Clinical Studies

Effects of Percutaneous Transluminal Coronary Angioplasty on Segmental Left Ventricular Function in Patients with Acute Myocardial Infarction

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SUMMARY

In order to investigate the usefulness of percutaneous transluminal coronary angioplasty (PTCA) on subsequent left ventricular (LV) function in patients with acute myocardial infarction (AMI), regional ejection fraction (REF) was calculated from the left ventriculogram and compared in the acute and chronic phases (4 weeks after infarction) in 19 successful cases of PTCA (group A). In addition, 15 successful cases of intracoronary thrombolysis (PTCR) (group R) and 14 unsuccessful cases (group U) were also analyzed in this study.

From the results, the following points were elucidated.

(1) REF of group A in the chronic phase showed a significant increase compared to that in the acute phase ($10\pm18\%$ vs $20\pm19\%$, $p<0.01$), and this was similar to that observed in group R ($9\pm19\%$ vs $21\pm16\%$, $p<0.01$).

(2) All cases in group A showed a significant increase in REF ($p<0.02$), if recanalization occurred within 3 hours after the onset of AMI. Some cases in the 3–6 hour recanalization group showed a decrease in REF.

(3) In group A, only patients with subtotal occlusion on the initial coronary angiogram showed a significant increase in REF 4 weeks later ($p<0.01$), whereas patients with total occlusion on the initial coronary angiogram showed no significant increase in REF.

(4) In group A, only patients recanalized between 3 and 6 hours showed a severe degree of prolonged contrast staining immediately after successful recanalization following PTCA.

Thus, chronic phase regional wall motion was markedly improved

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by PTCA in those cases with residual flow. In contrast, abrupt recanalization after PTCA might causally decrease regional wall motion due to hemorrhagic infarction, if it is performed in cases with total occlusion.

Additional Indexing Words:
Acute myocardial infarction Coronary angioplasty Intracoronary thrombolysis Regional ventricular function Hemorrhagic infarction

It is conceivable that early recanalization of the coronary artery is important in the treatment of acute myocardial infarction (AMI). Recently, coronary thrombolysis (PTCR) has been performed and its usefulness is being established.[1)-5)] In the meantime, percutaneous transluminal coronary angioplasty (PTCA) is being tested for early recanalization following myocardial infarction; however, the effectiveness of this procedure for salvaging the ischemic myocardium from necrosis has not been fully established. This study was conducted to determine the effect of PTCA on left ventricular function based on an analysis of acute and chronic (4 weeks after infarction) phase left ventriculograms in patients with AMI who underwent PTCA.

Subjects and Methods

Patients:

We studied 48 consecutive patients admitted between May, 1983 and May, 1985 for suspected acute myocardial infarction (AMI) within 9 hours of onset of symptoms. Patients with previous MI were excluded from this study. All patients underwent left ventriculograms during both the acute and chronic (on average 32 days after onset) phases. Of the 48 patients, 29 were treated with urokinase alone; 15 successful cases (group R) and 14 unsuccessful cases (group U) were included. PTCA followed thrombolytic therapy in the remaining patients, and good revascularization was obtained in all 19 cases (group A). The details of these subjects are shown in Table I. Complete written informed consent was obtained from each patient before emergency cardiac catheterization during the acute phase of AMI.

Cardiac catheterization:

The femoral approach was used for the coronary angiography and a multiprojectional coronary angiogram was performed. In order to avoid spastic occlusion, nitroglycerin (0.25 mg) was administered via the intracoronary route. After injection of nitroglycerin, a continuous intracoronary infusion of urokinase was started. A coronary angiogram was taken every 5 min

Table I. Summary of Clinical and Catheterization Data

	PTCR successful	PTCR unsuccessful	PTCA successful
Patients (no.)	15	14	19
Age (years)	63±7	61±6	62±8
Sex	12M, 2F	12M, 2F	14M, 5F
CAD (no. of patients)			
1V	9	10	14
2V	1	3	4
3V	5	1	1
Site of infarct (no. of patients)			
Anterior	8	6	13
Inferior	7	8	6
Hours from chest pain to admission (hrs)	2.3±1.2	3.9±4.4	3.1±2.4
Dose of urokinase (10,000 U)	69±27	69±31	69±36

Values represent mean±SD.
M=male; F=female; CAD=coronary disease; V=coronary vessel with luminal stenosis>75%.

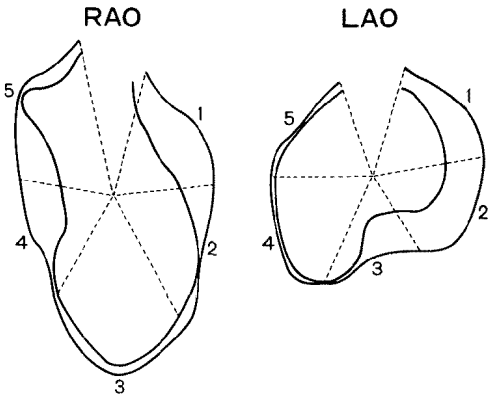
and the administration of urokinase was increased up to 960,000 U. Revascularization was evaluated by observing the reopening of the occluded vessels. In all patients, left ventriculography was performed with biplane 35 mm cineangiography in the acute stage and 4 weeks after the onset of AMI.

PTCA:

PTCA was usually performed by using the Gruentzig system, unless recanalization was successful with thrombolytic therapy alone. Thus, PTCA was performed in cases when total occlusion was observed even after PTCR, or in those patients who demonstrated subtotal occlusion (99% stenosis) with delayed filling. PTCA was determined to be successful when the occlusion or stenosis was reduced to less than 60% after treatment.

Quantification of left ventricular wall motion:

The left ventriculogram was projected into a video camera and ventricular silhouettes were traced with a light pen on a video screen. A computer system (Philips LVV 100) was used to calculate the volumes by using Simpson's rule. The angiographic ejection fraction (EF) was calculated according to the standard formula. For the purpose of segmental wall contraction analysis, each ventricular silhouette of the right and left anterior oblique projections was divided into 5 sector areas (Fig. 1). A regional EF (REF) was calculated as follows: regional EF (%)=Ad−As/Ad×100, where Ad is the area of each segment in end-diastole and As in end-systole.



$$\text{Regional ejection fraction (REF)} = \frac{A-B}{A} \cdot 100\%$$

A : Segmental area in end-diastole
B : Segmental area in end-systole

Fig. 1. Reference system for left ventricular segmental wall motion analysis.

Statistics:

The statistical analysis of the data was performed with Student's t-test for paired and non-paired comparisons between groups. Values were expressed as a mean±SD and changes were considered statistically significant if $p<0.05$.

Results

1) Changes in the global and regional EF (Tables II and III)

Global EF (GEF) was compared between the acute and chronic phases as shown in Table II. The average GEFs before treatment were 54±17% (group R), 55±8% (group U) and 55±12% (group A). The baseline values of GEF in these 3 groups were close and no significant difference was observed among the groups. PTCR or PTCA did not increase GEF in the chronic phase in any group. The average REF values of infarcted and non-infarcted

Table II. Changes in Ejection Fraction between Acute and Chronic Stages

	PTCR successful (n=15)	PTCR unsuccessful (n=14)	PTCA successful (n=19)
Global EF (%) Acute	54±17	55±8	55±12
Chronic	59±8	54±11	52±12

Values represent mean±SD.

Table III. Changes in Regional Ejection Fraction in the Infarcted and Non-infarcted Areas

	Regional EF in the infarcted area (%)		Regional EF in the non-infarcted area (%)	
	Acute	Chronic	Acute	Chronic
PTCR successful	(n=42)		(n=45)	
	9±19	21±16***	61±18	58±20
PTCR unsuccessful	(n=35)		(n=42)	
	12±14	18±17**	60±20	53±18*
PTCA successful	(n=53)		(n=57)	
	10±18	20±19***	59±18	50±16

Values represent mean±SD. * $p<0.05$ vs acute stage, ** $p<0.005$ vs acute stage, *** $p<0.001$ vs acute stage.

segments in the acute and chronic phases are shown in Table III. In group A and group R, REF increased significantly from 9±19% to 21±16%, and from 10±18% to 20±19%, respectively ($p<0.01$).

2) Changes in the regional EF in successful PTCA cases (Fig. 2)

A significant increase in REF of infarcted segments was observed in the chronic phases. Further analysis disclosed that REF in most regions increased, however, a decrease in REF in the chronic phase was also observed in 9 of 53 segments (6 of 19 cases).

We then studied factors which would be related to the recovery of REF in the chronic phase.

3) Time to recanalization (Fig. 3)

Based on the time from the onset of symptoms to recanalization, group A was divided into 3 subgroups; 0–3 hours, 3–6 hours and 6–9 hours, and their average REF values were compared. A significant increase in REF during the chronic phase was observed in the 0–3 hour and 6–9 hour patients ($p<0.02$). Specifically, the chronic phase REF markedly increased in cases recanalized within 3 hours, and reduction of REF was not observed in any segment. On the contrary, in the 3–6 hour recanalization group, significant reduction of REF was recognized in some segments, although no decrease in the average REF was observed.

4) Residual flow in infarcted segments (Fig. 4)

Nineteen PTCA cases were divided into 2 groups; subtotal and total occlusion groups, based on the findings of infarct-related vessels on the initial angiogram. REFs were compared between the acute and chronic phases. In the subtotal occlusion group with residual flow to the ischemic myocardium, REF rose significantly from 8±19 to 23±19% ($p<0.001$). However,

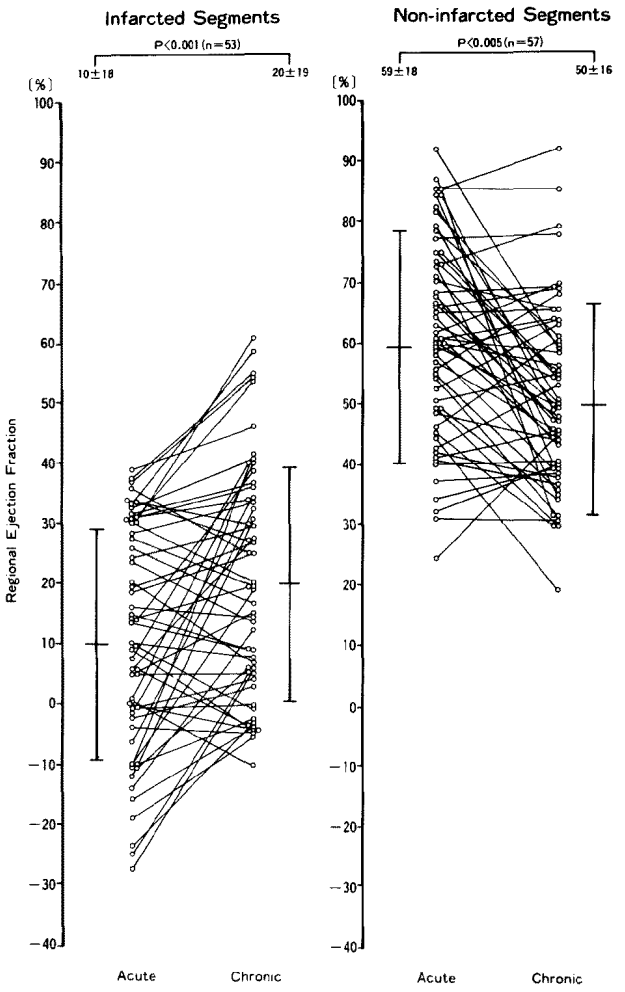


Fig. 2. Changes in regional wall motion after successful PTCA following intracoronary UK infusion in acute myocardial infarction.

REF in the total occlusion group which lacks residual flow to the ischemic myocardium did not change in the chronic phase.

5) Prolonged contrast staining (Figs. 5 and 6)

Myocardial staining with a contrast medium was occasionally observed immediately after recanalization by PTCA. This is explained by the penetration of the contrast medium into the extravascular space. Transient staining was excluded from the study, and those stainings which remained until the completion of catheterization were divided into 3 groups according to their size and intensity (Fig. 5). Fig. 6 shows the intensity of staining with respect to the time from the onset until recanalization. The high intensity of stain-

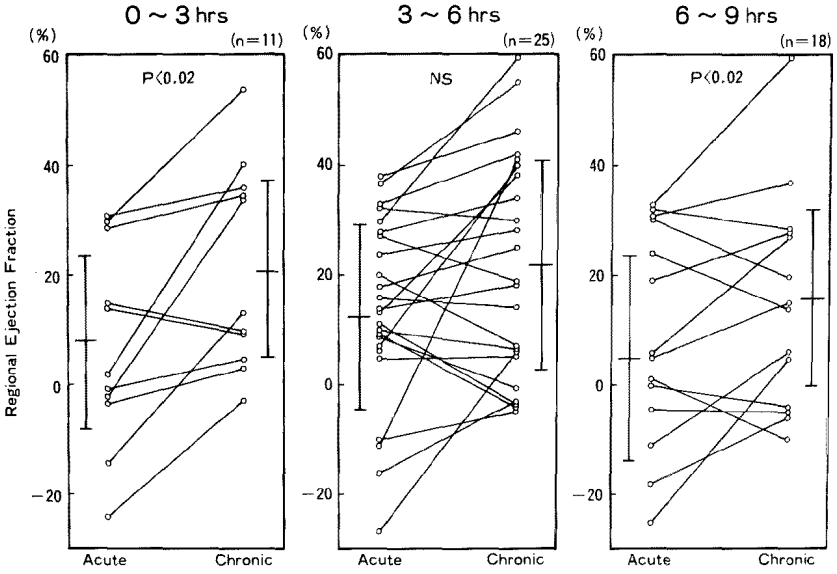


Fig. 3. Comparative changes in regional ejection fraction in the infarcted segments between acute and chronic stages after successful coronary angioplasty in patients group evaluated by time intervals from symptom onset to recanalization.

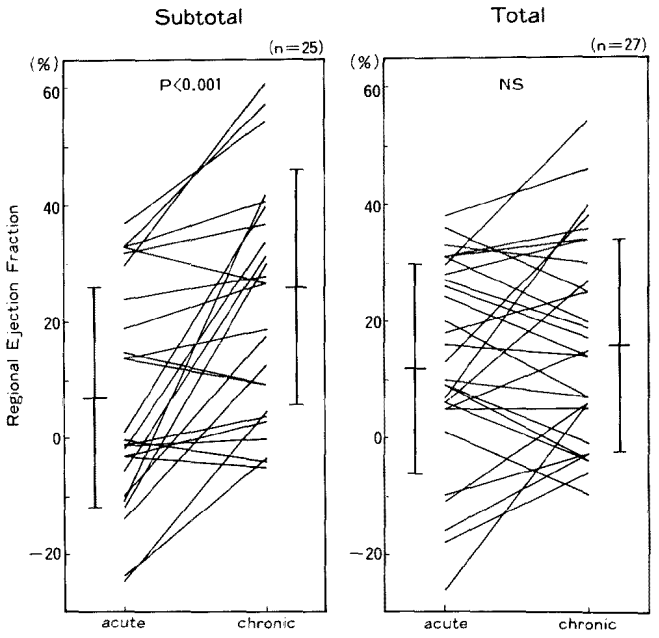
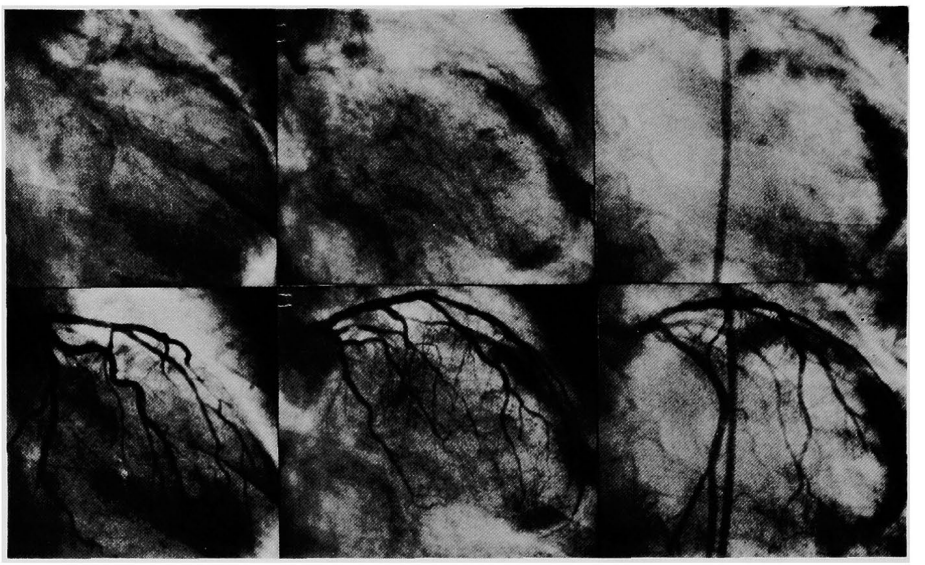


Fig. 4. Changes in regional ejection fraction in the infarcted segments between acute and chronic stages after successful coronary angioplasty in patients with and without total occlusion on the initial angiogram.



grade 1 grade 2 grade 3

Fig. 5. Prolonged contrast staining.

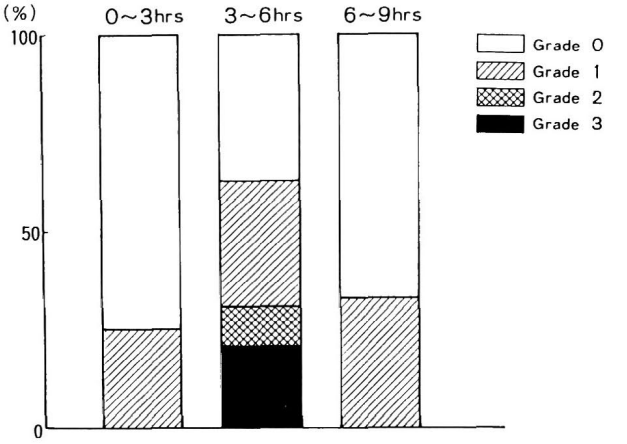


Fig. 6. Prevalence of prolonged contrast staining of different degrees after acute coronary recanalization by angioplasty in patients group evaluated by time intervals from symptom onset to recanalization.

ing, grades 2 and 3, was observed only in those cases where recanalization took place between 3 and 6 hours.

Discussion

In the cases where recanalization was successful following PTCR, recovery of left ventricular function was often observed in the chronic phase.[1)-5)] Accordingly, in this study, the application of PTCA to AMI was limited to the cases in which sufficient recanalization was not accomplished with PTCR alone. Since the left ventricular function during the acute phase of AMI is sometimes overestimated due to the compensatory motion of non-infarcted segments, REF was used as the indicator of regional left ventricular function. Thus, REF in the chronic phase of the PTCA group showed a significant improvement of left ventricular function similar to that of the successful PTCR group ($p<0.001$). Although the average REF of the PTCA group was improved, 9/53 segments (6 cases out of 19) showed marked reduction in the chronic phase. Thus, successful recanalization by PTCA did not always produce an improvement in regional wall motion, so we studied those factors which influence the recovery of left ventricular function in the chronic phase.

The interval from the onset of symptoms to recanalization of the infarct-related artery is an important factor. By using anesthetized dogs, Higginson et al[6)] reported that the hemorrhagic infarction was small when the interval between the onset and reperfusion was short enough. Schwarz et al[7)] also reported that the recovery of left ventricular function after PTCR in the chronic phase was better in cases where recanalization was accomplished within 4 hours than in those where it was accomplished after 4 hours. In our PTCA cases, REF for the cases recanalized within 3 hours showed a marked improvement, but it decreased when recanalization was accomplished between 3 and 6 hours. Residual flow in the infarcted segment during PTCA is important for the recovery of LV function. Schwartz et al[8)] examined the spontaneous improvement of left ventricular function after MI and concluded that it is dependent upon the presence of residual flow. Furthermore, Rogers et al[9)] emphasized the importance of forward flow through the subtotal stenosis or intact collateral for maintaining good left ventricular function following AMI in patients who underwent PTCR, PTCA or CABG. Our study also demonstrated a marked increase of REF in the subtotal occlusion group. Whereas in the total occlusion group only a few regions demonstrated improvements in REF, others showed deterioration. This may have been because in the total occlusion group, the ischemia was so severe that necrosis began at a very early stage. A hemorrhagic infarction immediately after revascularization was also postulated to explain this reduction in LV function.[10)-12)] We were not able to evaluate the role of the collateral circulation in maintaining residual flow in this study, due to the lack of a large enough

number of good cases. However, we believe that antegrade flow is more important than collateral flow.

Prolonged contrast staining is currently observed after the application of PTCR or PTCA during the acute phase of AMI. It was not determined in this study whether this phenomenon reflects the leakage of formed elements of blood into the extravascular space. Mathey et al[10] reported 6 deaths resulting from cardiogenic shock and 4 from hemorrhagic infarction in 101 AMI cases with successful recanalization by streptokinase. In all cases, good recanalization was obtained 3 hours after the onset of AMI or later. They emphasized that hemorrhagic infarction was not observed in the 2 cases where recanalization occurred within 3 hours.[10] In our study, high intensity staining, grades 2 and 3, was seen in most cases recanalized between 3 and 6 hours, therefore a close relationship between the degree of staining and the elapsed time before the recanalization was suggested. Furthermore, in those cases with high intensity staining, left ventricular function deteriorated during the chronic phase. Two patients who died were excluded from our study. In these cases recanalization was established by PTCA 4 hours after the onset of infarction with the appearance of staining immediately after PTCA. They subsequently developed refractory heart failure and died about 2 months after the onset of MI; no evidence of hemorrhagic infarction was observed at autopsy.

Conclusion: Despite the elapsed time before recanalization, improvement of chronic phase regional wall motion was observed in the successful cases of PTCA with residual flow to the ischemic myocardium. On the contrary, in some cases without residual flow to the ischemic myocardium, even though recanalization was successfully achieved after PTCA, regional wall motion decreased possibly due to the hemorrhagic infarction induced by abrupt recanalization. Therefore, caution should be advised in the application of PTCA to AMI patients with total occlusion.

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