

# Sequential Change in Myocardial Perfusion in Ischemic Heart Disease Post Percutaneous Coronary Intervention: A longitudinal study using first-pass contrast-enhanced MRI

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## Abstract

In this study, we performed first-pass contrast-enhanced (FPCE) myocardial perfusion in a serial follow-up to determine the timing, magnitude and transmural difference of myocardial perfusion recovery by evaluating the change in stress perfusion, rest perfusion, and myocardial perfusion reserve (MPR). All patients received baseline MR studies one day before PCI treatment and follow-up MR studies at one day, one week and one month after the PCI treatment. We found that the myocardial perfusion in the ischemic regions can be restored as early as 24 hours after PCI, and perfusion in the inner wall of the myocardium improves more significantly than that in the outer wall. The improved myocardial perfusion can persist at least one month following PCI.

## Introduction

Percutaneous coronary intervention (PCI) has been used to restore myocardial blood flow in the stenotic coronary arteries. Conventional methods such as coronary angiography and nuclear tracer imaging are limited in the assessment of the magnitude, timing and transmural difference of the recovered myocardial perfusion after PCI. In this study, we performed first-pass contrast-enhanced (FPCE) myocardial perfusion in a serial follow-up to determine the timing and magnitude of myocardial perfusion recovery by evaluating the change in stress perfusion, rest perfusion, and myocardial perfusion reserve (MPR). In addition, we analyzed the difference in perfusion recovery between inner layer and outer layer of the myocardium.

## Materials and Methods

**Study protocol** Five patients (N=5) with angiographically-documented coronary artery stenosis were enrolled in this study. All subjects underwent both rest and stress first-pass CEMR studies on a 3T MR scanner (Tiro, Siemens, Erlangen, Germany). All patients received baseline MR studies one day before PCI treatment and follow-up MR studies at one day, one week and one month after the PCI treatment. **Image acquisition** Three short-axis planes at basal, mid left ventricular (LV) and apical levels were acquired using saturation-recovery prepared T1-weighted turbo FLASH pulse sequence. Right after the scanning started, Gd-DTPA (0.025mmole/kg) was bolus injected via left antecubital vein at a rate of 4–6ml/sec. After the rest perfusion study, vasodilator (dipyridamole, 140µg/kg/min) was infused intravenously for 4 min and the stress perfusion study began at the 7th min when the maximal vasodilatation was achieved. **Image analysis** LV myocardium was segmented semi-automatically and divided into 16 equiangular segments according to the guidelines provided by AHA/ACC [1]. After the background signal correction, myocardial perfusion at rest and stress, in the unit of ml/min/g, was quantified segment by segment by model-independent deconvolution analysis [2]. MPR was calculated by dividing the perfusion at stress by the perfusion at rest. All segments were categorized into two regions, ischemic region and non-ischemic region, according to the findings of the coronary angiography. Regional perfusion indices, including rest perfusion, stress perfusion and MPR, were computed in the ischemic region and non-ischemic region. Comparisons were made (1) between regional perfusion indices in the ischemic region and those in the non-ischemic region at each time point, (2) between regional perfusion indices at baseline and those at day 1, day 7 and day 30, and (3) between regional perfusion indices in the inner wall and those in the outer wall. **Statistical Analysis** Data were presented as mean±SD or as numbers and percentages. Concurrent comparison of the perfusion indices was performed between ischemic and non-ischemic segments using student T test. Pair-wise comparison was performed using paired T test between perfusion indices at the baseline and those at three different time points post PCI. The same statistical analysis was applied to full wall, inner wall and outer wall. Statistical significance was considered if p<0.05.

## Results

Among the recruited 5 patients at four time points, a total of 40 regions of the myocardium were successfully analyzed, 20 ischemic regions and 20 non-ischemic regions. Compared with the non-ischemic regions, the ischemic regions showed significant impairment of myocardial perfusion during hyperemia ( $2.04 \pm 0.88$  vs.  $3.13 \pm 0.69$ ,  $p=0.018$ ) and MPR ( $1.23 \pm 0.36$  vs.  $1.76 \pm 0.32$ ,  $p=0.009$ ) before PCI (Fig. 1). There was no significant difference of rest perfusion between two regions. For layer analysis, the inner wall of the ischemic regions was significantly lower than that of the non-ischemic regions in stress perfusion ( $2.19 \pm 0.96$  vs.  $3.90 \pm 0.86$ ,  $p=0.003$ ) and MPR ( $1.11 \pm 0.41$  vs.  $1.70 \pm 0.30$ ,  $p=0.006$ ). No significant difference in the perfusion indices was found in the outer wall. After PCI treatment, the differences in stress perfusion and MPR between these two regions disappeared at day 1, day 7 and day 30 (Table 1). The stress perfusion and MPR of the ischemic regions significantly improved 24 hours after PCI. This improvement persisted through one month following PCI. The stress perfusion and MPR in non-ischemic regions increased at day 1 and then gradually returned to baseline at day 30 following PCI.

## Conclusion

We have demonstrated that the myocardial perfusion in the ischemic regions can be restored as early as 24 hours after PCI, and perfusion in the inner wall of the myocardium improves more significantly than that in the outer wall. The improved myocardial perfusion can persist at least one month following PCI. The myocardial perfusion in the non-ischemic regions increased transiently 24 hours following PCI, which may indicate a hyperemic response in remote segments after coronary intervention. This hyperemic change disappears by 1 month following PCI.

## References

1. Cerqueira MD et al. Circulation 2002;105:539-542.
2. Jerosch-Herold M et al. Med Phys 2002;29:886-897.

PCI regions			Non-PCI regions			
pre-PCI MPR	post-PCI MPR	p value	pre-PCI MPR	post-PCI MPR	p value	
	24 hours	$1.86 \pm 0.29$	0.007	24 hours	$1.97 \pm 0.53$	0.178
$1.23 \pm 0.36$	1 week	$2.07 \pm 0.78$	0.011	1 week	$2.34 \pm 0.72$	0.027
	1 month	$1.87 \pm 0.81$	0.051	1 month	$1.69 \pm 0.57$	0.382

Table 1. Pre and post-PCI MPR changes in ischemic regions and non-ischemic regions

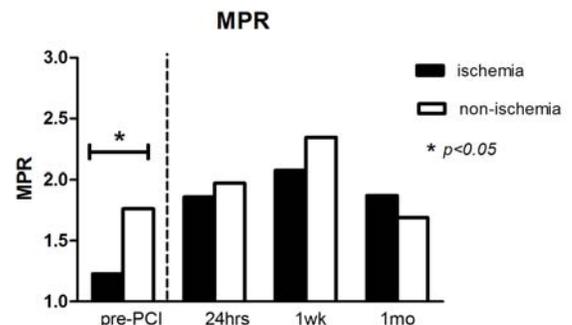


Fig 1. MPR differences between ischemic and non-ischemic regions at baseline, 24 hrs, 1 week and 1 month following PCI.