantages of each.

MATERIALS AND METHODS

We prospectively studied 13 consecutive patients with depressed left ventricular function (ejection fraction $<$ 45%) who were referred for myocardial viability assessment. All patients signed a consent form before the study. For each patient, images were acquired using DISA and DIDA protocols.

TABLE 1
Comparison Between DISA and DIDA ^{99m}Tc Studies

DISA	DIDA			
	Normal	Mild	Moderate	Severe
Normal	36	9	8	2
Mild	8	6	12	4
Moderate	6	3	13	12
Severe		2	1	34

Data are numbers of segments.

TABLE 2
Comparison Between DISA and DIDA ^{18}F-FDG Studies

DISA	DIDA			
	Normal	Mild	Moderate	Severe
Normal	80	5	2	
Mild	5	4	3	
Moderate	2	6	12	7
Severe	2	1	4	23

Data are numbers of segments.

First, resting ^{99m}Tc-tetrofosmin (TET) studies were performed with intravenous injection of 1,110 MBq of the tracer. Thirty minutes after the injection, gated SPECT images were obtained for 30 s per frame. Blood glucose levels were monitored. A baseline between 110 and 140 mg/dL was desired before the ^{18}F-FDG administration. Depending on the patient's blood glucose level, 1–5 units of regular human insulin injection, U.S. Pharmacopeia, were administered intravenously. If necessary, 25–50 g of oral glucose were administered orally before insulin administration. The ^{18}F-FDG studies were performed with intravenous administration of 370–555 MBq of the tracer and an uptake period of 30–45 min. The ^{18}F-FDG gated SPECT images were acquired at 40 s per frame, concluding the DIDA protocol. Immediately after the ^{18}F-FDG acquisition, a final acquisition was performed at 40 s per frame. For this DISA protocol, both ^{99m}Tc-TET gated SPECT and ^{18}F-FDG gated SPECT were acquired with a single acquisition and photopeaks set at both 140 and 511 keV using a 20% energy window. Images were acquired during a 90° rotation (3° per

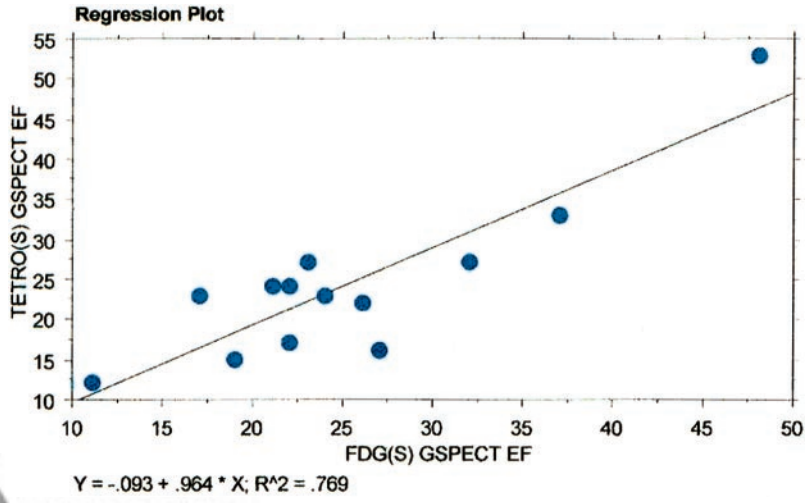

FIGURE 1. Linear regression plot demonstrates strong correlation between ^{99m}Tc-TET gated SPECT ejection fraction using single-acquisition protocol (TETRO[S] GSPECT EF) and ^{18}F-FDG gated SPECT ejection fraction using single-acquisition protocol (FDG[S] GSPECT EF).

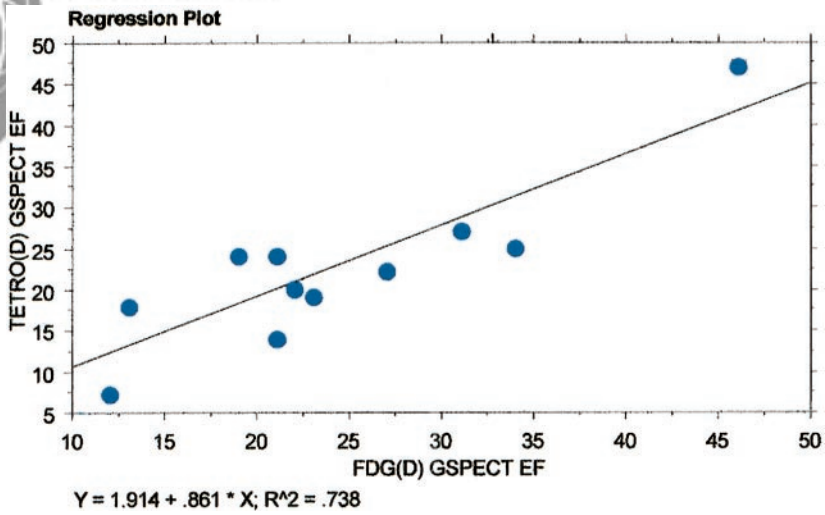

FIGURE 2. Linear regression plot demonstrates strong correlation between ^{99m}Tc-TET gated SPECT ejection fraction using dual-acquisition protocol (TETRO[D] GSPECT EF) and ^{18}F-FDG gated SPECT ejection fraction using dual-acquisition protocol (FDG[D] GSPECT EF).

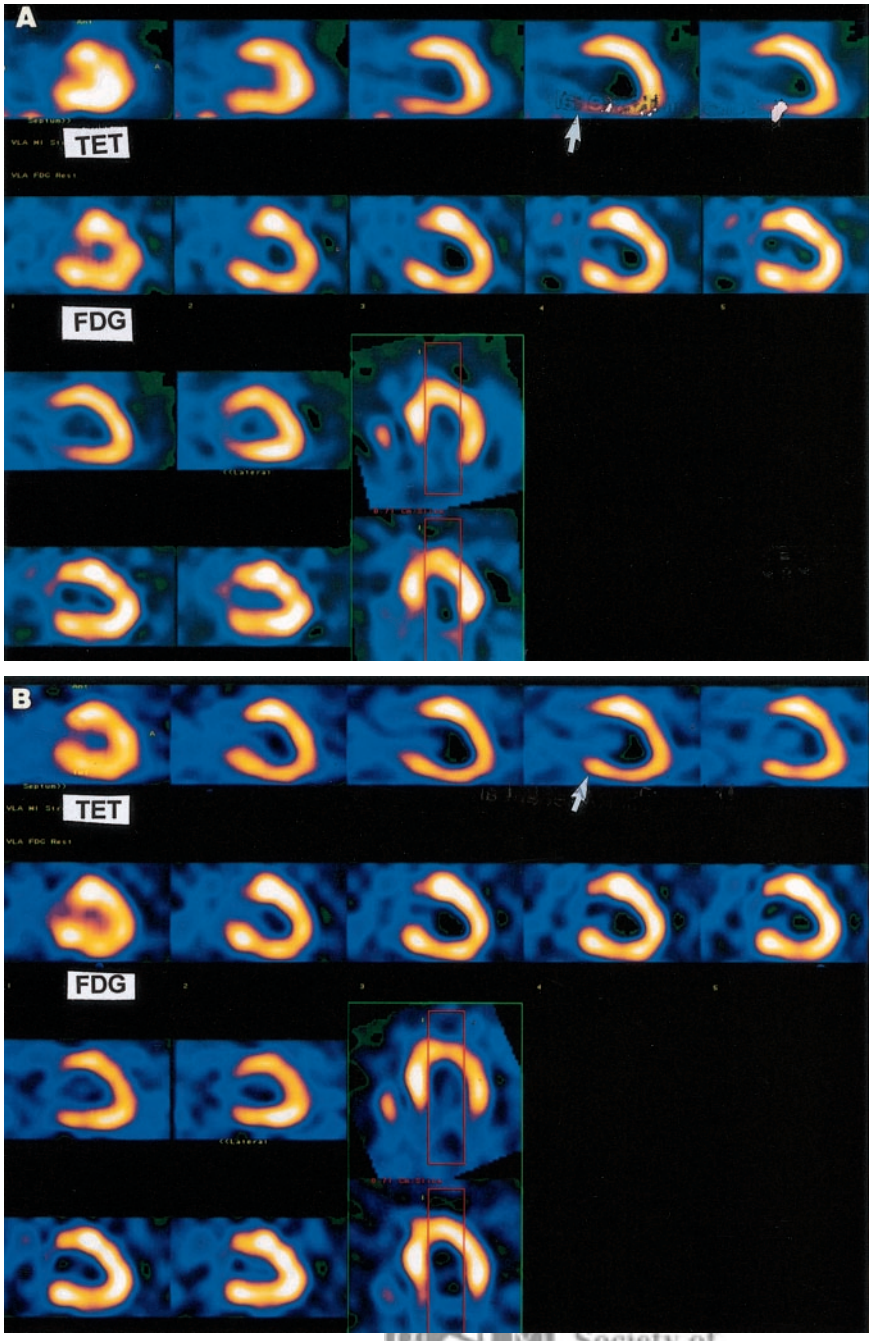

FIGURE 3. Vertical long-axis slices from ^{99m}Tc-TET (first row) and ^{18}F-FDG (second row) studies of same patient using dual-acquisition protocol (A) and single-acquisition protocol (B). Inferior wall perfusion defect (arrow) but viable myocardium is seen on dual-acquisition ^{18}F-FDG study, but perfusion abnormalities (arrow) are underestimated on single-acquisition ^{99m}Tc-TET study, likely related to down-scatter from ^{18}F 511-keV photons.

stop) using a 2-headed scintillation camera with ultra-high-energy parallel-hole collimators. The imaging heads were oriented at 90° and contained 16-mm (⅝ in.) NaI (thallium) crystals (Varicam; Elscint, Haifa, Israel). A matrix size of 64 × 64 × 8 was used. Images were gated for 8 frames per cardiac cycle with 100% beat acceptance. A Butterworth filter with a cutoff of 0.35 cycles per pixel and a power of 5.0 was applied to the ^{99m}Tc-TET data. A Metz filter with a cutoff of 0.36 and a power of 3 was applied to the ^{18}F-FDG data. Images were reconstructed with filtered backprojection, and no attenuation correction was applied. After reconstruction, the short-axis images underwent preprocessing for quantification of gated left ventricular ejection fraction using software that had been previously validated (*7*).

A single reader who did not know whether the ^{99m}Tc-TET and ^{18}F-FDG images had been acquired by a DISA or a DIDA protocol interpreted the studies. A summed rest score (SRS) was calculated using a 12-segment model, with 0 = normal, 1 = mildly abnormal, 2 = moderately abnormal, and 3 = severely abnormal for each segment. A total of 156 segments were analyzed for concordance between DISA and DIDA studies for the severity and extent of abnormalities and viability assessment.

RESULTS

The concordance of the DISA and DIDA protocols for ^{99m}Tc-TET studies, in terms of severity when allowing no difference in the SRS between the 2 acquisition protocols, was 57%, or 89 of 156 segments. This low concordance relates to the large number of segments graded more severely abnormal by the separate acquisition protocol versus the single-acquisition studies (Table 1). When allowing for a difference ≥ 1 in the SRS, the concordance was 76%, or 119 concordant segments of 156 segments. The concordance of DISA and DIDA protocols for ^{18}F-FDG when allowing for no difference in the SRS was 86%, or 134 concordant segments of 156 segments. When allowing for a difference of 1 or >1 in the SRS, the concordance was 96%, or 149 of 156 segments (Table 2).

The concordance of segments determined to be viable was 92%, or 143 of 156 segments.

A linear regression analysis demonstrated a significant correlation between ^{99m}Tc-TET and ^{18}F-FDG for left ventricular ejection fraction measurements by gated SPECT using the DISA protocol ($r^2 = 0.769$) (Fig. 1). Likewise, there was a highly significant correlation between ^{99m}Tc-TET and ^{18}F-FDG for left ventricular ejection fraction measurements by gated SPECT using the DIDA protocol ($r^2 = 0.738$) (Fig. 2).

DISCUSSION

SRS for the ^{18}F-FDG images was similar for the DISA and DIDA protocols. An overall good clinical concordance was shown between gated DISA and gated DIDA studies using ^{18}F-FDG. No significant difference was found between gated ^{99m}Tc-TET and ^{18}F-FDG measurements of left ventricular ejection fraction using either imaging protocol. The acceptable, although lower, concordance between the ^{99m}Tc-TET DISA and ^{99m}Tc-TET DIDA severity segment scores is believed to be a result of downscatter from the ^{18}F annihilation radiation into the ^{99m}Tc energy window. Downscatter into the ^{99m}Tc window results in a "filling in" of defects in ^{99m}Tc-TET images, making the defects appear less severe (Figs. 3A and 3B). Other studies have acknowledged this potential problem and attempted to correct the ^{99m}Tc perfusion images for scatter, with limited success (*8*).

CONCLUSION

The SRS of the ^{99m}Tc-TET segments acquired with DISA were lower than the SRS of the segments acquired with DIDA. Despite a strong clinical correlation between the ^{18}F-FDG DISA and ^{18}F-FDG DIDA studies, a limited clinical concordance exists between ^{99m}Tc-TET DIDA and ^{99m}Tc-TET DISA studies. Therefore, our study strongly suggests that using a separate acquisition protocol will likely avoid underestimating perfusion defects that would be important in determining the ischemic-versus-nonischemic nature of a cardiomyopathic process. Such an underestimation would have a tremendous impact on how these patients would be treated clinically (medically vs. surgically).

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