**99mTc-N-NOET Myocardial Uptake Reflects Myocardial Blood Flow and Not Viability in Dogs With Reperfused Acute Myocardial Infarction**

Gérald Vanzetto, MD, PhD; David K. Glover, ME; Mirta Ruiz, MD; Dennis A. Calnon, MD; Roberto Pasqualini, PhD; Denny D. Watson, PhD; George A. Beller, MD

**Background**—N-Ethoxy-N-ethyl-dithiocarbamato-nitrido-99mTc (99mTc-N-NOET) is a new neutral lipophilic 99mTc-labeled myocardial perfusion agent with a high first-pass extraction fraction and delayed redistribution kinetics after transient ischemia comparable to what is observed with 201Tl. It is unknown whether the uptake of this tracer reflects myocardial viability or just reperfusion flow in the setting of a reperfused myocardial infarction.

**Methods and Results**—In 13 anesthetized open-chest dogs, the left anterior descending coronary artery was occluded for 180 minutes, followed by 180 minutes of reperfusion. 201Tl and 99mTc-N-NOET were injected after either 60 (group 1, n=9) or 175 (group 2, n=4) minutes of reperfusion. Myocardial blood flow was measured by radioactive microspheres, and 201Tl and 99mTc-N-NOET tissue activities were determined by gamma-well counting. Normalized myocardial blood flow in the central infarct zone fell from 0.80±0.03 (SEM) and 0.89±0.01 at baseline to 0.18±0.04 and 0.13±0.02 during the occlusion in groups 1 and 2, respectively. Normalized 201Tl activity in these segments was 0.39±0.04 and 0.43±0.04 and reflected myocardial viability rather than reperfusion flow (P<0.001). Normalized 99mTc-N-NOET activity in the same segments was 0.84±0.08 and 0.64±0.03, respectively (P<0.01 versus 201Tl; P=NS versus reperfusion flow) and more accurately reflected reperfusion flow (0.99±0.17 and 0.70±0.04) than residual viability.

**Conclusions**—The myocardial uptake of 99mTc-N-NOET reflects reperfusion myocardial blood flow and not viability in a canine model of reperfused acute myocardial infarction. The clinical use of early 99mTc-N-NOET imaging to assess the success of coronary reperfusion in patients with acute myocardial infarction should be investigated. (Circulation. 2000;101:2424-2430.)

**Key Words:** radioisotopes ■ myocardial infarction ■ thallium ■ technetium

The aim of thrombolytic therapy in the acute phase of myocardial infarction is to achieve early reperfusion of the infarct-related artery achieving TIMI-3 flow. Despite advances in this field, failure to achieve successful reflow still occurs in 30% to 40% of cases.1 Rescue PTCA may be useful in subsets of patients who fail to reperfuse with thrombolytic therapy.2 Clinical and ECG criteria for assessing the success or failure of thrombolysis are suboptimal,3 and deciding whether a patient is a candidate for rescue PTCA is often difficult. Myocardial contrast echocardiography has been shown to be of interest for such indication, but an intravenous myocardial contrast agent has not yet been validated for clinical applicability.4

Radionuclide perfusion imaging theoretically should be an excellent approach for assessing the efficacy of reperfusion early after thrombolytic therapy, but the myocardial uptake of tracers in clinical use is dependent on myocardial metabolic status and cellular viability and therefore will underestimate reperfusion flow in this setting.5-9 Results from studies using 99mTc-teboroxime, a neutral, highly lipophilic agent, in this setting are conflicting.10,11 Furthermore, rapid myocardial clearance of 99mTc-teboroxime limits its clinical usefulness for acute single photon emission CT (SPECT) imaging.12,13 N-Ethoxy-N-ethyl-dithiocarbamato-nitrido-99mTc (99mTc-N-NOET) is a new neutral, lipophilic myocardial perfusion imaging agent that has an uptake pattern that correlates well with myocardial blood flow in a canine model of myocardial ischemia14 and undergoes significant rest-redistribution over time in experimental models of transient coronary occlusion and sustained low coronary flow.14,15 Furthermore, cellular uptake of 99mTc-N-NOET has recently been shown to be independent of metabolic poisons that damage cell membranes and the cellular ATP content in cultured newborn rat cardiomyocytes.16

The aim of this study was to determine whether 99mTc-N-NOET uptake after coronary reperfusion, preceded by 180...
minutes of coronary occlusion, will be more reflective of reperfusion flow than of cellular viability, because cellular uptake of $^{99m}$Tc-N-NOET is not energy-dependent and does not require intracellular uptake for myocardial sequestration.

**Methods**

**Surgical Preparation**

Thirteen fasted male adult mongrel dogs were anesthetized with sodium pentobarbital (30 mg/kg), intubated, and ventilated on a respirator (Harvard Apparatus) with 4 cm H$_2$O of positive expiratory pressure. Arterial blood gases were closely monitored, and appropriate ventilation adjustments were performed to maintain pH, P$_{O_2}$, P$_{CO_2}$, and HCO$_3$ within physiological ranges. Lead II of the ECG was continuously monitored during the experiments. The left femoral vein was cannulated with an 8F polyethylene catheter (Cordis) for fluid administration, additional anesthesia, and $^{99m}$Tc-N-NOET injections. Both femoral arteries were cannulated with similar catheters for arterial blood samples for blood gas determinations and radiolabeled microsphere reference blood withdrawals. The left main carotid artery was cannulated with an 8F sheath for monitoring systemic arterial pressure. A Millar high-fidelity pressure-recording catheter was introduced through this sheath and advanced into the LV cavity for measurement of LV pressure and dP/dt.

The open-chest canine surgical preparation used in these experiments was described previously.$^{17}$ Briefly, a left thoracotomy was performed at the level of the fifth intercostal space, and the heart was suspended in a pericardial cradle. A 1.5-cm section of the LAD was dissected free of the epicardium and loosely encircled with a snare occluder. LAD and LCx coronary blood flows were measured with ultrasonic flow probes (T206, Transonic Systems), and regional systolic thickening in the LAD zone was measured with an epicardially located Doppler crystal (Crystal Biotech). Throughout each experiment, heart rate, systemic arterial pressure, left atrial pressure, LV pressure, dP/dt, ultrasonic flows, and LAD systolic wall thickening were continuously recorded on a 16-channel strip-chart recorder (Astromed) and simultaneously digitized and stored on a 133-MHz Pentium-based personal computer. All experiments were performed with the approval of the University of Virginia Animal Research Committee and were in compliance with the position of the American Heart Association on the use of research animals.

**Experimental Protocol**

After instrumentation, steady-state hemodynamic measurements were made for 30 minutes, and radiolabeled microspheres were injected for determination of baseline myocardial blood flow (Figure 1). Next, the LAD was totally occluded, and a second set of microspheres was injected 165 minutes later for determination of occlusion myocardial blood flow. After a total of 180 minutes of occlusion, the LAD was completely reperfused for an additional 180 minutes. After either 60 (group 1, n = 9) or 175 (group 2, n = 4) minutes of reflow, $^{201}$Tl (18.5 MBq; 0.5 mCi) and $^{99m}$Tc-N-NOET (296 MBq; 8 mCi) were co-injected with a third set of microspheres. Group 1 dogs also had a fourth set of microspheres injected at the end of the experiment. Before the dogs were euthanized with an overdose of sodium pentobarbital, the LAD was briefly reoccluded, and 20 mL of monastral blue dye was rapidly injected into the left atrial catheter to delineate the anatomic risk area.

**Preparation and Quality Control of $^{99m}$Tc-N-NOET**

$^{99m}$Tc-N-NOET kits were obtained from Cis-bio international. The preparation of this radiopharmaceutical has been described in detail.$^{16}$ Quality control was performed with thin-layer chromatography with Silica gel plates (J.T. Baker) and dichloromethane. Radiochemical purity was $>$90% in each experiment.

**In Vivo Image Acquisition and Defect Magnitude Quantification**

In the group 1 dogs, planar images were acquired in the left lateral oblique projection with a standard gamma-camera (Technicare 420, Ohio Nuclear) equipped with an all-purpose, low-to-medium-energy collimator at 5, 15, 30, 60, 90, and 120 minutes after tracer injection. Background was subtracted from all images by use of a previously validated interpolative algorithm$^{18}$ without thresholding or filtering. To quantify the $^{99m}$Tc-N-NOET activity on images, regions of interest (ROIs) were drawn on the defect area of the anterosetal wall supplied by the LAD and on the posterior wall supplied by the LCx. The LAD/LCx defect count ratio was computed by dividing the average counts in the ischemic ROI by the average counts in the nonischemic ROI.

**Microsphere-Derived Regional Myocardial Blood Flow and $^{201}$Tl and $^{99m}$Tc-N-NOET**

**Myocardial Activities**

The technique used in our laboratory to quantify myocardial blood flow by radiolabeled microspheres was described previously.$^{19}$ After the dogs were euthanized, the LV was divided into 4 slices $\sim$1.5 cm thick, and each slice was divided into 6 transmural sections. Each of these transmural sections was then subdivided into epicardial, midwall, and endocardial segments, resulting in 72 LV segments. The myocardial segments were counted for $^{99m}$Tc activity in a gamma-well counter (MINAXI 5550, Packard Instruments) within 24 hours. The myocardial segments were recounted for $^{201}$Tl activity 3 days later after $^{99m}$Tc had decayed. Finally, a third count was performed 3 weeks later for quantification of microsphere activities when $^{201}$Tl activity was negligible. The gamma-counter window settings were $^{113}$Sn, 340 to 440 keV; $^{103}$Ru, 450 to 550 keV; $^{95}$Nb, 640 to 840 keV; and $^{82}$Sc, 842 to 1300 keV. Tissue counts were corrected for background, decay, and isotope spillover, and regional myocardial blood flow was calculated by computer software developed for this purpose (PCGERDA, Scientific Computing Solutions, LLC).

**Postmortem Determination of Risk Area and Infarct Size**

The endocardial and epicardial surfaces of each heart slice and the borders of the monstral blue dye–determined risk area were traced on acetate sheets. The heart slices were then incubated for 10 minutes at $37°C$ in a 2% solution of TTC to delineate infarct area. The infarct area was then traced onto the previous acetate sheets. Risk area (monstral blue dye–negative) and infarct areas (TTC-negative) were determined with a digital planimeter program as previously described.$^{17}$

**Data Analysis**

Myocardial blood flows and tracer activities in each sample were normalized to the average activity of 15 reference samples from the posterior LV wall (5 transmural segments â 3 layers) that exhibited normal absolute myocardial blood flow during occlusion. Each segment was then grouped according to the flow reduction observed during the occlusion period. Segments with flow $<0.3$, $\geq0.3$ and $<0.5$, and $\geq0.5$ mL $\cdot$ min$^{-1}$ $\cdot$ g$^{-1}$ were classified as infarct, border, and normal zones, respectively.
The risk area (monastral blue dye–negative area) was 29.9 ± 1.8% of the left ventricle (LV). By triphenyltetrazolium chloride (TTC) staining, 15.9 ± 2.1% of the LV was infarcted. The infarct size was 43.4 ± 3.3% of the risk area.

**Microsphere Blood Flow**

Table 2 summarizes the normalized myocardial blood flow and \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET activities in normal, border-zone, and infarcted samples from the 2 groups of dogs. In group 1 dogs, regional myocardial blood flow ratios in the normal samples did not change throughout the experiments. In group 2 dogs, there was a statistically significant decrease in normal-zone flow between baseline and occlusion. Nevertheless, flow in these segments during occlusion (0.89 mL·min \(^{-1}\)·g \(^{-1}\)) remained within the normal flow range of a canine heart (0.8 to 1.2 mL·min \(^{-1}\)·g \(^{-1}\)). In border-zone and infarcted samples of both groups, there was a trend toward slightly higher myocardial blood flow at baseline in group 2 versus 1; however, this difference did not reach statistical

**TABLE 1. Hemodynamic Variables**

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>Occlusion</th>
<th>Reperfusion</th>
<th>End</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate, bpm</td>
<td>129±7</td>
<td>129±6</td>
<td>124±8</td>
<td>120±7</td>
</tr>
<tr>
<td>AP, mm Hg</td>
<td>111±6</td>
<td>102±4</td>
<td>96±5*</td>
<td>89±5*</td>
</tr>
<tr>
<td>LAP, mm Hg</td>
<td>7±0</td>
<td>9±1*</td>
<td>10±1†</td>
<td>9±1†</td>
</tr>
<tr>
<td>LAD flow, mL/min</td>
<td>21±3</td>
<td>0±0‡</td>
<td>24±4</td>
<td>16±2‡</td>
</tr>
<tr>
<td>LAD wall thickening, %</td>
<td>21±2</td>
<td>−6±1§</td>
<td>−6±1§</td>
<td>−6±1§</td>
</tr>
<tr>
<td>LCx flow, mL/min</td>
<td>32±4</td>
<td>36±5</td>
<td>32±4</td>
<td>27±3</td>
</tr>
<tr>
<td>dP/dt, mm Hg/s</td>
<td>2104±162</td>
<td>1842±183</td>
<td>1868±225</td>
<td>1863±212</td>
</tr>
</tbody>
</table>

End indicates end of the experiment; AP, mean arterial pressure; LAP, mean left atrial pressure. Values are mean±SEM.

\( ^*P<0.05 \) vs baseline; †P<0.01 vs baseline; ‡P<0.01 vs baseline and \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET injection; §P<0.001 vs baseline.

**RESULTS**

**Statistical Analysis**

Mean and SEM computations were performed with SYSTAT software (SPSS, Inc). Comparisons within each group were made with either a paired Student’s \(t\) test or repeated-measures ANOVA with post hoc comparisons of changes determined, a priori, to be of interest. In the group 2 dogs, linear regression analyses were performed to assess the correlations between \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET myocardial uptake with regional myocardial blood flow.

**Hemodynamics**

Hemodynamic data for the 13 dogs are summarized in Table 1. There was no significant difference in hemodynamic data between the 2 groups, and therefore, the hemodynamic data were pooled. Heart rate, left circumflex coronary artery (LCx) ultrasonic flow, and maximum positive first derivative of LV pressure (dP/dt) did not change throughout the experiments. Mean arterial pressure remained constant during baseline, occlusion, and reperfusion but decreased significantly at the end of the experiments. Mean left atrial pressure increased significantly after occlusion and then remained unchanged during occlusion and reperfusion. Ultrasonic left anterior descending coronary artery (LAD) flow fell from 21±3 mL/min during baseline to 0±0 mL/min after the occlusion was set (\(P<0.001\)). Sixty minutes after reflow, at the time when \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET were injected in 9 of the 13 dogs, LAD flow had returned to baseline (24±4 mL/min). However, as is frequently observed in experimental models of coronary occlusion and reperfusion with severe infarction, coronary flow gradually decreased in the reperfused LAD zone over 3 hours. Regional systolic wall thickening in the central region supplied by the LAD distal to the occluder decreased from 21±2% during baseline to −6±1% after occlusion (\(P<0.001\)) and remained constant throughout the rest of the experiment during occlusion and after reperfusion.

**Risk Area and Infarct Size**

The risk area (monastral blue dye–negative area) was 29.9 ± 1.8% of the left ventricle (LV). By triphenyltetrazolium chloride (TTC) staining, 15.9 ± 2.1% of the LV was infarcted. The infarct size was 43.4 ± 3.4% of the risk area.

**TABLE 2. Normalized Myocardial Blood Flow and \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET Activities**

<table>
<thead>
<tr>
<th></th>
<th>Baseline MBF</th>
<th>Occlusion MBF</th>
<th>Injection MBF</th>
<th>2 hr Postinjection MBF</th>
<th>(^{201})Tl Activity</th>
<th>NOET Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal samples</td>
<td>0.97±0.01</td>
<td>0.93±0.02</td>
<td>0.98±0.02</td>
<td>0.94±0.02</td>
<td>0.95±0.01</td>
<td>1.01±0.01§</td>
</tr>
<tr>
<td>Border-zone samples</td>
<td>0.84±0.03</td>
<td>0.48±0.03*</td>
<td>1.15±0.12</td>
<td>0.74±0.06</td>
<td>0.65±0.02</td>
<td>1.02±0.05§</td>
</tr>
<tr>
<td>Infarct samples</td>
<td>0.80±0.03</td>
<td>0.18±0.04*</td>
<td>0.99±0.17</td>
<td>0.57±0.06*</td>
<td>0.39±0.04</td>
<td>0.84±0.08§</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal samples</td>
<td>0.98±0.01</td>
<td>0.89±0.01*</td>
<td>0.93±0.02†</td>
<td>...</td>
<td>0.93±0.01</td>
<td>0.94±0.01†</td>
</tr>
<tr>
<td>Border-zone samples</td>
<td>0.90±0.03</td>
<td>0.39±0.04*</td>
<td>0.82±0.03</td>
<td>...</td>
<td>0.64±0.06</td>
<td>0.77±0.02‡</td>
</tr>
<tr>
<td>Infarct samples</td>
<td>0.89±0.01</td>
<td>0.13±0.02*</td>
<td>0.70±0.04†</td>
<td>...</td>
<td>0.43±0.04</td>
<td>0.64±0.03§</td>
</tr>
</tbody>
</table>

MBF indicates myocardial blood flow determined by radiolabeled microspheres; Injection, at the time of \(^{201}\)Tl and \(^{99m}\)Tc-N-NOET injection after either 1 hour (group 1) or 3 hours (group 2) of reperfusion.

\( ^*P<0.01 \) vs baseline; †P<0.05 vs baseline; ‡P<0.05 group 1 vs group 2; §P<0.01 NOET vs \(^{201}\)Tl.
figure 2. Normalized reperfusion flow (solid bars), 201 Tl activity (open bars), and 99mTc-N-NOET activity (hatched bars) according to subendocardial blood flow values during LAD occlusion in 9 group 1 dogs. 201 Tl uptake is severely reduced in infarct region, reflecting degree of necrosis. 99mTc-N-NOET uptake is significantly higher than 201 Tl uptake in border-zone and infarct regions and is more reflective of flow at time of tracer injection during reperfusion. Normal, border, and infarct zones are defined by subendocardial myocardial blood flow >0.5, 0.3 and <0.3 mL min⁻¹.g⁻¹, respectively. *P<0.05 vs reperfusion flow, †P<0.001 vs 201 Tl.

Comparison Between Myocardial 99mTc-N-NOET and 201 Tl Activities

Group 1
As shown in Figure 2, when 99mTc-N-NOET was injected 1 hour after reperfusion followed by 2 additional hours of reperfusion flow, the final activity ratios in the border-zone and infarcted segments (1.02±0.05 and 0.84±0.08) were significantly higher than those of 201 Tl in the same segments (0.65±0.02 and 0.39±0.04). In addition, there was no significant difference between the final 99mTc-N-NOET activity ratios and the myocardial blood flow ratios at the time of injection (1.15±0.02 and 0.99±0.17) in these same segments. There was no significant difference between 99mTc-N-NOET and 201 Tl activities in the normal-zone segments.

99mTc-N-NOET Activity by In Vivo Imaging
Figure 3 depicts mean 99mTc-N-NOET defect count ratios (LAD/LCx) obtained from serial quantitative imaging in the group 1 dogs. Substantial myocardial 99mTc-N-NOET uptake was observed initially, with a defect count ratio of 0.72±0.06 at 5 minutes after injection. In addition, significant redistribution resulted from differential myocardial clearance of 99mTc-N-NOET over the next 2 hours, with defect count ratios of 0.71±0.08, 0.74±0.05, 0.77±0.04, 0.80±0.04, and 0.82±0.03 at 15, 30, 60, 90, and 120 minutes after injection, respectively (ANOVA P<0.001).

Discussion
The main finding of this study is that 99mTc-N-NOET uptake in reperfused, acutely injured myocardium is significantly higher than that of simultaneously administered 201 Tl and reflects myocardial blood flow restoration at the time of tracer injection, rather than myocardial viability. This finding is unique when 99mTc-N-NOET is compared with most of the other myocardial perfusion imaging agents administered in this setting.

Because 60% of 201 Tl uptake is related to Na⁺/K⁺-ATPase activity, necrotic cells with membrane disruption and loss in ATP content cannot retain 201 Tl. In cultured myocardial cells submitted to ischemia-like injury, as well as in isolated rat hearts under hypoxic and energy-depletion conditions, 201 Tl uptake is dramatically reduced compared with controls. This
decrease in $^{201}$Tl uptake is correlated to the amount of lactate dehydrogenase efflux and therefore to cell necrosis. Similarly, myocardial uptake of $^{99m}$Tc-sestamibi is depressed in infarcted myocardium. This decrease is thought to be related to the diminution of sarcolemmal and mitochondrial membrane potentials. In a similar canine model of reperfused, acutely infarcted myocardium, $^{99m}$Tc-sestamibi defect magnitude on planar images correlated with the extent of necrosis as assessed by histochemical analysis rather than reperfusion flow. Using a rabbit model, Heller et al found that $^{99m}$Tc-teboroxime uptake in this setting reflects myocardial blood flow and is independent of myocardial viability. However, results from studies examining the uptake of this agent in reperfused acute myocardial infarction are conflicting. Using a rabbit model, Heller et al found that $^{99m}$Tc-teboroxime uptake in this setting reflects myocardial blood flow and is independent of myocardial viability. Conversely, in a study in pigs by Abraham et al, the infarct-to-normal $^{99m}$Tc-teboroxime uptake ratio (0.85±0.32) is intermediate between myocardial blood flow ratios during occlusion (0.25±0.35) and after reperfusion (1.54±0.94) and thus could be dependent on both flow and viability.

![Figure 4](image)

**Figure 4.** Individual scatterplots of $^{201}$Tl (○) and $^{99m}$Tc-N-NOET (●) activities vs flow at time of tracer injection after reflow in 4 group 2 dogs. In all 4 dogs, $^{99m}$Tc-N-NOET activity was highly correlated with reperfusion flow, even though some segments were nonviable. In contrast, $^{201}$Tl activity fell below identity line, and there was poor correlation with flow in reperfused, nonviable segments. Tracer activities were comparable in nonreperfused (no reflow) and in reperfused, viable segments.

![Figure 5](image)

**Figure 5.** TTC-stained heart slice (left) and $^{201}$Tl (middle) and $^{99m}$Tc-N-NOET (right) images of same heart slice. Prominent anteroseptal defect observed on $^{201}$Tl image reflects large transmural infarct on TTC photograph. In contrast, there was substantial heterogeneous $^{99m}$Tc-N-NOET uptake in same anteroseptal region despite presence of severe infarction. Heterogeneous pattern of $^{99m}$Tc-N-NOET uptake resulted from a similar pattern of reperfusion flow.

The exact uptake mechanism of $^{99m}$Tc-teboroxime, a highly lipophilic perfusion agent, is unknown, but it is thought to bind nonspecifically to cell membranes. Like $^{99m}$Tc-N-NOET, $^{99m}$Tc-teboroxime uptake is not dependent on cellular metabolism and viability. However, results from studies examining the uptake of this agent in reperfused acute myocardial infarction are conflicting. Using a rabbit model, Heller et al found that $^{99m}$Tc-teboroxime uptake in this setting reflects myocardial blood flow and is independent of myocardial viability. Conversely, in a study in pigs by Abraham et al, the infarct-to-normal $^{99m}$Tc-teboroxime uptake ratio (0.85±0.32) is intermediate between myocardial blood flow ratios during occlusion (0.25±0.35) and after reperfusion (1.54±0.94) and thus could be dependent on both flow and viability.

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viability. These divergent findings may result from species differences or from differing delays between tracer injection and image acquisition or sacrifice, a potentially major source of variation due to the rapid myocardial clearance of this agent.12

Although the precise mechanism of 99mTc-N-NOET myocardial uptake is unknown, this radiopharmaceutical has been demonstrated to associate with the lipophilic components of the myocytes,26 to have an extremely high myocardial retention in isolated perfused rabbit hearts,27 and to undergo increased clearance after severe cell membrane damage.27 In cultured newborn rat cardiomyocytes, 99mTc-N-NOET uptake has also been demonstrated to be independent of cellular metabolic status or ATP content.16

Thus, the data from the present study could be explained by the fact that in reperfused, acutely infarcted myocardium, 99mTc-N-NOET may bind to cell membranes, even if the myocytes are significantly damaged by ischemia and reperfusion. Within the first hour after reperfusion after acute myocardial infarction, microvascular integrity may permit almost complete reflow, as demonstrated in the present study.28 This reflow allows 99mTc-N-NOET to gain access to myocytes that may be in the phase of irreversible cell injury.4 Another potential explanation for high 99mTc-N-NOET uptake in zones of ongoing necrosis is binding of the tracer to neutrophils that aggregate in reperfused myocardium, ultimately contributing to the no-reflow phenomenon.28 The experimental findings of the present study do not necessarily contradict the diminution in 99mTc-N-NOET uptake observed in patients with chronic myocardial infarction.29 In this setting, no myocyte membranes available for 99mTc-N-NOET binding exist, and fibrosis and scar prevent the uptake of 99mTc-N-NOET.

**Study Limitations**

In the present study, 99mTc-N-NOET and 201Tl were injected under the same flow conditions, yet their uptake patterns were quite different.30 Another potential explanation for high 99mTc-N-NOET uptake in zones of ongoing necrosis is binding of the tracer to neutrophils that aggregate in reperfused myocardium, ultimately contributing to the no-reflow phenomenon.28 The experimental findings of the present study do not necessarily contradict the diminution in 99mTc-N-NOET uptake observed in patients with chronic myocardial infarction.29 In this setting, no myocyte membranes available for 99mTc-N-NOET binding exist, and fibrosis and scar prevent the uptake of 99mTc-N-NOET.

**Clinical Implications**

Our experimental model of reperfused, acutely infarcted myocardium suggests that 99mTc-N-NOET uptake reflects more the magnitude of flow restoration rather than the extent of myocardial salvage. Clinically, it remains to be determined whether 99mTc-N-NOET imaging performed 15 to 20 minutes after injection in the setting of thrombolysis in acute myocardial infarction can prove useful in assessing vessel patency. Another clinical implication of this study is that 99mTc-N-NOET will not be a valid viability agent in attempts to assess the degree of salvage very early after coronary reperfusion. Myocardial perfusion agents such as 201Tl, 99mTc-sestamibi, and 99mTc-tetrofosmin would appear to be preferable in this setting. Finally, studies comparing radionuclide imaging using 99mTc-N-NOET with other noninvasive techniques, such as contrast echocardiography and contrast MRI imaging, for accurate assessment of the degree of reflow after reperfusion in the setting of acute myocardial infarction appear warranted.

**Acknowledgment**

This study was supported in part by a research grant from Cis-bio international. The authors thank Cis-bio international for its support of this experimental study.

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Circulation. 2000;101:2424-2430
doi: 10.1161/01.CIR.101.20.2424

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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