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Differentiation of transiently ischemic from infarcted myocardium by Thallium-201 exercises scintigram after active ergometer rehabilitation

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It has been frequently reported that while myocardial viability is neglected in conventional methods of diagnosis such as left ventriculography, ECG, and exercise thallium-201 myocardial scintigraphy (Ex-Tl), revascularization often results in improving left ventricular wall motility. In the present study, the authors contrived a method to accurately evaluate the viability ot the myocardium by means of exercise rehabilitation, and tested the method in clinical cases. Among patients with myocardial infarction, we selected a patient with negative viability in the diseased area as determined by chronic ECG, left ventriculography (LVG), coronary angiography and Ex-Tl. This patient went through two weeks of active exercise rehabilitation gauged with an ergometer, and was then re-examined by Ex-Tl. After the evaluation, revascularization was performed for the patient who demonstrated viability of the infarcted myocardium in EX-Tl after rehabilitation, and significant improvement in contractility was shown in the chronic LVG. These findings indicate that our method of detecting potential viability of the infarcted myocardium is of clinical significance.

Key words: Exercise Tl-201 myocardial scintigraphy, Viability, Rehabilitation, Revascularization, SPECT

INTRODUCTION

In differentiating infarcted myocardium in the chronic stage from ischemic myocardium in patients with myocardial infarction, exercise Tl-201 myocardial scintigraphy (Ex-Tl) is frequently used and its usefulness has been widely accepted.[1,2] Nonetheless, it has frequently been reported that while myocardial viability is neglected in Ex-Tl, reascularization by percutaneous transluminal coronary angioplasty (PTCA), or coronary artery bypass grafting (CABG) restores the contractility of the myocardium.[3] In this regard, various procedures such as a delayed scan have been developed in an attempt to measure the viability of the myocardium more accurately.[5]

The present study was designed to develop a method to clearly diagnose the presence of ischemic myocardium while noting viable myocardium within the infarcted region, as it has not been possible to

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confirm this by conventional procedures. There are reports showing that exercise rehabilitation has the effect of developing collateral coronary circulation for the ischemic myocardium. On the other hand, many reports show that exercise rehabilitation would not help in developing collateral circulation for the infarcted myocardium.[5,6] Thus, if exercise rehabilitation accelerates the development of collateral circulation for the ischemic myocardium, located in the peripheral area of the infarcted region in patients with chronic myocardial infarction, it would become a useful procedure in diagnosing ischemic myocardium around the infarcted myocardium.

A new way to distinguish the ischemic myocardium from the infarcted myocardium is shown below.

First, patients with acute myocardial infarction (AMI) in the chronic stage, for whom the conventional methods failed to determine the viability of the myocardium, are selected.

Second, these patients are subjected to active exercise rehabilitation on a bicycle ergometer for a specific period.

Then, finally, the amount of viable myocardium in the infarcted myocardium is re-evaluated by Ex-Tl.

In this study, we discussed whether it is possible to accurately diagnose the presence of myocardial viability by this method, and compare the results with those obtained by conventional diagnostic procedures.

SUBJECT AND METHOD

1) Patient selection

Of the patients admitted to our or affiliated hospitals for anterior AMI, those having fulfilled the following four conditions during the examination, were included in the present study over four weeks after the onset of the disease.

(1) QS pattern in the anterior wall area is recognized on the electrocadiogram (ECG).
(2) Dyskinesis or akinesis in the anterior wall disclosed by left ventriculography (LVG) or ultrasonic cardiography (UCG).
(3) Stenosis of 90% or more of the left anterior descending artery is shown in the coronary angiography (CAG).
(4) Persistent defect disclosed by Ex-Tl.

The first patient who met the above requirements had stable hemodynamic parameters. Treatment with a calcium antagonist and a nitrite agent resulted in good clinical development, and he completed the routine program for rehabilitation following myocardial infarction.

2) Viability identification protocol

The protocol of the present study is shown in Fig. 1. For exercise scintigraphy, a bicycle ergometer was used. It followed a multi-stage incremental method, starting at 25W and increasing by 25W every three minutes. The exercise was ended following the appearance of chest pains or fatigue in the lower extremities, attaining the target heart rate, the appearance of remarkable ST-T changes on the ECG, or the onset of arrhythmia.

Immediately after the exercise was stopped, 2 or 3 mCi of Tl-201 was injected intravenously, then the exercise was restarted and continued for about a minute. Pictures were taken, 4–5 min and 4 hr after intravenous injection with a Gamma Camera (ZLC-3700. Siemens) fitted with a singlehead high—resolution collimator. A Shimadzu Scintipac 2400 was used (ZLC-3700. Siemens) in processing nuclear medicine data.

For the patients selected, an active exercise rehabilitation program with the bicycle ergometer was followed for two additional weeks. The exercise program provided for the patients to operate the ergometer twice daily (morning and evening) with the load near their capacity (50 to 75W for 5 to 10 min). HR was maintained within 50–150 beats/min. After two weeks of exercise rehabilitation, Ex-Tl was performed and scintigram results were analyzed.

If any improvement is recognized on the scintigrams after two weeks of rehabilitation, myocardial viability should be determined at this point.

RESULTS

In the first patient selected for this study, there was significant improvement in the Ex-Tl after active

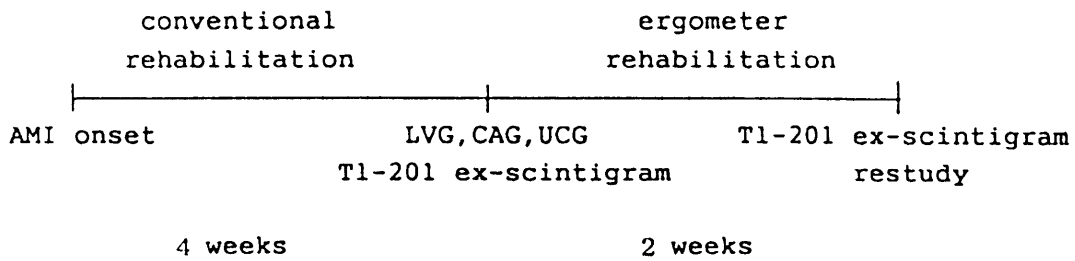

Fig. 1 Protocol for the procedure.

rehabilitation with the bicycle ergometer compared with EX-Tl before active rehabilitation. This suggested that there are clinical cases, whose viable myocardium within the infarcted area cannot be detected by conventional clinical examination, but can be detected by our newly developed method. The first case subjected to this study is described below.

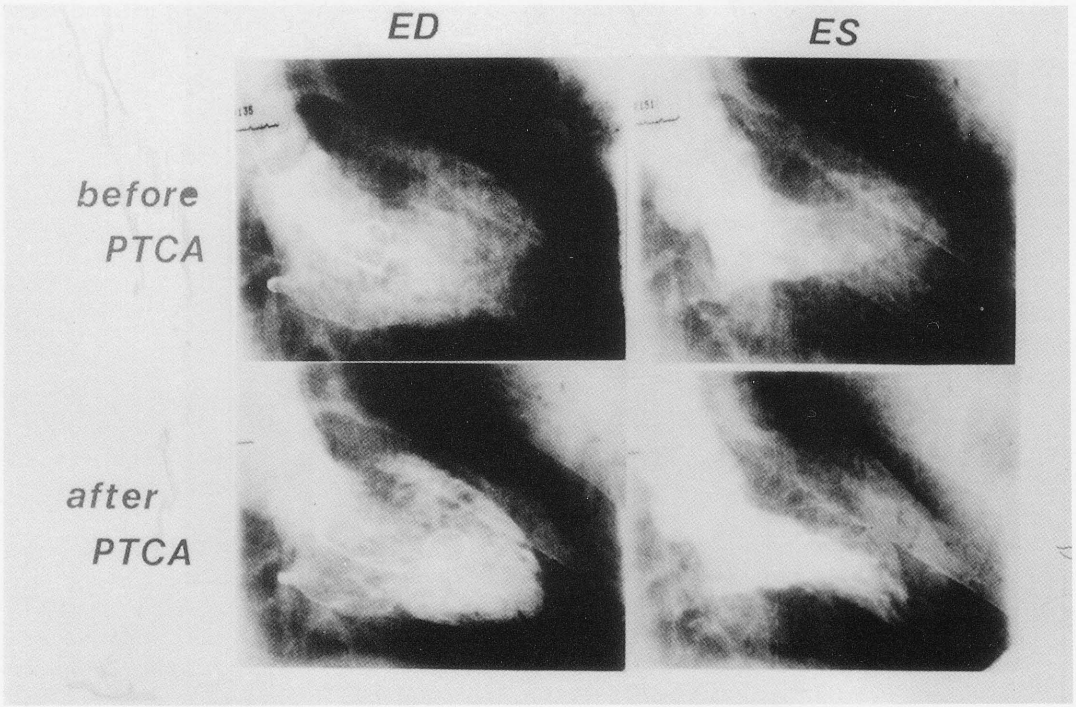

Fig. 2 Left ventriculography before and after the percutaneous transluminal coronary angioplasty (PTCA). Anterior wall movement was significantly improved after the PTCA procedure, suggesting the existence of the viable myocardium in the anterior wall.

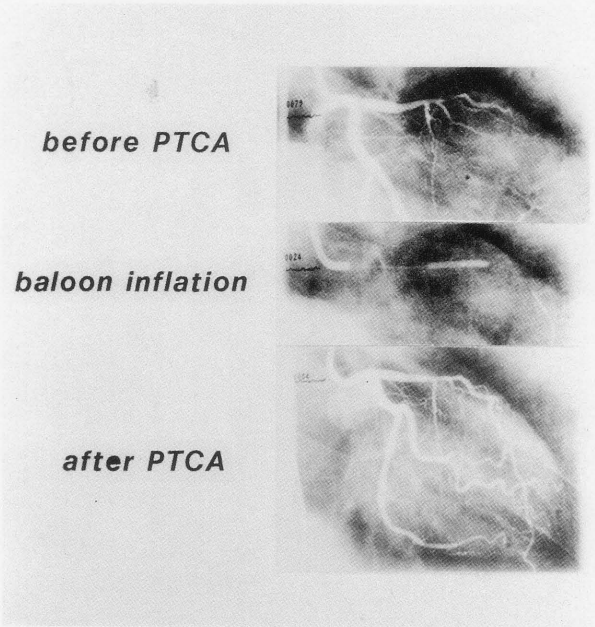

Fig. 3 Left coronary angiography during PTCA.
a) Before PTCA: Significant 99% stenosis was shown at the #7 of the left anterior descending artery with significant contrast delay. b) During PTVA: PTCA was performed by the use of the Hatzler-micro 3.0 balloon catheter. c) After PTCA: Significantly smooth dilatation was shown.

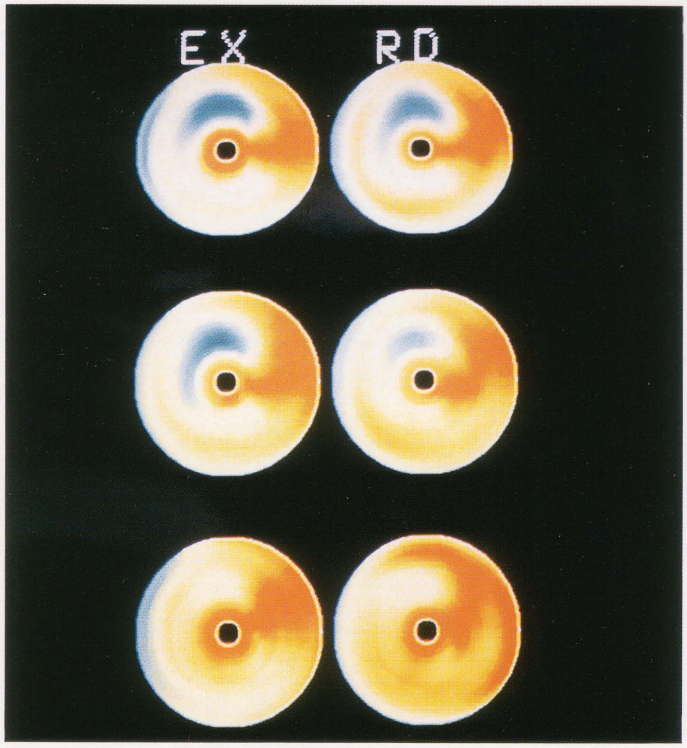

Fig. 4 Exercise thallium-201 myocardial scintigraphy before and after the active rehabilitation program using bicycle ergometer, and after the PTCA procedure. Significant improvement of the anterior wall was shown, suggesting the existence of the viable myocardium. And after the PTCA procedure, ischemic myocardium could not be detected.

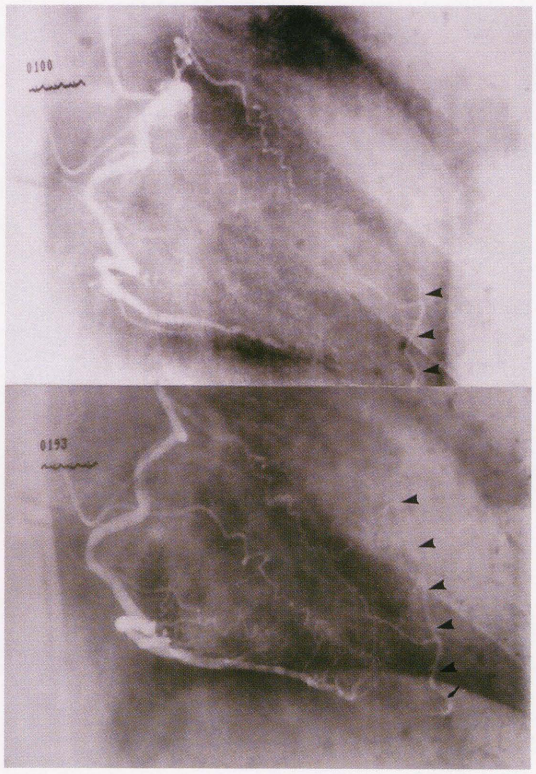

Fig. 5 Coronary angiography before and after the active rehabilitation program using bicycle ergometer. Collateral circulation to the left anterior descending artery was significantly increased after the active rehabilitation program.

CASE REPORT

The patient is a 58-year-old man with acute myocardial infarction seen at our hospital four days after the onset of the disease. The left ventricular and coronary angiograms taken during the chronic phase showed akinesis in the anterior wall as shown in Fig. 2, and there was 99% stenosis of the coronary artery with a remarkable contrasting delay in the #7 left anterior descending artery as shown in Fig. 3. Ex-Tl disclosed a persistent defect in the anterior wall as shown in Fig. 4, and together with the ECG findings evident in Fig. 5 and the left ventricular image in Fig. 2, viability of the anterior wall was virtually ruled out.

Bicycle ergometer rehabilitation was instituted for this patient, resulting in a fill-in in the anterior wall as shown by Ex-Tl, demonstrating possible viability in the anterior wall. And collateral circulation to the left anterior descending artery tended to increase in the coronary angiography (Fig. 5). Thus, PTCA was performed as shown in Fig. 3 to obtain satisfactory dilatation of the left anterior descending artery from 99% to 25% stenosis. The left ventricular image taken three months later disclosed a marked improvement in the motility of the anterior wall.

DISCUSSION

Ex-Tl is frequently used for the evaluation of viable myocardium in patients with old myocardial infarction to determine the indications for revascularization such as PTCA or CABG.[3] A persistent defect in the Ex-Tl is diagnosed as the infarcted zone and is not taken as an indication for the revascularization.[4] However, several investigators reported that while myocardial viability is ruled out by Ex-Tl, revascularization restores the contractility of the myocardium.[4,6] Since Braunwald et al. reported the concepts of stunned myocardium and hibernating myocardium, the existence of this phenomena suggested to us that movement of the left ventricular wall shown in the LVG and UCG is not useful in the evaluation of myocardial viability.[7] It is therefore very important to develop a method to diagnose clearly the presence of ischemic but noting viable myocardium within the infarcted region, as it has not been possible to confirm this by conventional procedures.

One of the major findings in this study is the

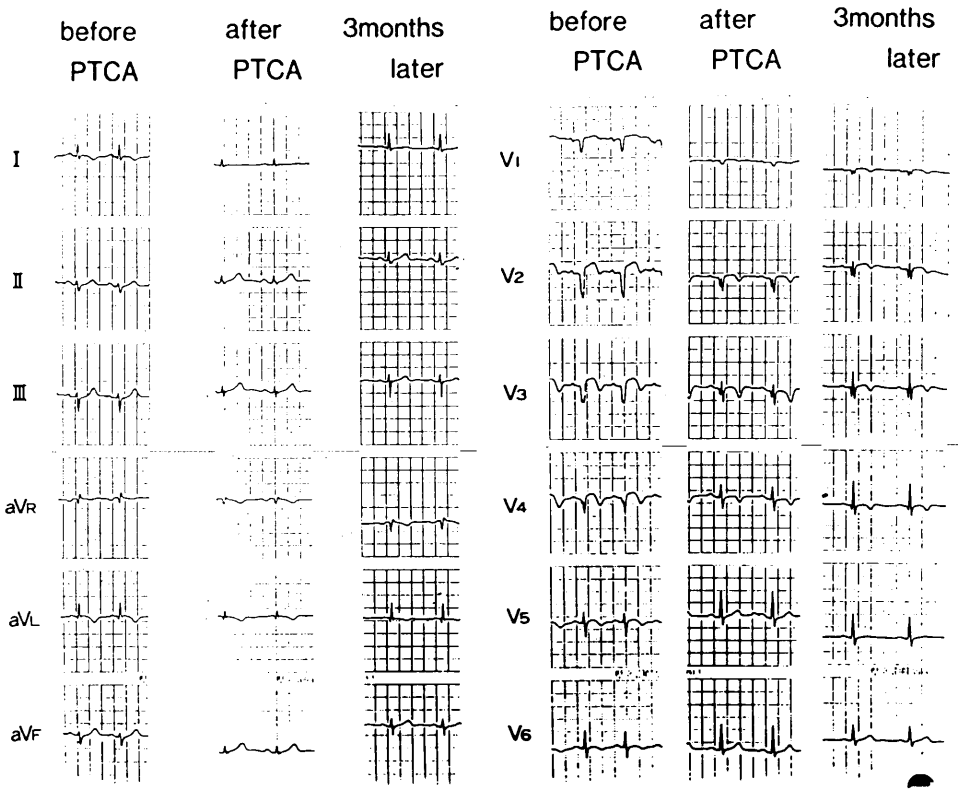

Fig. 6 Electrocardiograph before, immediately after and three months after the PTCA procedure. Before PTCA significant Q wave were shown in the anterior wall area, and immediately after PTCA, slight r wave suggesting the existence of the viable myocardium were shown. Three months later, significant R wave were shown in the anterior wall area of the ECG.

existence of a clinical case whose viable myocarium within the infarcted area could not be detected by the conventional clinical examination, but could be detected by our newly developed method, suggesting the clinical efficiency of our procedure. This phenomenon is probably due to the development of the collateral circulation to the ischemic, but viable, myocardium within the infarcted myocardium. Many reports show that exercise rehabilitation does not help in developing the collateral circulation for the infarcted myocardium, but has the the effect of developing collateral coronary circulation for the ischemic myocardium.[4,8]. Therefore, acceleration of the development of collateral circulation for the ischemic myocardium located in the peripheral area of the infarcted region in patients with chronic myocardial infarction by means of active rehabilitation with a bicycle ergometer, becomes a useful procedure in diagnosing ischemic myocardium around the infarcted myocardium.

Another procedure for the evaluation of the ischemic myocardium within the infarcted myocardium has been developed by various investigators using positrontomography.[5] However, it is evident that it is not useful for a small hospital like ours because positrontomography is too expensive.

It is very important for us to develop a simple and economical procedure to determine the indications for the revascularization. Our newly developd procedure shown here is a very simple and economical method for the small hospital and useful in accurately diagnosing the presence of myocardial viability.

To sum up, the authors contrived a method to accurately evaluate the viability of the myocardium by means of exercise rehabilitation, and tested the method in a clinical case. From among the patients with myocardial infarction, we selected a patient with negative viability in the diseased area as determined by chronic ECG, LVG, CAG, and Ex-Tl. This patient went through two weeks of active exercise rehabilitation gauged with an ergometer, and was then re-examined by scintigraphy. After the evaluation, revascularization was performed on the patient who demonstrated viability of the infarcted myocardium in EX-TI after rehabilitation, and showed improvement in contractility, according to the chronic LVG. These findings indicate that our method of detecting potential viability of the infarcted myocardium is of clinical significance.

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REFERENCES

1. Phost GM, Zir LM, Moore RH, et al.: Differentiation of transiently ischemic from infarcted myocardium by serial imaging after a single dose of thallium-201. *Circulation* 55: 294–302, 1977
2. Velani MS, Jhingam S, Attar M, et al.: Poststress redistribution of thallium-201 in patients with coronary artery disease, with or without prior myocardial infarction. *Am J Cardiol* 43: 1114–1122, 1979
3. Liu P, Keiss MC, Okada RD, et al.: The persistent defect on exercise thallium imaging and its fate after myocardial revascularization: Does it represent scar or ischemia? *Am Heart J* 110: 996–1001, 1985
4. Mutoh T.: Assessment of thallium-201 late redistribution in exercise myocardial SPECT. *Kaku-Igaku* 25: 639–646, 1988
5. Cohen MV.: Coronary collaterals. Furuta Publishing Company, Inc., 1985
6. Yambe T, Takeda H, Unno K, et al.: Expanded indication of percutaneous transluminal coronary angioplasty to the infarcted zone—using thallium-201 exercise scintigraphy after rehabilitation. *Kaku Igaku* 26: 781–786, 1989
7. Braunwald E, Kloner RA: The stunned myocardium: Prolonged postischemic ventricular dysfunction. *Circulation* 65: 905–912, 1982
8. Shaper W: Influence of physical exercise on coronary collateral blood flow in chronic experimental two vessel occlusion. *Circulation* 65: 905–912, 1982
9. Ratib O, Philps ME, Huang SC: Positrontomography with deoxyglucose for estimating local glucose metabolim. *J Nucl Med* 23: 577–586, 1982