Gated ⁹⁹mTc-Tetrofosmin and ¹⁸F-FDG Studies: A Comparison of Single-Acquisition and Separate-Acquisition Protocols

Robert A. Pagnanelli, CNMT¹; Michael W. Hanson, MD¹,²; Timothy Turkington, PhD¹; R. Edward Coleman, MD¹; and Salvador Borges-Neto, MD¹,²

¹Division of Nuclear Medicine, Department of Radiology, Duke University Medical Center, Durham, North Carolina; and ²Division of Cardiology, Department of Internal Medicine, Duke University Medical Center, Durham, North Carolina

¹⁸F-FDG is a well-established tracer for evaluating myocardial viability, as is ⁹⁹mTc-tetrofosmin (TET) for evaluating myocardial perfusion. Dual-isotope single-acquisition (DISA) studies using a ⁹⁹mTc perfusion agent and ¹⁸F-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 ⁹⁹mTc-TET/¹⁸F-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 ⁹⁹mTc and ¹⁸F-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 ⁹⁹mTc-TET when allowing no difference in the SRS was 57%, or 89 of 156 segments. The concordance of DISA and DIDA protocols for ¹⁸F-FDG was 86%, or 134 of 156 segments. The concordance of segments determined to be viable versus non-viable was 92%, or 143 of 156 segments. Ejection fraction measurements obtained by gated ⁹⁹mTc-TET studies correlated strongly with those obtained by gated ¹⁸F-FDG studies.

Conclusion: A high concordance for ¹⁸F-FDG studies was shown between gated DISA and gated DIDA. A lower concordance was shown between gated DISA and gated DIDA studies using ⁹⁹mTc-TET, most likely because of downscatter from ¹⁸F into the ⁹⁹mTc window. An excellent concordance was demonstrated between the 2 techniques for viability assessment. The gated ⁹⁹mTc-TET/¹⁸F-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; ¹⁸F-FDG


The most commonly used single-photon tracer for the evaluation of myocardial viability is ²⁰¹Tl. However, several investigators have reported that SPECT using ¹⁸F-FDG, when compared with other commonly used tracers for determining myocardial viability, identifies additional viable tissue (1–3). These findings have made ¹⁸F-FDG the imaging gold standard for assessment of myocardial viability. The widespread use of ¹⁸F-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 ¹⁸F, on scintillation cameras using ultra-high-energy parallel-hole collimators. For cardiac applications, the camera–collimator combination has acceptable spatial resolution and sensitivity for ⁹⁹mTc and ¹⁸F single-acquisition SPECT imaging studies (4). The available data show that ¹⁸F-FDG SPECT provides comparable information to ¹⁸F-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 ¹⁸F-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.
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

<table>
<thead>
<tr>
<th>DISA</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>36</td>
<td>9</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Mild</td>
<td>8</td>
<td>6</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Moderate</td>
<td>6</td>
<td>3</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Severe</td>
<td>2</td>
<td>1</td>
<td>34</td>
<td>34</td>
</tr>
</tbody>
</table>

Data are numbers of segments.

TABLE 2

<table>
<thead>
<tr>
<th>DISA</th>
<th>Normal</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>80</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Mild</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Moderate</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>7</td>
</tr>
<tr>
<td>Severe</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>23</td>
</tr>
</tbody>
</table>

Data are numbers of segments.

FIGURE 1. Linear regression plot demonstrates strong correlation between $^{99m}$Tc-TET gated SPECT ejection fraction using single-acquisition protocol (TETO[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 (TETO[D] GSPECT EF) and $^{18}$F-FDG gated SPECT ejection fraction using dual-acquisition protocol (FDG[D] GSPECT EF).
(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 (5/8 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 99mTc-TET data. A Metz filter with a cutoff of 0.36 and a power of 3 was applied to the 18F-FDG data. Images were reconstructed with filtered backprojection, and no attenuation correction was applied. After reconstruction, the short-axis images underwent pre-processing 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 99mTc-TET and 18F-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.

FIGURE 3. Vertical long-axis slices from 99mTc-TET (first row) and 18F-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 18F-FDG study, but perfusion abnormalities (arrow) are underestimated on single-acquisition 99mTc-TET study, likely related to downscatter from 18F 511-keV photons.
RESULTS

The concordance of the DISA and DIDA protocols for 99mTc-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 \( \geq 1 \) in the SRS, the concordance was 76%, or 119 concordant segments of 156 segments. The concordance of DISA and DIDA protocols for 18F-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 99mTc-TET and 18F-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 99mTc-TET and 18F-FDG for left ventricular ejection fraction measurements by gated SPECT using the DIDA protocol (\( r^2 = 0.738 \)) (Fig. 2).

DISCUSSION

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

CONCLUSION

The SRS of the 99mTc-TET segments acquired with DISA were lower than the SRS of the segments acquired with DIDA. Despite a strong clinical correlation between the 18F-FDG DISA and 18F-FDG DIDA studies, a limited clinical concordance exists between 99mTc-TET DIDA and 99mTc-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).

REFERENCES