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Original Article

Reperfusion-induced hypotension during primary percutaneous coronary intervention after acute myocardial infarction

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Abstract: Objective: This study aims to investigate the predictors of reperfusion-induced hypotension (RIH) during primary percutaneous coronary intervention (PCI) after acute ST-segment elevation myocardial infarction (STEMI), as well as the impact of RIH on prognosis. Methods: A retrospective analysis was performed for 204 STEMI patients who underwent primary PCI in our hospital from January 2009 to June 2013. The patients were divided into RIH and non-RIH groups, and clinical data for the 2 groups were collected and compared. Alogistic regression equation was used to analyze the RIH predictors; a 12-month follow-up was performed to compare the differences in major adverse cardiac events (MACE) between the 2 groups. Results: The intergroup comparison showed that in the RIH group, the infarct-related artery (IRA) was mainly the right coronary artery (RCA) (75.0% to 27.7%, *P*=0.000), and the reperfusion time was shorter (4.7±0.8 to 6.8±2.8, *P*=0.040). The logistic regression analysis showed that the IRA (odds ratio [OR]: 5.956, 95% confidence interval [CI]: 1.298-10.878, *P*=0.015) and reperfusion time (OR: 4.262, 95% CI: 0.110-0.944, *P*=0.039) were predictors of RIH. During hospitalization and the 12-month follow-up, there was no significant difference in MACE between the 2 groups (*P*=0.608 and 0.499, respectively). Conclusions: RCA lesions and short reperfusion time were predictors of RIH, and there was no significant increase in MACE during the 12-month follow-up period for RIH patients.

Keywords: Myocardial infarction, angioplasty, transluminal, percutaneous coronary, myocardial reperfusion injury, hypotension, risk factor, prognosis

Introduction

For ST-segment elevation myocardial infarction (STEMI) patients, reperfusion by means of percutaneous coronary intervention (PCI) is the most effective treatment. However, about 50% of patients exhibit blood pressure reduction in the early stage of infarct-related artery (IRA) dredging [1-3]. This phenomenon is known as reperfusion-induced hypotension (RIH). Severe RIH could cause hemodynamic disturbances and thus increase procedural risks [4]. To date, the exact mechanism of RIH is still unclear [3], and its impact on long-term prognosis is infrequently studied. In this study, patients with and without RIH during PCI were set as the research subjects, aiming to investigate RIH predictors and its influence on prognosis.

Subjects and methods

Subjects and data collection

The clinical and angiographic data of STEMI patients who underwent primary PCI in Tianjin Union Medicine Center from January 2009 to June 2013 were collected. STEMI was defined in accordance with the naming and diagnostic criteria of ischemic heart disease from the International Society and Federation of Cardiology/World Health Organization [5, 6] and determined according to the symptoms of chest pain, electrocardiogram (ECG) changes, and blood-myocardial injury markers (cardiac troponin T and cardiac enzymes). The criteria for primary PCI were (1) chest pain lasting ≥30 min; (2) ECG exhibiting at least 2 adjacent chest

Table 1. Comparison of clinical baseline data and angiographic data of the two groups [cases (%)]

Parameter	RIH group (n=92) (n, %)	Non-RIH group (n=112), (n, %)	*P*
Male	68 (73.9)	93 (83.0)	0.123
Age (years)	63.0±10.2	60.7±9.1	0.405
Diabetes (cases)	38, 41.3	45, 40.2	0.887
Hypertension (cases)	63, 68.5	80, 71.4	0.645
Hyperlipidemia (cases)	37 (40.2)	47 (42.0)	0.886
Smoking (cases)	53 (57.6%)	71 (63.4%)	0.471
IRA (cases)			
RCA	69 (75.0%)	31 (27.7%)	0.000
LAD	15 (16.3%)	76 (67.8%)	0.000
LCX	8 (8.7%)	5 (4.5%)	0.257
Lesion vessel counts (cases)			
Single	15 (16.3%)	19 (16.9%)	1.000
Two	23 (25.0%)	30 (26.8%)	0.873
Three	54 (58.7%)	63 (56.3%)	0.777
Reperfusion time (h)	4.7±0.8	6.8±2.8	0.040

Table 2. Multifactor Logistic regression analysis towards the RIH occurrence

Factors	Wald χ^2	*P*	*OR*	95% *CI*
IRA	5.956	0.015	3.757	1.298-10.878
Reperfusion time	4.262	0.039	0.322	0.110-0.944

IRA: infarct-related artery.

lead ST-segment elevations ≥0.2 mV or a limb lead ST-segment elevation ≥0.1 mV; and (3) onset of chest pain within 12 h or over 12 h, while the chest pain continued.

In addition to complying with the primary PCI criteria, this research also required that the IRA be completely occluded, namely thrombolysis in myocardial infarction (TIMI) flowgrade 0, when performing the coronary angiography. The exclusion criteria included (1) past history of myocardial infarction; (2) preoperative systolic blood pressure <90 mmHg; (3) preoperative intravenous vasopressor use; and (4) no-reflow or slow flowphenomenon during the PCI procedure.

Operative method and perioperative medication

In preparation for primary PCI, the patients received 300 mg aspirin and 300 mg clopidogrel immediately. We utilized the standard PCI method: the Judkins method was used to perform selective coronary angiography from the left radial artery approach, then combined with the myocardial infarcted region on the ECG to determine the IRA. After passing the guide wire through the lesion, we performed balloon dilatation as well as thrombus aspiration, if necessary, followed by stenting. The enrolled patients were all successfully reperfused. During the PCI procedure, invasive blood pressure and heart rate were monitored. Before the angiography, 5000 IU heparin was conventionally injected through the radial arterial sheath, and another 3000 IU heparin was administered before the intervention. When RIH occurred, the operator could use dopamine to correct the low blood pressure according to the patient's condition; patients with severe bradycardia were administered a bolus injection of atropine or had a temporary cardiac pacemaker implanted. During the surgery, the platelet membrane glycoprotein II b/III a antagonist tirofiban was conventionally injected into the coronary artery through the guiding catheter. After the operation, tirofiban was maintained for 24-48 h. Low-molecular-weight heparin was used for anticoagulation for 5-7 d. Patients were prescribed 100 mg aspirin once/day for life-long administration and 75 mg clopidogrel once/day for at least 12 months. Major adverse cardiac events (MACE), which included cardiovascular death, reinfarction, refractory angina, and heart failure, were recorded during hospitalization and for 12 months after discharge.

Definition and grouping

After the guide wire passed through the occlusive lesions, balloon dilatation or the suction catheter passed through the lesions. Contrast or "smoking" demonstrated the restoration of forward blood flow. The patients whose invasive systolic blood pressure dropped <12 kPa (90 mmHg) or systolic blood pressure dropped ≥20 mmHg within 15 min immediately after dredging were assigned to the RIH group. Others were assigned to the non-RIH group. Reperfusion time referred to the time period

Table 3. Incidence of MACEs of the 2 groups during the hospitalization and 12-month follow-up after discharged [cases (%)]

Item group	Cardiovascular death	Re infarction	Heart failure	Refractory angina	Total MACEs	*P*
During the hospitalization						
RIH group	1 (1.1%)	0	2 (2.2%)	0	3 (3.3%)	0.608
Non-RIH group	1 (0.9%)	0	3 (2.7%)	0	4 (3.6%)	
During 12-months follow-up						
RIH group	1 (1.1%)	2 (2.2%)	2 (2.2%)	0	5 (5.4%)	0.499
Non-RIH group	1 (0.9%)	1 (0.9%)	2 (1.8%)	1 (0.9%)	5 (4.5%)	

from the onset of chest pain symptoms to the reopening of the IRA.

Statistical analysis

SPSS19.0 statistical software (SPSS Inc., Chicago, Illinois, USA) was used to process the variables. Measurement data were expressed as the mean ± standard deviation. We used the t-test for comparing measurement data; the χ^2 test for counting data; and the logistic regression model for analyzing the predictive values of various factors in the occurrence of RIH, with $P<0.05$ considered statistically significant.

Results

General results

Among the 248 patients who met the inclusion criteria, 204 patients completed the 12-month follow-up, including 161 men (78.9%) and 43 women (21.1%). The mean age was 61±9.4 years. Ninety-two patients experienced RIH, accounting for 45.1%. The 2 groups showed statistically significant differences in the IRA and reperfusion time. Compared with the non-RIH group, the RIH group mainly showed the right coronary artery (RCA) as the IRA, with fewer left anterior descending artery (LAD) lesions ($P=0.001$); the reperfusion time of the RIH group was shorter than that of the non-RIH group ($P=0.040$, **Table 1**).

RIH predictors

RIH was set as the dependent variable. Sex, age, complications, IRA, and reperfusion time were input into the logistic regression. The results showed that RCA lesions and short reperfusion times were the predictors of RIH ($P=0.015$ and 0.039, respectively, **Table 2**).

Follow-up data analysis

During hospitalization, the RIH group had one death caused by cardiogenic shock on postoperative day 2, and 2 patients experienced acute left ventricular failure. The non-RIH group had one death caused by cardiac rupture 6 h after surgery, and 3 patients experienced acute left ventricular failure during hospitalization. MACE between the 2 groups during hospitalization and at the 12-month follow-up did not differ significantly ($P=0.608$ and 0.499, respectively, **Table 3**).

Discussion

Directly opening the culprit coronary artery is the best means to treat STEMI; however, more than 50% of patients exhibit RIH after the occluded coronary artery is reopened. This hypotension usually recovers within 30 min to 24 h [2], but it also can last for several days. RIH can cause severe hemodynamic disturbances, thereby affecting the perfusion of vital organs, causing hypoxemia and metabolic acidosis [7]. Thus, it is necessary to correct RIH with the timely application of vasopressors, as well as with intra-aortic balloon pump-assisted support when necessary [8]. The accurate prediction and timely treatment of RIH are critical clinically.

Some research has shown that reopening the acute RCA occlusion, especially the RCA proximal lesion [1-3], causes RIH, while reopening the LAD is less likely to cause RIH [9]. The reasons might include the following: (1) the left ventricular inferior wall, supplied by the RCA, is rich with the vagus nerve plexus, and the excitabilities of the nerve plexus would be increased during reperfusion, thus causing the Bezold-Jarisch reflex [10, 11], resulting in cardiac

depression and blood pressure reduction [2]; (2) arrhythmias, including bradycardia or accelerated idioventricular rhythm, more commonly occur when reopening the RCA than when reopening the LAD [1-3, 12] so cardiac output would be impaired [3, 13]; (3) patients with inferior wall myocardial infarction caused by the acute RCA occlusion would be more likely to sweat and vomit before direct PCI, so hypovolemia would occur. The results of this study were consistent with this research. Furthermore, it can be seen from **Table 1** that although RCA lesions accounted for 75.0% of the lesions in the RIH group, 16.3% of patients exhibited the LAD as their IRA. The mechanism of RIH after LAD reopening differed from that of the RCA, and the reperfusion injury caused myocardial stunning, which might be the main reason [14]. The findings of this study also suggested that the short reperfusion time, especially within 6 h (4.7±0.8 h in the RIH group), was a predictor of RIH occurrence, which might be related to the fact that relatively more cardiac muscle survived during that time, and the reperfusion injury was significant [15]. According to these 2 predictors, patients with a higher likelihood of RIH should receive rapid fluid expansion before PCI, have a temporary pacemaker implanted to prevent dramatic bradyarrhythmia, and be rationally administered vasoactive drugs. Further, calm handling could reduce the risks during PCI.

Relatively few studies about the influence of RIH on prognosis exist. JEE followed 236 STEMI patients without cardiogenic shock, and the results showed that postoperative hypotension had no significant effect on MACE 30 days and 1 year after PCI [16]. Our results also showed no significant difference in the 12-month follow-up MACE between the 2 groups. Previous studies had shown that the reperfusion time of primary PCI was closely related to prognosis, and the sooner the IRA was opened, the better the prognosis would be [17]. In this study, the reperfusion time of the RIH group was shorter than that of the non-RIH group. The RIH occurrence itself also manifested a considerable number of surviving cardiac muscles, and the benefits of reperfusion therapy were greater. In addition, the RIH phenomenon mostly lasted a short period. After timely and effective treatments, such as dopamine, fluid expansion, and arrhythmia correction, hypotension would mostly be corrected within 24 h. Only one patient developed cardiogenic shock. Therefore, RIH had less impact on the long-term prognosis. While this did not indicate that the reperfusion injury had no adverse effect on STEMI prognosis, Georg M considered reperfusion injury to be responsible for up to half of the final infarct size related to acute myocardial infarction [18]. The mechanisms of reperfusion injury were also very complicated [14, 19, 20], and fewer patients were enrolled in this study. Therefore, a larger scale study is still needed to confirm the relationship between RIH and prognosis. In addition, because the mechanisms of LAD and RCA opening that caused RIH were different, the former involved more left ventricular muscles, thus indicating a high probability of long-term heart failure [21, 22].

In summary, nearly half of STEMI patients experience RIH after reopening of the RCA. RCA lesions and reperfusion time <6 h might be used as predictors for RIH occurrence. When RIH occurs, active treatment to promptly correct the low blood pressure condition will lead to a good prognosis, and MACE will not be significantly increased in the 12-month follow-up period.

Disclosure of conflict of interest

None.

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