Assessment of Myocardial Viability: the Value of 24-Hour Thallium-201 (^{201}Tl) Redistribution Imaging to Enhance Viability Detection in Stress Reinjection Protocol

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Abstract

Background- To assess the value of 24-hour redistribution imaging after ^{201}Tl reinjection for the detection of myocardial viability, we compared the results of ^{201}Tl reinjection imaging with those obtained 24 hours after reinjection.

Methods- In total, 35 patients aged 57±8 years (mean ± SD) who showed one or more persistent perfusion defects on stress reinjection images after myocardial infarction were assessed for myocardial viability. After pharmacological stress and 4-hour reinjection imaging, 25 patients who showed non-viable segments at reinjection image underwent 24-hour redistribution imaging. The stress, reinjection, and 24-hour redistribution images were analyzed quantitatively. Criteria for viability definition were:1) segments which showed at least 50% uptake of peak activity of normal regions at stress phase and 2) segments with less than 50% uptake at stress image which showed at least 20% redistribution at the later phases.

Results- Of the 102 abnormal myocardial regions on the stress images, 19 segments at reinjection images and another 17 segments at 24-hour redistribution images demonstrated redistribution. On the other hand, 24-hour imaging showed viability in 17 out of 83 segments (20.4%), which were considered non-viable regions at reinjection image, occurring in 8 out of 25 patients.

Conclusion: In stress reinjection protocol by ^{201}Tl, 24-hour redistribution imaging is proposed to be performed in patients who show significant non-viable myocardial tissue at 4-hour reinjection imaging for a better recognition of viable myocardium ***(Iranian Heart Journal 2009; 10 (1):16-20).***

Key words: nuclear medicine ■ viability ■ Thallium 201 ■ redistribution ■ myocardial infarction

Myocardial viability testing for the recognition of viable myocardium at high risk, including ischemic, stunned, and hibernating tissue is important for predicting the clinical benefits of revascularization as well as prognosis in patients with coronary artery disease.[1]

Thallium-201 (^{201}Tl) redistribution imaging has been widely used for the identification of myocardial ischemia and viability after myocardial infarction. A standard imaging protocol that includes stress and redistribution images with ^{201}Tl reinjection as necessary will

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provide most of the viability information that can be obtained from ^{20}Tl imaging. One other approach to assess myocardial viability while saving time involves the routine reinjection of ^{201}Tl 3-4 hours after stress, without acquiring redistribution images; however, some studies have shown that in a small subset of patients the reinjection images may underestimate viability.[2]

Bonow et al., who advocated thallium uptake quantification as an index for viability detection for the first time, showed that most irreversible segments at stress redistribution ^{201}Tl imaging that show more than 50% of peak activity of normal regions are viable on the basis of FDG uptake, which is the standard method for viability detection.[3] On the other hand, although segments with a fixed defect tracer activity equal to or greater than 50% do not often show functional improvement following revascularization, revascularization of these segments may prevent remodelling and be important for long-term prognosis.[4] Therefore, we only investigated the viability of segments with less than 50% uptake at stress phase. If these segments showed at least 20% redistribution at a later 24-hour image, they were defined as viable.

The purpose of this study was to evaluate the potential advantage of the 24-hour redistribution ^{201}Tl imaging in stress-reinjection protocol to estimate viable myocardium in patients with myocardial infarction.

Methods

Thirty–nine patients with myocardial infarction, diagnosed on the basis of confirmatory case histories, clinical manifestations, electrocardiogram, cardiac markers, and/or coronary angiogram, underwent imaging tests. Fourteen patients with complete viability at reinjection imaging were excluded from study; the remaining 25 patients received the 24-hour redistribution imaging.

All medications that interfere with dipyridamole (methylxanthines…) were withheld 24 hours before the test and caffeine on the morning of the imaging and were resumed after the completion of the first phase of imaging. Written informed consent was obtained from all the patients.

For pharmacological stress, all the patients received 56mg/kg dipyridamole intravenously in 4 minutes, and after 3 minutes, 3-3.5 mCi ^{201}Tl was administered. Forty-five minutes later, the patients underwent ^{201}Tl single photon emission computed tomography (SPECT). After 4 hours, all the patients were reinjected with 1-1.5 mCi ^{201}Tl and were imaged 30 minutes later. 24-hour redistribution imaging was performed if reinjection images revealed at least one segment without viability criteria (equal or more than 20% redistribution).

All images were obtained by a single-head SPECT camera (ADAC GENESYS series) equipped with a low-energy all-purpose collimator. The acquisitions were performed using ^{201}Tl energy windows of 76±10% kev and 167±10% kev, with matrix size of 64×64 and zoom factor of 1.3. Imaging was performed in 180° circular arc (RAO to LPO) at 6° intervals. The acquisition time was 30 and 40 seconds for the first two and the last images, respectively. Myocardial images were reconstructed using filtered back projection method with Butterworth filter, and displayed as a series of short-axis, horizontal, and vertical long-axes slices. The slice thickness was 4 mm (Fig. 1).

Images were analyzed quantitatively by Autoquant software. All segments with radiotracer uptake less than 50% maximum uptake in stress images were re-evaluated in reinjection; and if they did not show viability criteria, 24-hour redistribution phase was performed. These segments were defined as viable if they showed at least 20% redistribution.

Statistical analysis

Results were analysed by SPSS 15 software. All parameters were expressed as mean ± SD. Paired T-test was used to compare the number of viable and non-viable segments as well as thallium uptake at the infarcted and peri-infract segments at the three mentioned phases of the study. P-values <0.05 were considered statistically significant.

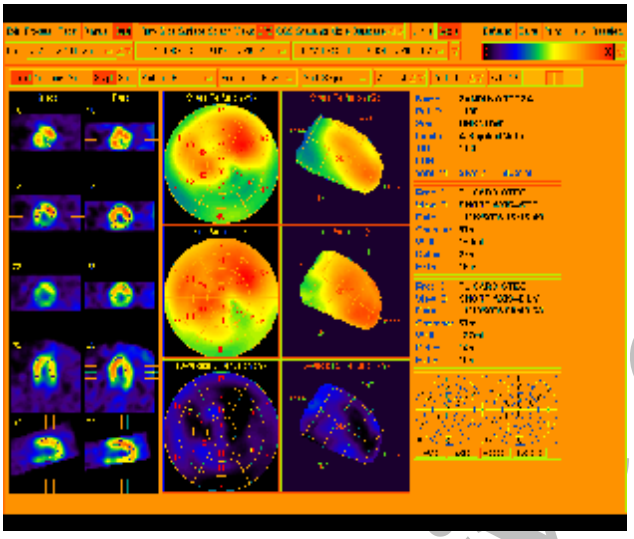

Fig. 1. Reinjection image as compared to 24-hour image showing considerable increase in viability detection

Results

Twenty-five patients aged 57±8 years (17 male and 8 female) who showed persistent defect after stress reinjection images were assessed for myocardial viability after myocardial infarction.

The total number of abnormal segments on the initial study was 102. At 4-hour reinjection images, 19 (18.6%) segments and at 24-hour redistribution imaging, an additional 17 (20.4%) segments showed viability. The redistribution image in 8 (32%) patients and 17 (20.4%) segments increased the detection of viable segments in comparison with reinjection imaging ($p<0.05$). In 15 patients, there was no significant change between the two phases of imaging; and 2 cases revealed reverse redistribution. The mean thallium uptake at infarcted and peri-infarct segments at the redistribution images was higher than that in the reinjection images (51.8% vs. 47.7%), which was statistically significant ($p<0.05$).

Discussion

The concept of hibernation has been challenged in recent years and an alternative concept has been proposed, that of persistent left ventricular dysfunction caused by repeated episodes of myocardial ischemia leading to repetitive stunning.[5,6] Independent of the mechanism, which is difficult to determine clinically, the important clinical issue is that viable but dysfunctional myocardium in patients with chronic coronary artery disease will improve in function only if identified and revascularized. At present, several clinically reliable physiological markers of viability can be used for this purpose. These include indexes of regional coronary blood flow, regional wall motion, and regional systolic wall thickening. These are accurate markers of viability when they are normal or nearly normal but have limitations in the identification of viable myocardium when severely reduced or absent. In the setting of hibernating myocardium by definition, indexes of regional perfusion and systolic function will be severely reduced or absent despite the maintenance of tissue viability.[7,8] Thus these indices are imprecise in differentiating hibernating myocardium from myocardial scar. During the past decade, numerous studies have demonstrated that nuclear cardiology techniques involving single photon methods as well as positron emission tomography (PET) also provide critically important information about viability. Imaging agents that reflect regional myocardial blood flow and membrane integrity should provide excellent information regarding tissue viability.[8, 9]

Because of poor negative predictive accuracy, it is now accepted that standard stress–redistribution thallium scintigraphy does not satisfactorily increase the precision in differentiating hibernating myocardium from fibrotic myocardium. It is well established that modification in imaging protocols in thallium considerably enhances the ability of thallium imaging to depict viable myocardium.[2,10,11] These include late redistribution imaging and thallium reinjection techniques. An imaging protocol that includes stress and redistribution images with thallium reinjection as necessary will provide most of the viability information that can be obtained from thallium imaging. Dilsizian et al. believed that rarely do late redistribution images after reinjection provide important additional information not achieved with the earlier three-image acquisition image.[12] However this protocol requires two sets of images at the redistribution and then reinjection phases. Thus it is suboptimal from the point of view of patient convenience and time consuming in the setting of a busy laboratory. Therefore, several modifications of the reinjection technique to streamline the imaging protocol are currently in clinical practice. One of these involves the routine reinjection of thallium 3-4 hours after stress without acquiring redistribution images. This approach improves efficiency and helps with the identification of viable myocardium in most patients in whom redistribution images would have been misleading by showing persistent defects.

As was mentioned above, hibernation refers to a segment which shows hypoperfusion at rest,[13] and differentiating between scar and hibernating tissue is the aim of viability detection studies. There has been a gradual evolution and refinement of thallium imaging protocol in recent years to study myocardial viability. Quantification of relative thallium uptake in the left ventricle, as an important development in viability detection studies, was first advocated by Bonow et al., who showed that most myocardial segments with at least 50% of the maximal left ventricular uptake were demonstrated to be viable at FDG PET.[3] In our study, we investigated the segments with less than 50% of maximal uptake at stress phase. If these segments showed at least 20% redistribution in later phases, they were considered viable. We concluded that 20.4% of segments (17 out of 83 segments), which remained persistently hypoperfused at reinjection, showed viability at 24-hour redistribution imaging. The mechanism of this phenomenon has been proposed in previous studies:[2-13] reinjection of thallium at rest increases thallium uptake in the normally perfused territories to a greater extent than in hypoperfused territories, resulting in the appearance of relative thallium washout compared with the redistribution image. This differential uptake of thallium results in a defect on stress images that improves or normalizes on the redistribution images but then reappears on the reinjection images.[14]

In such patients, the reinjection image may mirror the stress image; and it is the redistribution image, not the reinjection image, that provides the important information regarding reversibility of the defect, hence, viability.

In this subset of patients, the elimination of redistribution data creates uncertainties regarding the interpretation of an irreversible defect when a stress–reinjection protocol is used.[2-13] Antanopolous et al. compared early post-exercise images with delayed 4 and 24-hour redistribution and revealed that delay imaging showed 11% improvement in the detection of viable segments.[15]

This value was 20.4% in our study; however, patient selection, stress, and imaging protocol as well as viability detection criteria were different.

We believe that our study not only does not overestimate the value of delay imaging for viability detection but also may underestimate it because of our strict criteria for viability definition.

Conclusion

In patients with previous myocardial infarction who are referred for viability detection and undergo stress 4-hour reinjection imaging, 24-hour delay imaging is recommended if reinjection images reveal considerable non-viable segments.

Conflict of Interest

No conflicts of interest have been claimed by the authors.

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