Effect of Coronary Blood Flow on Thallium-201 Uptake and Washout

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SUMMARY  Myocardial uptake and washout of thallium-201 (201TI) were studied in an experimental dog model in which regional blood flow to the posterior wall was varied by transient 2-minute occlusion of the circumflex coronary artery to produce transient ischemia and reactive hyperemia. Thallium-201 myocardial activity in a region of interest was determined continuously after i.v. administration by a gamma camera and computer program. Activity in the posterior wall was compared with that in the anterior wall in the same dog and the posterior wall of control dogs. Thallium-201 uptake was directly related to blood flow. With reactive hyperemia, there was a rapid and absolute increase in uptake followed by rapid washout; with ischemia, there was slow and decreased uptake followed by a slow washout. The calculated myocardial activity during washout in both ischemic and hyperemic areas approached values in control dogs long after blood flow had returned to baseline levels. Significant differences in washout slopes were found between the three groups of dogs (−0.156%/min in control dogs, −0.244%/min after reactive hyperemia, and −0.076%/min after transient ischemia, with half-washout times of 5.3 hours, 3.4 hours and 11.0 hours, respectively). These data suggest that both the initial decrease in activity in the ischemic area and the initial excess in the hyperemic area are corrected by different washout rates of ischemic and hyperemic cells during redistribution.

DESPITE extensive investigation of thallium-201 (201TI) kinetics, the mechanisms responsible for a positive 201TI exercise test, i.e., an initial defect which disappears on delayed images, are not known. The test is useful in clinical assessment of coronary artery disease but, as with any test, an understanding of its limitations depends on knowledge of its basic mechanisms.

Differences in findings between experimental studies often result from differences in design. There is general agreement that myocardial uptake of 201TI is closely related to coronary flow at rest and exercise. Myocardial uptake is also increased by other interventions that increase coronary perfusion, including reactive hyperemia, adenosine or dipyridamole. The fraction of 201TI extracted by myocardial cells from blood is a potential variable, but apparently remains relatively constant under most conditions. One of the aims of this study was to investigate the time course of myocardial uptake after transient ischemia and reactive hyperemia.

Considerably less attention has been paid to the role of myocardial washout of 201TI during the redistribution process which follows peak accumulation. The few studies of the myocardial washout phase have produced significant differences in results that could be explained by differences in experimental design. This study was designed to elucidate myocardial 201TI activity quantitatively and continuously during the uptake and washout phases in an experimental intact dog model in which regional coronary blood flow could be decreased during transient ischemia produced by 2-minute occlusion of the circumflex coronary artery and increased during reactive hyperemia.

Methods

Preparation

Five mongrel dogs that weighed 26–32 kg were anesthetized with sodium pentobarbital and respiration was controlled with a mechanical respirator. Through a left thoracotomy, a Konigsberg micro-manometer was inserted through the left ventricular apex to record pressure. To record dimensional changes, a pair of ultrasonic dimension crystals was implanted subendocardially, approximately 10 mm apart in the posterolateral wall (experimental area), and another pair was implanted in the anterior wall (control area). A Gould electromagnetic flow probe was placed around the circumflex coronary artery, immediately proximal to a hydraulic occluder. The ends of the occluder and wires were tunneled dorsally to the base of the neck. The dog was allowed to recover for 10 days. Use of ultrasonic dimension gauges to record shortening patterns of a myocardial segment has been reported. Three dogs without surgical intervention served as a control group. At the time of study, a catheter was placed in the superior vena cava for withdrawal of blood samples. Activity of 201TI was calibrated against a standardized Ge(Li) detector, and activities of 2–3 mCi were given intravenously in each study.

Data Collection

Each dog was anesthetized with 30 mg/kg of sodium pentobarbital and placed in the right decubitus position under an Ohio Nuclear (series 100) gamma camera with a parallel-hole, high-sensitivity colimator (to maximize count statistics), which was angled at a 45° left anterior oblique view to visualize the anteroseptal wall (control area: anterior wall) and the posterolateral wall (ischemic area: posterior wall).
Measurements of left ventricular performance included left ventricular pressure, left ventricular dp/dt and segment length changes. These measurements were made to verify ischemia and return to control conditions. In addition, coronary blood flow, heart rate and lead 2 of the ECG were recorded. Arterial blood pH was maintained at 7.40 ± 0.05 and PCO₂ at 30 ± 5 mm Hg throughout the experiment.

The left circumflex coronary artery was occluded for 2 minutes in the dogs with implanted oculuders. For the ischemia study, ²⁰¹TI was administered as an i.v. bolus at the onset of the occlusion. For the reactive hyperemia study, ²⁰¹TI was administered 30 seconds after release of the occlusion at a time which coincided with peak coronary blood flow. Residual ²⁰¹TI activity in the syringe was measured for later correction of the total activity given. Time 0 was designated as the time of ²⁰¹TI administration in each study group. The dynamic ²⁰¹TI activity from the entire field of view, including the left ventricle, were stored continuously in a 64 x 64 matrix and accumulated for each 30-second frame in the computer (Modumed System, MDS) during the initial 30 minutes and then for two successive 1-minute frames at 10-minute intervals thereafter. The studies in control dogs and in the ischemia group were terminated after 3 hours and after 4 hours in the reactive hyperemia group. Each dog served as its own control and was studied for both ischemia and reactive hyperemia at intervals of 1 week.

Blood samples were obtained through an indwelling catheter at 1, 3 and 5 minutes after ²⁰¹TI administration and at 10-20-minute intervals. Activity in each sample was counted in a well scintillation counter, corrected for decay at the time each sample was withdrawn and expressed as activity per milliliter of whole blood. The blood volume was determined using ⁵¹Cr-labeled red blood cells and ¹⁸⁵I-labeled human serum albumin after residual ²⁰¹TI had decayed sufficiently.

Data Analysis

To determine the blood clearance of ²⁰¹TI, expressed as percent activity remaining in the blood pool, a value for 100% ²⁰¹TI activity per milliliter blood at a time 0 was calculated. The calculation assumed that an even distribution of ²⁰¹TI within the blood pool had occurred and was based on the activity of administered ²⁰¹TI and the blood volume. Each measured activity of a given blood sample was expressed as percent activity relative to the time 0 value and the mean value ± SD was calculated at each data point in three groups of dogs (table 1).

Upon completion of the myocardial imaging data collection, 7-10 mCi of technetium-99m pertechnetate was given as a bolus to define the region of the background, and regions of interest from the anterior and posterior walls were defined (fig. 1). Counts obtained over the anterior and posterior walls and the background area were normalized and the background counts were subtracted from the counts obtained over the anterior and posterior walls at each data point (net counts in anterior and posterior walls). Finally, the net counts derived from two adjacent 30-second frames were totaled for each plotted point during the initial 30 minutes; thereafter, two 1-minute frames were averaged to derive the counts per minute at each plotted data point.

The region of the left anterior descending coronary artery received no direct mechanical intervention; therefore, the anterior wall was considered to be a control region in each dog. The peak myocardial activity of ²⁰¹TI in the anterior wall was designated as 100% activity and the rest of the activities in the anterior and posterior walls were expressed relative to this value. Then, the mean value ± SD was calculated at each data point in three groups of dogs to express percent changes of ²⁰¹TI in the myocardium. Similarly, the background activity was expressed relative to the peak activity in the anterior wall. Therefore, the time-activity curves in the anterior and posterior walls and the background were directly comparable. Decay correction was not made for these calculations.

Results

Transient Ischemia

Figure 2 shows typical changes in one dog indicative of regional ischemia and return of these measures of left ventricular performance to control values after recovery. During the occlusion, heart rate increased about 40% (p = 0.05). The left ventricular

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Control (n = 3) (%</th>
<th>Ischemia (n = 5) (%)</th>
<th>Reactive hyperemia (n = 5) (%)</th>
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<tr>
<td>240</td>
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Values are mean ± SD.
systolic pressure tended to be slightly lower during the occlusion. The left ventricular end-diastolic pressure increased significantly ($p < 0.005$). Left ventricular $dP/dt$ did not change significantly. A typical ECG change during the occlusion was an elevation of the ST segment, but depression was also observed in two of 10 experiments.

During ischemia, segment length shortening in the control region of the anterior wall remained within 10% of the baseline segment length. The ultrasonic crystals in the ischemic region of the posterior wall showed diminished systolic shortening or even passive elongation (fig. 2).$^{27,28}$ No abnormal changes in shortening pattern were seen in the anterior wall.

**Figure 1.** (upper) The blood pool image of the left ventricular cavity and the great vessels in the left anterior oblique view (LAO) after i.v. technetium-99m and (lower) upon completion of the data collection of thallium-201. This allowed definition of a region of background (Bkg) between the aorta and left atrium, and regions of interest in the anterior and posterior walls (ROI). At each data point after normalization, the background activity was subtracted from the region of interest to calculate the net counts from the myocardium.

**Figure 2.** Measurements of left ventricular performance before, during and after occlusion of the circumflex coronary artery. The ischemic changes (see text) have disappeared within a few minutes after release of the occlusion.
Immediately after release of the occlusion, an increase in segmental shortening was found in the ischemic area. These functional changes returned to near-baseline levels within a few minutes.

Reactive Hyperemia

Blood flow in the circumflex coronary artery reached its peak within 15 seconds after release of the occlusion, and peak flow was about three times greater than baseline flow in all dogs (fig. 3). The peak flow continued for more than 1 minute and returned to the approximate baseline level in 3–4 minutes.

Time Activity Changes of $^{201}$TI

The changing $^{201}$TI myocardial activity in the anterior and posterior walls in the control group is shown in figure 4. The peak $^{201}$TI activity from the anterior wall was seen 40 minutes after administration. Thallium-201 activity was consistently higher in the posterior wall than in the anterior wall ($p < 0.001$) (figs. 4 and 5), as more muscle tissue was included in the posterior wall because the right decubitus position was used.

The time-activity curves in the ischemia studies are shown in figure 6. The peak $^{201}$TI activity in the anterior wall occurred 50 minutes after administration, while activity in the posterior wall peaked at 80 minutes and, on the average, equaled that in the anterior wall at 120 minutes; the two time-activity curves tended to cross over with time. Because of a large variability of activities in the posterior walls of the small number of dogs studied, only a marginally significant statistical difference in uptake was found ($p \approx 0.05$). The left ventricular scintigrams in a given dog, however, clearly demonstrated decreased activity in the posterior wall relative to the anterior wall during the first hour after release of the occlusion (fig. 5).

Data from the reactive hyperemia studies are shown in figure 7. The peak $^{201}$TI uptake in the anterior wall occurred 50 minutes after time 0, whereas the peak uptake in the posterior wall was found in 10 minutes. The peak activity in the posterior wall was 1.8–3.0 times higher than the peak value in the anterior wall. When uptake values in the posterior and anterior walls were compared at 10 minutes the posterior wall showed 2.3–3.7-fold higher $^{201}$TI activity. That is, the increase in $^{201}$TI activity in the posterior wall was approximately proportional to the increase in circumflex coronary flow induced by reactive hyperemia, and significantly higher than that in the anterior wall, where coronary flow presumably was little changed ($p < 0.001$). However, the peak flow and the peak $^{201}$TI uptake did not coincide in time. Peak $^{201}$TI uptake followed peak flow by approximately 10 minutes in all dogs. These changes in myocardial $^{201}$TI activity were confirmed visually (fig. 5).

Thallium-201 washout was approximately linear after peak uptake (figs. 4, 6 and 7). Thus, washout data were fitted by least-squares analysis to a straight line, $y = a + bx$. A normalized rate of change, $b/a$, was calculated for each dog and this was designated as the washout slope, and expressed as a percent of loss of activity per minute ($%/\text{min}$). The washout slopes were expressed as the mean ± sd in the anterior wall of the control, ischemia, and reactive hyperemia groups, and were $-0.122 \pm 0.032\%/\text{min}$, $-0.138 \pm 0.063\%/\text{min}$, respectively. Washout slope in the posterior wall was $-0.156 \pm 0.030\%/\text{min}$, compared with $-0.076 \pm 0.020\%/\text{min}$ in the ischemia group and $-0.244 \pm 0.034\%/\text{min}$ in the reactive hyperemia group. The washout slopes of the anterior
Scintigrams obtained during typical experiments in three dogs: control (top), ischemia (middle) and reactive hyperemia (bottom).

Figure 5. Scintigrams obtained during typical experiments in three dogs: control (top), ischemia (middle) and reactive hyperemia (bottom).

Figure 6. Time-activity curves in the anterior and posterior walls were obtained in the ischemia group of five dogs by the same method as described in figure 4. The ischemic posterior wall had a significantly slower uptake and reached its peak 80 minutes after thallium-201. This was followed by slower washout slope, \(-0.076 \pm 0.020\) \%/min, compared to the anterior wall, \(-0.122 \pm 0.032\) \%/min.

There was a tendency for activity crossover between anterior and posterior walls after 120-140 minutes, suggesting that the similar activity ratio between anterior and posterior walls (fig. 4) will follow with time.

Figure 7. Time-activity curves in the anterior and posterior walls obtained from the same group of dogs shown in figure 6. A significantly increased uptake in the posterior wall was found, which peaked 10 minutes after maximal blood flow induced by reactive hyperemia. The peak activity was followed by rapid washout in the posterior wall \(-0.244 \pm 0.034\) \%/min, compared with a relatively slow washout in the anterior wall \(-0.138 \pm 0.063\) \%/min.
The mean half-washout time from the posterior wall was 5.3 hours in the control group, 3.4 hours in the reactive hyperemia and 11.0 hours in the ischemia group.

**Uptake and Washout of $^{201}$Tl**

In contrast to the significant differences in the time-activity curves in the posterior walls of the three study groups, the range of average time activities from the anterior walls was small in the three groups (fig. 9). The percent activity in the anterior wall and in background approximated each other soon after the peak uptake in the anterior wall was realized, and the approximate myocardium to background ratio of 1:1 persisted thereafter. This has been observed previously in humans and experimental animals. The highest background activity was seen in the ischemia group in the initial several minutes, but a significant difference was found only at 1 minute ($p < 0.005$). Although the blood pool activity is not the same as the background activity, it is largely responsible for background counts soon after administration, and this is noted in the significantly delayed $^{201}$Tl clearance at 1 minute in the ischemia group ($p < 0.01$) (table 1). The residual percent $^{201}$Tl activity in blood was nearly identical in the three groups at 3 minutes and thereafter. Background counts during the first several minutes shift rapidly from the blood pool to other tissues (table 1). In addition, percent activity in the anterior wall in the three groups at each data point showed no significant difference. These findings of nearly equal activity in anterior wall, background and residual blood pool activity in three groups provide a basis for comparing activity in the posterior wall. The activities in the posterior wall in three groups were all significantly different from each other at each data point, except at 160 and 180 minutes in the comparison between control and reactive hyperemia groups. These findings emphasize the differences in $^{201}$Tl kinetics in the uptake and washout phases as a result of altered coronary blood flow and the timing of $^{201}$Tl administration. Further, a rapid washout of $^{201}$Tl after its rapid and increased uptake in the reactive hyperemia group corrected its initial excess to about the same level as the control group at 160 minutes. Thus, the activity in the posterior wall was absolutely increased with reactive hyperemia and absolutely decreased with ischemia.

**Discussion**

A better understanding of $^{201}$Tl kinetics during and after regional myocardial ischemia requires careful interpretation of reported findings in relation to experimental design. Our findings are applicable to a situation in which $^{201}$Tl is given during transient ischemia or during the peak flow of reactive hyperemia. Thallium uptake by myocardial cells depends on both myocardial perfusion and extraction by myocardial cells. Our findings strongly suggest that a major determinant of $^{201}$Tl uptake during transient ischemia is the magnitude of coronary blood flow at the time of $^{201}$Tl administration. During total occlusion of the circumflex coronary artery, uptake occurs but is markedly diminished. That any uptake occurs at all is presumably attributable to collateral circulation, which is ex-

![Figure 8](http://circ.ahajournals.org/)

**Figure 8.** Mean (± sd) time-activity curves in the posterior wall of the control group, ischemia group, and reactive hyperemia group. The washout slopes are significantly different.

![Figure 9](http://circ.ahajournals.org/)

**Figure 9.** Time-activity curves in the anterior wall (AW) and background (Bkg) in the three groups. Since the background was expressed relative to the peak net count of the anterior wall, both the AW and Bkg are directly comparable. The percent activities in both AW and Bkg become virtually identical soon after the peak activity in the AW in three groups of dogs, and remain equal during the subsequent washout phase. This finding indicates the equal washout rate of thallium-201 from the unaffected AW and the surrounding tissue, and also supports the assumption that the different activities observed in the posterior walls in three groups of dogs are absolute.
tensive in the dog. Immediately after release of the 2-
minute occlusion, uptake may have been enhanced 
transiently by reactive hyperemia. Thereafter, myo-
cardial perfusion was normal. Peak myocardial ac-
itivity in the ischemic area was not reached until 80 
minutes, presumably because of a very low concentra-
tion of $^{201}$TI in circulating blood and, hence, a low con-
centration gradient between blood and ischemic cells. 
Diminished extraction seems unlikely. Ultrasonic 
measurements of left ventricular performance, which 
have been shown to be a reliable indicator of isch-
emia,27 returned to normal within a few minutes 
after release of the occlusion. During reactive 
hyperemia, uptake appeared to be directly propor-
tional to coronary blood flow.

The rapid and large net gain of $^{201}$TI in reactive 
hyperemia was followed by rapid net loss. The slow 
gain after transient ischemia was followed by a slow 
loss. These induced abnormal states slowly ap-
proached the normal resting state over time by cor-
recting initial excess or deficit after flow returned to 
baseline levels. The observed differences of $^{201}$TI up-
take and washout are absolute, not relative, differ-
ces that reflect the magnitude of coronary blood 
flow. Thus, redistribution is likely a dual phenomenon 
in which the initial excess or deficit is corrected by 
differential clearance of $^{201}$TI from the normal or 
hyperemic tissue compared with the ischemic area and 
an absolute increase in activity in the ischemic area. 
The latter process probably predominates during first 
hour; differences in regional myocardial washout 
precede thereafter.

Apparent differences between our results and those 
of others may be explained by differences in experi-
mental design. The timing and frequency of observa-
tions may be critical in explaining widely divergent 
results when coronary blood flow in dogs was experi-
mentally increased. An increase in $^{201}$TI uptake was 
found in coronary blood flow was increased by 
adenosine or dipyridamole and myocardial activity 
was evaluated by either serial imaging or tissue 
samples. On the other hand, Weich and co-workers89 
found a logarthmic decrease in $^{201}$TI uptake where 
coronary blood flow was increased in excess of de-
mands by drugs, including adenosine. These investi-
gators counted blood samples from the coronary sinus 
during hyperemia for only 25 seconds. We have shown 
that when $^{201}$TI was given during peak flow of reactive 
hyperemia, peak myocardial activity occurred 10 
minutes after administration, by which time flow had 
already returned to the baseline level. Failure to ap-
preciate the time lag between peak flow and peak 
myocardial activity may also explain the lack of cor-
relation between regional blood flow measured by the 
labeled-microsphere technique and tissue activity. In 
one such study,14 microspheres and $^{201}$TI were given 
simultaneously during reactive hyperemia and the dog 
was sacrificed 1 minute later, well before the expected 
peak activity. Our experimental design required col-
lections of counts every 30 seconds and relatively 
high activities were given. The delay in accumulating 
counts was no more than 30 seconds. Wharton et al.86 
performed a study with many design characteristics 
similar to ours. They only examined the uptake phase 
of $^{201}$TI kinetics, however, after transient regional 
ischemia or reactive hyperemia. Dogs were sacrificed 
and sampled counted 6-10 minutes after circumflex 
occlusion. They concluded that the perfusion defect 
observed on the initial scintigram was influenced by 
the duration of ischemia. As in our experiments, if 
$^{201}$TI was given during maximum reactive hyperemia, 
the defect was almost entirely obliterated.

Nielsen and co-workers31 evaluated initial $^{201}$TI up-
take in exercising dogs in which circumflex coronary 
flow was restricted with a mechanical snare. Thal-
lum-201 and radioactive labeled microspheres were 
administered during exercise. Dogs were sacrificed 
after 5 minutes and tissue samples were counted in 
vitro. They found a close linear relationship (correla-
tion coefficient 0.98 or greater) between $^{201}$TI uptake 
and regional coronary blood flow. Blood flow in-
creased three- to sevenfold in the region with un-
restricted blood flow, compared with a blood flow of 
less than 0.1 ml/min/g of tissue in a region with re-
stricted flow. Differences between their findings and 
ours may be explained by differences in experimental 
design. We found similar directional changes in cor-
ary flow and $^{201}$TI uptake, but of somewhat lesser 
magnitude, in the posterior walls of dogs with either 
reactive hyperemia or ischemia. There are several 
reasons for these apparent differences. Increases in 
flow to normally perfused tissue are probably greater 
with exercise than with reactive hyperemia. Decreases 
in $^{201}$TI uptake in our ischemic preparation were par-
tially neutralized by the transitory nature of the occlu-
sion, which was followed by reactive hyperemia. A 
major limitation is in vivo measurements of myo-
cardial activity; that is, the inherent resolution of the 
gamma camera results in averaged regional differ-
ences in activity, which is not a problem with in vitro 
counting of small samples. In addition, the gamma 
camera requires a longer period of time to collect 
足够的 counts to ensure accurate imaging. A major 
difference between Nielsen’s study and ours is that 
they evaluated only initial $^{201}$TI uptake, whereas we 
examined the washout phase as well.

Few critical and quantitative data are available 
relative to the washout phase of myocardial activity 
after $^{201}$TI administration. Some of these studies were 
performed in humans after an episode of unstable 
angina pectoris4 or during exercise-induced ischemia 
with and without prior myocardial infarction1 by 
serial imaging in which the anterior and posterior 
walls were compared by qualitative criteria. Results of 
myocardial washout from ischemic myocardium dur-
ing continuous occlusion of a coronary vessel are 
probably inapplicable to results derived from tran-
siently ischemic myocardium. In dog studies, Gewirtz 
and co-workers88 administered $^{201}$TI 10 minutes before 
occlusion of a coronary artery. Myocardial activity in 
the persistently ischemic region was followed by se-
quential drill biopsy specimens. They found no signifi-
cant differences in myocardial clearance between con-
trol and ischemic areas at 15 minutes and at 2 hours.
In accord with our findings, Pohost and co-workers, using nonquantitative serial scintigraphy in dogs, showed that the apparent difference in activity between a transiently ischemic region and a normal myocardium gradually lessened over a 100-minute period. Schelbert and co-workers* studied washout by analyzing myocardial activity in tissue samples of sacrificed dogs in whom 201TI was given during transient ischemia. During the initial 30 minutes after release of the occlusion, the percent increase in myocardial uptake in the ischemic area exceeded the percent decrease in activity in normal myocardium. At 4 hours, the percent decrease in activity in normal myocardium exceeded the decrease in the previously ischemic myocardium. These results are in general agreement with ours, although the time course of myocardial activity was limited by the infrequent samples.

Clinical Implications

Patients who have a positive 201TI exercise test generally have underlying coronary occlusive disease, and reactive hyperemia in the ischemic area is probably not important. Rather, reactive hyperemia is a model for understanding the increased perfusion of normal myocardium. The maximum difference in myocardial activity between overperfused normal myocardium and ischemic myocardium occurs within 10 minutes after administration of the radionuclide (fig. 8), emphasizing the need for early imaging. Thereafter, activity falls rapidly in the normal myocardium (probably reflecting an excessive concentration gradient) while it is still increasing in the ischemic area. The difference in activity is probably related to the degree of exercise. Appreciation of the different washout characteristics of hyperemic normal tissue and ischemic tissue gives the clinician insight into the need for delayed images to differentiate ischemic from infarcted tissue. The delayed washout of 201TI from ischemic myocardium long after coronary blood flow has returned to normal is best explained by a decrease in the concentration gradient between the previously ischemic area and blood. Slow washout from an ischemic area should accelerate the redistribution process, which in some patients may be completed within 1 hour. Additional factors that we did not evaluate but that undoubtedly influence the development and persistence of an initial scintigraphic defect and perhaps the new appearance of a delayed defect include the duration of the ischemic episode, the presence of underlying critical stenosis of one or more coronary arteries, the extent and distribution of collateral flow, and the presence of underlying infarcted cells that share the same area as the ischemic cells.

The recognition of an ischemic defect in clinical practice, considering the limitations of gamma camera resolution of small differences in activity, depends on relative differences between ischemic and nonischemic myocardium. Flow can increase in a narrowed coronary artery, but if the increase is much greater in the fully patent vessels, a defect may be observed. Identification of a regional scintigraphic defect during rest angina or after inadequate exercise is made more difficult by the absence of significantly increased uptake in normal myocardium as is seen with high-level exercise.

References

19. Wackers FJT, Sokole EB, Samson G, Van Der Schoot JB:
Gamma Camera Quantitation of Thallium-201 Redistribution at Rest in A Dog Model

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SUMMARY Defects seen at rest on thallium-201 (201TI) scintigraphy can disappear over time. We obtained sequential 5-minute scans over 127 ± 9.4 minutes in seven open-chest dogs with fixed, stable regional flow reductions (normal zone flow 0.76 ± 0.09 ml g−1 min, ischemic zone flow 0.49 ± 0.04 ml g−1 min [mean ± SEM], p < 0.05) as determined by microsphere injection. Sequential 5-minute scans were obtained after i.v. injection of 1.5 mCi of 201TI. Data were stored in a 64 × 64 pixel computer matrix. Qualitatively, defects that showed redistribution were seen in all dogs. Quantitatively, greater count loss from peak activity distinguished the normal zone, but overlap was great. Alternate quantitative methods using background subtraction altered the characteristics of the time-activity curves, but did not enhance the separation of ischemic from normal zones. Patterns of 201TI redistribution from gamma camera imaging are profoundly influenced by the method of quantitation. No single method of quantitative analysis separated ischemic from normal zones in all dogs.

The clinical significance of patterns at rest requires redefinition.

IN PATIENTS with severe angiographic coronary artery disease, defects at rest on thallium-201 (201TI) scintigraphy can disappear over time. Quantitative analysis of the scans in these patients suggested that 201TI uptake in hypoperfused, but presumably viable, regions played the dominant role in 201TI redistribution. If correct, the concept of delayed uptake of 201TI into myocardial regions with subnormal coronary flow is important for two reasons. First, it would aid in identifying ischemic zones in patients with qualitatively normal scans and help separate infarct from ischemia. Second, it could lead to a quantitative method of blood flow determination from time-activity curves, because preliminary data indicate that the rate of uptake is related to the degree of flow reduction.

However, Leppo et al. presented data showing that washout rather than washin dominates the process of redistribution when flow is segmentally enhanced. If the animal model of Schelbert et al. applies, delayed uptake will occur only when resting flow has been reduced by 80% of normal. Patients reported to show areas of myocardium with delayed 201TI uptake were asymptomatic and showed no ECG evidence of acute ischemia at the time of 201TI injection. Catheterization at another time revealed no wall motion abnormalities in many of these patients.

Thus, the mechanism and significance of scintigraphic patterns of redistribution are controversial. Our study was designed to explore methods of quantitating gamma camera scans and to use these methods to characterize patterns of 201TI redistribu-
Effect of coronary blood flow on thallium-201 uptake and washout.
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