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Comparison of thallium-201 SPECT redistribution patterns and rubidium-82 PET rest-stress myocardial blood flow imaging *

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Abstract

To compare regional thallium-201 SPECT redistribution patterns with rubidium-82 PET, we studied 81 patients with both imaging modalities. Sixty patients had significant coronary artery disease. All patients underwent PET imaging after dipyridamole infusion, while SPECT imaging was performed after exercise stress (38 patients) and dipyridamole (43 patients). Sixty-eight percent of patients with prior infarct had fixed defects on SPECT, compared to 39% with PET. Sixty-one percent of patients with prior infarct had PET perfusion defects which exhibited 'reflow' or normal rubidium-82 tracer uptake ($p < 0.05$ vs. SPECT). Similar results were seen in patients without prior infarct (26% fixed defects on SPECT vs. 12% for PET, $p < 0.05$). Regional analysis showed that 57% of fixed SPECT defects corresponded to PET defects with reflow or normal rubidium-82 uptake, while 78% of 'fixed' PET defects corresponded to fixed SPECT defects. PET reflow and normal rubidium-82 uptake in sites of fixed thallium-201 SPECT perfusion defects suggest that imaging modalities employing separate tracer injections at rest and after stress, such as rubidium-82 PET, may be more specific in the assessment of myocardial viability, especially in patients with prior myocardial infarction.

Introduction

Stress and delayed myocardial perfusion imaging with thallium-201 has been established as an important clinical tool for the detection and assessment of coronary artery disease [1]. Thallium-201 perfusion defects which demonstrate redistribution (or reversibility) on 3 to 4 hour delayed images have been associated with hypoperfused viable myocardium [2]. Studies investigating late redistribution of thallium-201 single photon emission computed tomography (SPECT) defects, along with correlation with other imaging modalities such as positron emission tomography (PET), suggest that approximately 50% of viable myocardial segments are assessed as non-reversible or 'fixed' at four hours [3, 4]. Study protocols involving 24-hour delayed imaging and reinjection of thallium-201 after initial stress imaging are being used to improve the diagnostic performance of thallium-201 in assessing myocardial viability [5, 6]. However, due to logistical consideration, many institutions still employ standard stress-redistribution imaging protocols with thallium-201.

Positron emission tomography imaging with the potassium analog rubidium-82 has been shown to represent a diagnostically accurate alternative to thallium-201 SPECT for the detection of coronary artery disease [7–9]. Unlike perfusion imaging with thallium-201 SPECT, rubidium-82 requires two separate injections of tracer at baseline and after stress. The favorable imaging characteristics of PET in addition to the attractive physical properties of rubidium-82 (half-life of 76 sec) offer the ability to perform baseline and stress

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imaging after intravenous dipyridamole or adenosine administration within a one hour time period [10]. Furthermore, rubidium-82 uptake in myocardium at rest occurs by a different mechanism than thallium-201 redistribution. Very little data has been reported comparing the pattern of rubidium-82 myocardial perfusion at rest and after pharmacologic stress with thallium-201 redistribution imaging. Accordingly, the purpose of the following study was to compare thallium-201 SPECT redistribution patterns with rubidium-82 PET imaging at rest and following intravenous dipyridamole infusion in the same patient population.

Methods

Patient population

The study group consisted of patients that formed the basis of a previous report [9] referred to our institution for diagnostic coronary angiography. All patients with previous surgical revascularization or percutaneous transluminal coronary angioplasty (PTCA) were excluded. Referral diagnosis included chest pain, history of myocardial infarction, pre-surgical evaluation, and abnormal stress tests. In addition, six patients with a low likelihood of coronary artery disease based on age, sex, and risk factors who did not undergo coronary angiography were selected. All studies were performed within a three-week time period. Patients with changing clinical status between studies were excluded. All patients were asked to sign an informed consent form approved by the committee for clinical research at the University of Michigan before entering the study.

Positron emission tomography

All patients were studied after overnight fast using a 15 slice whole body PET scanner (931 CTI/Siemens, Knoxville, TN). A transmission scan using a retractable Germanium-68 ring source was performed for 15–20 minutes (100–200 million counts) for patient positioning and attenuation correction. The transmission scan was followed by a baseline PET study with 60 mCi of rubidium-82 using the commercially available SR-82/Rb-82 generator (Squibb Diagnostics, Princeton, NJ) and infusion system (CTI, Knoxville, TN). Rubidium-82 was infused with a pump setting of 50 ml/min and a specific activity of 1 to 2 mCi/ml. Sixty seconds following the end of rubidium-82 infusion, data were acquired for seven minutes. Fifteen minutes following the resting study, an intravenous infusion of dipyridamole (0.56 mg/kg) was started for four minutes. Four minutes after the end of the dipyridamole infusion, the patients were asked to perform handgrip exercise at 30% of maximal strength [11]. One minute after the initiation of handgrip exercise, a second 60 mCi dose of rubidium-82 was infused using the same protocol as above. Handgrip stress lasted for a total of three minutes. The time required for rest and stress rubidium-82 PET imaging averaged approximately one hour.

PET image processing

The attenuation corrected projection data were used to reconstruct transverse images with a Hanning filter (cutoff frequency 0.35 cycles/pixel). Using a computer workstation (SUN Systems, Mountain View, CA) and dedicated software (Volumn Tool, CTI) the transverse images were realigned perpendicular to the long axis of the left ventricle, yielding cross-sectional short-axis and longitudinal images.

PET data analysis

All images were evaluated by two observers blinded to clinical, angiographic, and thallium-201 SPECT data. A four-point visual scoring system was used [9]. In cases of disagreement, a third observer graded the images. The cross-sectional images were displayed in the same format as the thallium-201 SPECT images. A score of one represented normal rubidium-82 uptake, with two being equivocal, three being mildly abnormal, and four markedly abnormal. Visual assessment was performed in four regions of three ventricular slices (apical level, mid level, and basal level). Each of these slices was divided into anterior, lateral, inferior, and septal regions. A final perfusion score for each region was derived from the average of the three ventricular slices. A tracer uptake defect was defined as a score of three or greater in at least one of the four regions. Reflow on a rubidium-82 PET study was present if the averaged perfusion score in the anterior, lateral, inferior, or septal regional differed by more than one between the stress (post dipyridamole) and rest studies.

Thallium-201 SPECT

Thallium-201 SPECT was performed either in combination with exercise testing or intravenous dipyri-

damole infusion. All patients were fasted for at least eight hours prior to the study. In those patients undergoing exercise stress testing, the standard Bruce protocol was utilized. At peak exercise, 3–4 mCi thallium-201 was injected intravenously and exercise continued for one minute. Immediately following exercise, patients were placed in the supine position, and a five minute planar image in the anterior position was acquired. SPECT acquisition began 10 to 15 minutes after the end of exercise and was completed within 45 minutes after tracer administration.

Patients undergoing pharmacologic stress testing received a four minute intravenous infusion of dipyridamole (0.56 mg/kg). Four minutes after the end of the infusion, the patient was asked to perform handgrip exercise for three minutes. Imaging was started ten minutes after the injection of thallium-201 using the same protocol as following exercise testing.

SPECT data acquisition

Image acquisition was performed using a General Electric 400 AC gamma camera system interlinked to a MicroDELTA Workstation (Siemens). Data were acquired over a 180 degree angle starting from the 45 degree right anterior oblique projection. Data collection consisted of 64 steps of 15 seconds each. All patients underwent redistribution imaging 4 to 6 hours after the initial thallium-201 injections.

SPECT image processing

Image processing consisted of filtered back projection of data in a 64×64 matrix with reconstruction of the transverse images using the Butterworth filter (cutoff frequency 0.35 cycles/pixel) and commercially available software (MicroDELTA Workstation, Siemens). The tomographic images were realigned perpendicular to the long axis of the left ventricle. All images were displayed in grey scale using a large screen display system and customized software. This method allowed direct comparison of stress and redistribution images in oblique, longitudinal, and sagittal views.

SPECT data analysis

As with rubidium-82 PET images, all studies were evaluated by two observers blinded to clinical, angiographic, and PET data using a four-point visual scoring system. In cases of disagreement, a third observer was consulted. The left ventricle was divided into 12 segments (anterior, lateral, inferior, and septal segments at the apical, mid, and basal levels) and the stress and redistribution images were evaluated using the same scoring system as with the PET studies. Reversibility on thallium-201 SPECT was defined as an averaged difference of one scoring point between stress and redistribution images in one or more left ventricular region (anterior, lateral, inferior, or septal).

Coronary angiography

Cineangiograms of the coronary arteries were obtained in multiple projections using a C-core Angiographic System (Siemens). Quantitative assessment of coronary artery stenosis was carried out as described previously [9]. A coronary artery diameter stenosis of greater than 50% was considered significant.

Determination of myocardial infarction

The presence of infarcted segmental myocardial regions was determined by 1) history of previous myocardial infarction; 2) presence of characteristic ECG changes (Q waves); 3) documentation of elevated serum creatinine kinase levels (> 225 IU/L, with 3% MB fraction levels); 4) evidence of regional resting wall motion abnormalities on ventriculography.

Statistical analysis

All data were expressed as the mean $\pm$ 1 standard deviation. Paired t-tests were used to compare differences in group data. A p value of < 0.05 was considered statistically significant.

Results

Patients

Eighty-one patients (52 male, 29 female) with a mean age of 57 ± 12 yrs comprised the study group. Thirty-eight patients had clinical, electrocardiographic, ventriculographic, or enzymatic evidence of prior myocardial infarction. Seventy-five patients underwent coronary angiography. Sixty of 81 patients had significant coronary artery disease ($\geq$ 50% diameter stenosis) involving at least one major coronary artery, while 21 patients were considered free from coronary artery disease.

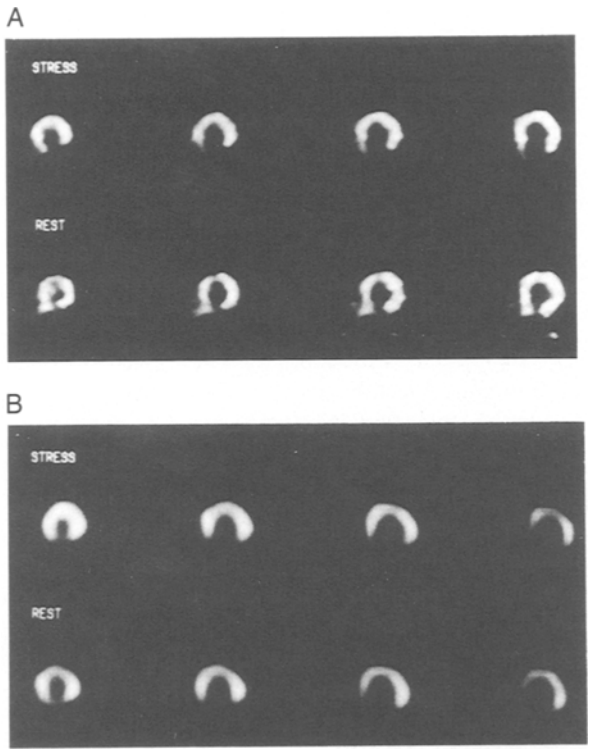

Fig. 1. Reconstructed short-axis rubidium-82 PET (A) and thallium-201 SPECT (B) images in a patient with significant coronary artery stenosis and previous myocardial infarction. Please see text for explanation.

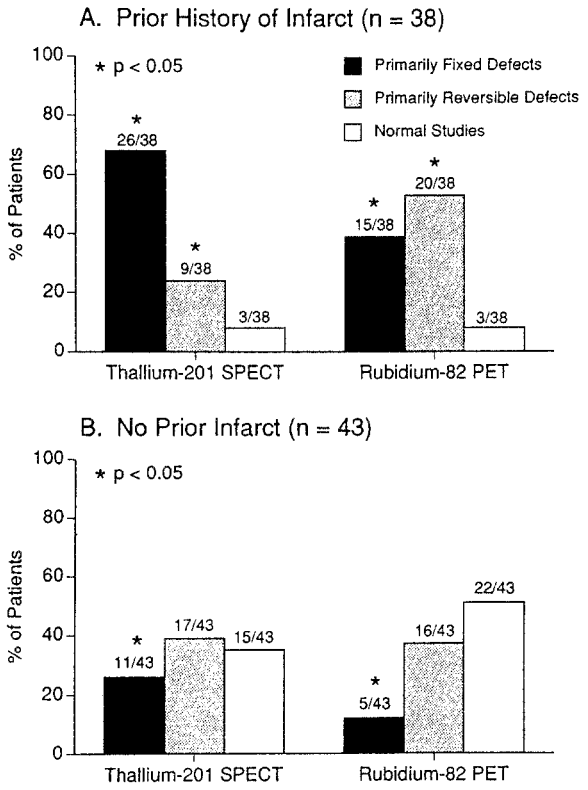

Fig. 2. Imaging results per patient. There is a significant difference ($p < 0.05$) in the imaging patterns between thallium-201 SPECT and rubidium-82 PET in patients with (A) and without (B) prior myocardial infarction. PD = perfusion defects.

Stress testing

All patients underwent intravenous dipyridamole infusion in combination with rubidium-82 PET imaging. Thirty-eight patients underwent exercise thallium-201 SPECT. The rate pressure product for exercise averaged 26,314 ± 3,077. Forty-eight patients underwent dipyridamole thallium-201 SPECT. There were no serious complications during or after dipyridamole infusion in any patient.

Overall imaging results per patient

Figure 1 shows a rubidium-82 PET (A) and thallium-201 SPECT (B) study in the short-axis view. Both PET and SPECT stress images reveal an inferior wall perfusion defect consistent with a high degree of coronary artery stenosis involving the right coronary artery. This example represents a patient with a previous inferior wall myocardial infarction. The thallium-201 SPECT images demonstrate a fixed inferior wall defect. The rubidium-82 PET images after dipyridamole stress show a larger inferior defect compared to the rest images, suggesting the coexistence of necrotic and viable but jeopardized myocardium.

Figure 2 shows the imaging results per patient with prior history of myocardial infarction. Sixty-eight percent (26/38) of patients that had primarily fixed perfusion defects on thallium-201 SPECT in comparison to 39% (15/38) of patients with 'fixed' (no reflow) rubidium-82 PET tracer uptake abnormalities ($p < 0.05$). Likewise, 24% (9/38) of patients had primarily reversible thallium-201 SPECT perfusion defects as opposed to 53% (20/38) of patients with rubidium-82 PET reflow defects ($p < 0.05$). Eight percent of patients (3/38) had normal SPECT and PET studies. In patients without prior myocardial infarction, 26% (11/43) of patients had fixed perfusion defects on thallium-201 SPECT compared to 12% (5/43) on PET studies ($p < 0.05$). A similar number of patients had reversible defects on SPECT (17/43, 39%) and

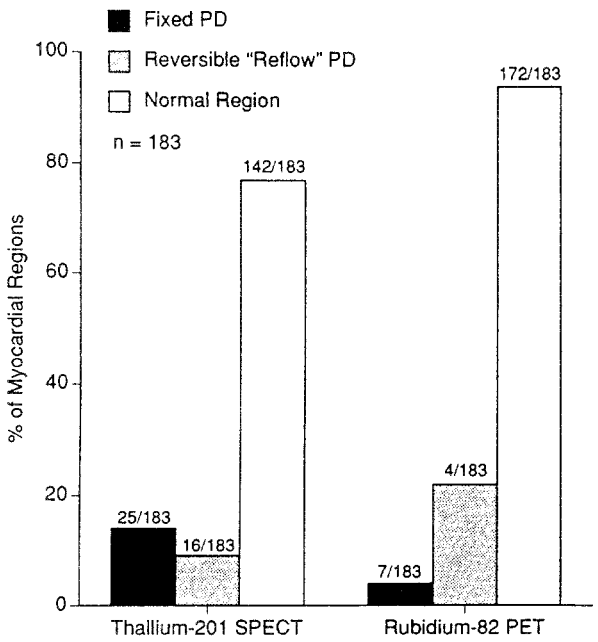

Fig. 3. Comparison of the frequency of regional perfusion defects and normal myocardial tracer uptake in 183 regions lacking significant coronary artery disease (< 50% diameter stenosis).

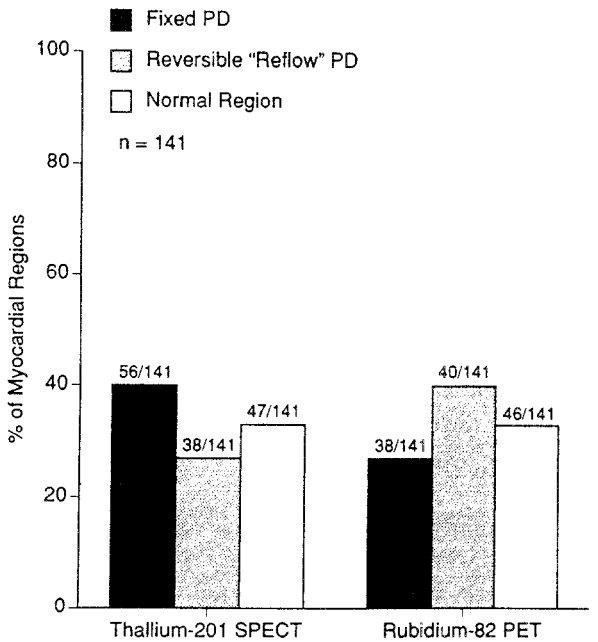

Fig. 4. Frequency of myocardial perfusion defects and normal tracer uptake in regions with ≥ 50% diameter stenosis (n = 141 regions).

rubidium-82 PET perfusion defects with reflow (16/43, 37%). Thirty-five percent of patients (15/43) had normal thallium-201 SPECT studies compared to 51% (22/43) for rubidium-82 PET ($p < 0.05$).

Overall imaging results per myocardial region

Three hundred twenty-four myocardial regions were evaluated. For thallium-201 SPECT studies, 81 regions (25%) had fixed perfusion defects without redistribution while 54 regions (17%) had reversible defects. One hundred eighty-nine regions (58%) were normal. For rubidium-92 PET studies, 45 regions (14%) had similar perfusion defects on both baseline and post-dipyridamole images, while 61 regions (19%) exhibited a smaller rubidium-82 defect at baseline as compared to post-dipyridamole studies (reflow). Two hundred eighteen regions (67%) showed normal rubidium-82 uptake. Agreement between thallium-201 SPECT and rubidium-82 PET was 79%.

Figure 3 shows the imaging patterns in myocardial regions without significant coronary artery disease (n = 183). Thallium-201 SPECT defects were fixed in 14% of regions (25/183), reversible 9% (16/183), and normal in 77% (142/183). This is in contrast to 94% (172/183) of myocardial regions demonstrating normal uptake of rubidium-82, 4% (7/183) showing fixed perfusion defects without reflow, and 2% (4/183) showing defects with rubidium-82 PET reflow.

Figure 4 shows all myocardial regions with significant coronary artery disease (n = 141). Fixed thallium-201 SPECT defects accounted for 40% (56/141) of regions, while 27% (38/141) of regions had reversible defects, and 33% (47/141) were normal. PET images revealed 27% (38/141) of regions fixed without reflow, 40% (57/141) demonstrating reflow, and 33% (46/141) normal.

In the 54 myocardial regions that had sustained infarction (Fig. 5), 67% (36/54) showed fixed defects on thallium-201 SPECT, while 22% (12/54) of regions had reversible defects, and 11% (6/54) were normal. Rubidium-82 uptake was fixed in 43% (23/54) of regions on PET studies, but showed reflow in 48% (26/54). Normal rubidium-82 uptake was present in 9% (5/54) of regions.

Relationship between fixed thallium-201 SPECT defects and regional rubidium-82 PET reflow

Table 1 shows all fixed thallium-201 SPECT and rubidium-82 PET perfusion abnormalities, and the imaging appearance of the corresponding myocardial regions as assessed by the other modality. Forty-

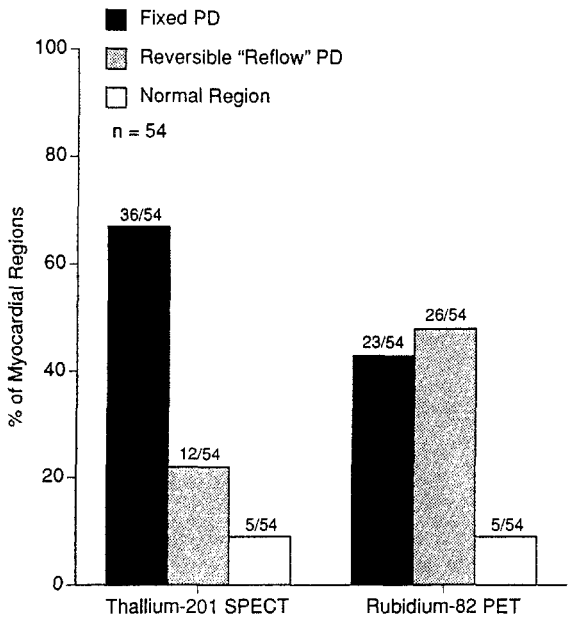

Fig. 5. Results of thallium-201 SPECT and rubidium-82 PET in 54 infarcted myocardial regions. Normal thallium-201 and rubidium-82 uptake was noted in only 9% of regions.

Table 1.

	Fixed PD	Reversible PD	Normal stress /rest
Rb-82 PET	35/45 (78%)	7/45 (15%)	3/45 (7%)
Tl-201 SPECT	35/81 (43%)	20/81 (25%)	26/81 (32%)

Appearance of corresponding myocardial segments to 'fixed' rubidium-82 PET (n = 45 segments) and thallium-201 SPECT (n = 81 segments) perfusion defects from both infarcted and non-infarcted myocardial segments. Fixed PD = corresponding fixed perfusion defects, reversible PD =corresponding reversible perfusion defects, and normal stress/rest = corresponding myocardial segments with normal tracer uptake.

three percent (35/81) of fixed thallium-201 SPECT defects had corresponding rubidium-82 PET tracer uptake abnormalities on PET studies which did not exhibit reflow, while 25% (20/81) of corresponding regions had rubidium-82 perfusion abnormalities with reflow. Thirty-two percent (26/81) of fixed thallium-201 SPECT perfusion defects corresponded to regions with normal rubidium-82 uptake. Conversely, 78% (35/45) of fixed rubidium-82 perfusion abnormalities had corresponding thallium-201 SPECT defects that appeared fixed, while only 15% (7/45) of fixed rubidium-82 PET defects corresponded to reversible thallium-201 SPECT defects. Only 7% (3/45) of corresponding myocardial regions were normal by thallium-201 SPECT.

Table 2.

	Fixed PD	Reversible PD	Normal stress /rest
Rb-82 PET	20/23 (87%)	2/23 (9%)	1/23 (4%)
Tl-201 SPECT	20/36 (56%)	13/36 (36%)	3/36 (8%)

Appearance of corresponding myocardial segments to 'fixed' rubidium-82 PET (n = 23) and thallium-201 SPECT (n = 36) perfusion defects from infarcted myocardial segments only.

In a similar format, Table 2 compares fixed regional SPECT and PET defects in the infarcted regions only. Fifty-six percent (20/36) of fixed thallium-201 SPECT perfusion defects corresponded to rubidium-82 PET defects without reflow, while 36% (13/36) corresponded to PET defect with reflow, and 8% (3/36) to regions with normal rubidium-82 uptake. Eighty-seven percent (20/23) of regions with fixed rubidium-82 uptake abnormalities on PET studies corresponded to fixed SPECT perfusion defects, while 9% (2/23) corresponded to reversible SPECT defects, and 4% (1/23) to regions appearing normal by SPECT.

Exercise versus dipyridamole thallium-201 SPECT

Since 43 patients underwent thallium-201 SPECT after dipyridamole infusion and 28 after maximal exercise, the imaging patterns obtained after these two modes of stress were compared. Summarized in Table 3 are the numbers of fixed and reversible regional thallium-201 SPECT perfusion defects along with normal regions. The incidence of fixed thallium-201 SPECT defects after dipyridamole infusion (29%) did not differ sig-

Table 3.

	Fixed PD	Reversible PD	Normal stress /rest
Exercise stress			
Rb-82 PET	23/172 (13%)	29/172 (17%)	120/172 (70%)
Tl-201 SPECT	37/172 (23%)	28/172 (16%)	107/172 (62%)
Dipyridamole			
Rb-82 PET	22/152 (14%)	26/152 (21%)	82/152 (65%)
Tl-201 SPECT	44/152 (29%)	26/152 (17%)	82/152 (54%)

Segmental rubidium-82 PET and thallium-201 SPECT imaging patterns after exercise (Bruce protocol) and dipyridamole stress.

nificantly from the post-exercise studies (22%). A similar result is seen with reversible defects (17% post-dipyridamole infusion vs. 16% post-exercise stress) and normal segments (45% vs. 62%).

Discussion

In the present study, the imaging patterns of thallium-201 SPECT and rubidium-82 PET were compared in a population with proven or suspected coronary artery disease. Overall, there was a higher incidence of myocardial regions with fixed, or non-reversible perfusion defects on thallium-201 SPECT studies (25%) than with rubidium-82 PET (14%). This result was also observed in the subpopulation of patients with proven coronary artery disease with and without prior myocardial infarction (Fig. 4). The agreement on fixed perfusion defects between both studies was only 43%, confirming previous studies using 24-hour delayed thallium-201 SPECT redistribution imaging or thallium-201 SPECT reinjection techniques [3, 6]. Resting rubidium-82 PET imaging may be more sensitive in detecting residual viable myocardium than thallium-201 SPECT, although a direct comparison of rubidium-82 PET rest imaging with functional outcome after revascularization or with F-18 fluorodeoxyglucose (FDG) imaging is required to prove this hypothesis.

A significantly larger number of patients with prior infarction have fixed thallium-201 SPECT defects in comparison to PET studies, as was also the case in the non-infarct patient population. Importantly, both in the overall study group and in patients with prior infarction, fixed thallium-201 SPECT regional perfusion defects corresponded to a higher number of myocardial segments with rubidium-82 PET reflow or normal rubidium-82 uptake (Table 1 and 2). Thus, the high incidence of fixed thallium-201 SPECT perfusion defects with normal rubidium-82 uptake confirms the limited specificity of thallium-201 SPECT which may be related to the lack of photon attenuation correction [9]. The higher incidence of tracer uptake abnormalities with reflow seen with rubidium-82 in myocardial regions with fixed thallium-201 SPECT defects suggest that perfusion imaging employing separate tracer injections at baseline (rest) and stress may offer an advantage in the assessment of tissue viability.

Redistribution of thallium-201 has been taken as a marker for transiently ischemic but viable myocardium resulting from coronary artery disease [12]. However, there are many instances where redistribution may be limited in detecting jeopardized tissue. Redistribution may not occur as readily in clinical situations where the myocardium is supplied by highly stenotic vessels with variable collaterals [13]. This was observed clinically in an early study by Ritchie et al. [12] who found that 44% of patients had thallium-201 perfusion defects that were more extensive on delayed images than post-stress images, suggesting an overestimation of scar. The explanations for this phenomenon are many, but probably involve the rapid reflux of tracer from infarcted cells interdigitated with viable myocardium [14], and the effect of hypoxia on net myocardial retention on thallium-201 [15]. As was shown by Nelson et al. [16], thallium-201 blood levels can play a role in determining the incidence of reversible defects. In their study, the authors showed nearly a two-fold increase in the number of reversible defects in patients with significantly higher plasma thallium levels resulting from fasting. Finally, the relationship between dietary state and thallium-201 kinetics resulting in increased tracer clearance from myocardium has previously been addressed [17].

Delayed imaging up to 24 hours with thallium-201 has been proposed as an alternative to the convention 3 to 4 hour redistribution imaging with thallium [3]. Although this approach takes advantage of existing technology and avoids the cost of a PET system, logistical difficulties with patient scheduling and gamma

camera time may limit its widespread application. The clinical trial comparing 24-hour thallium-201 redistribution imaging with post-revascularization functional recovery has indicated that 35% of segments with fixed defects demonstrated subsequent improvement in function. These data suggest improvement in the detection of viable myocardium using 24-hour imaging approaches, but the diagnostic accuracy is still limited [3].

More recently, reinjection of thallium in conjunction with a same-day imaging protocol has been introduced to accelerate the scintigraphic detection of tissue viability. Several studies have idicated that reinjection leads to increased thallium uptake in myocardial regions which were deemed fixed on 3 to 4 hour redistribution imaging [6, 18, 19]. Initial studies comparing the outcome of such regions following revascularization supports the notion that reinjection improves the identification of viable myocardium [20]. In the present study, standard stress-redistribution protocols with thallium-201 were employed without re-injection. However, it is still unclear at this time which thallium reinjection protocol is optimal for the assessment of tissue viability [21, 22]. The acquisition of 3 separate studies may pose similar scheduling problems for a busy imaging department as would a 24-hour study. Until this issue is settled, many institutions will continue to utilize thallium-201 in standard stress-redistribution imaging protocols.

Rubidium-82 is distributed in tissue in a matter similar to potassium and thallium. Rubidium-82 tissue retention has been shown to be decreased in myocardium during hypoxia and acidosis, but is unaltered by changes in the dietary state [23]. The extraction fraction of rubidium-82 by the myocardium is somewhat lower than that of thallium-201, but rubidium-82 has been successfully used as a blood flow marker in the detection of regional stress induced perfusion abnormalities. The major advantage of rubidium-82 over thallium-201 lies in its short physical half-life and in its properties which allow its use in combination with positron emission tomography. The physical half-life of 76 seconds allows for separate rest and stress evaluation of left ventricular perfusion within 1 hour, which compares very favorably with the 4 to 5 hours required for thallium-201 SPECT or technetium-99 sestamibi imaging. Based on the thallium-201 data, it becomes apparent that resting injections of blood flow tracers are useful for the identification of tissue viability. Animal studies have shown that myocardial blood flow is closely linked to myocardial oxygen consumption and, hence, to tissue viability [24, 25].

There also appears to be additional information on myocardial viability provided by the retention and clearance of rubidium-82 at rest. Thallium-201 redistribution following resting injection, which occurs in delayed images of thallium distribution in myocardium, may be diagnostically superior to thallium stress reinjection images [26]. Similarly, Goldstein et al. have demonstrated in the animal model that rubidium-82 tissue kinetics in acute ischemia and necrotic myocardium are distinctly different [27, 28]. Work by Gould et al. indicates that the same principle can be applied to clinical data obtained with rubidium-82 PET [29]. Comparison of early tracer distribution after injection with delayed tracer distribution may allow for the differentiation of viable from non-viable myocardium by assessment of rubidium-82 tissue retention. Using dynamic data acquisition protocols with PET, the regional kinetics of rubidium-82 can be assessed. These data can then be compared to metabolic imaging with tracers such as FDG to help differentiate viable myocardium from irreversibly injured tissue in patients with recent myocardial infarction. Such techniques were not employed in the current study and require further validation in order to define the best imaging approach for rubidium-82 as a marker of tissue viability.

Conclusions

Both thallium-201 SPECT and rubidium-82 PET detect coronary artery disease with similar sensitivities. The presence of rubidium-82 reflow and normal rubidium-82 uptake in sites of 'fixed' thallium-201 SPECT perfusion defects suggests that imaging modalities employing separate stress and rest injection of tracer, such as rubidium-82 PET, may offer improved specificity in the assessment of myocardial viability, especially in patients with prior myocardial infarction. Metabolic imaging studies using tracers such as FDG are needed for the validation of these methods.

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