Original Article

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Effect of Early Coronary Collateral Circulation in Patients with ST Elevation Myocardial Infarction

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Abstract

Background and Aims: Coronary collateral circulation can develop early after STEMI and patients having these coronary collaterals have favorable outcomes. The aim of this study was to evaluate the prognostic impact of coronary collateral circulation in STEMI.

Methods: This is an observational prospective study of 106 consecutive STEMI patients undergoing Primary PCI admitted and treated at a tertiary cardiac centre from May 2019 to April 2020. Clinical profile, complications at index admission and atone month follow up were analyzed.

Results: Out of 106 consecutive patients, 50(47%) had early coronary collateral supplying the infarct related artery. The baseline characteristics of the patients in the two groups, with collateral and without collateral, were similar. Among patients with collateral circulation, only 5% had very well developed (Rentrop3) collaterals. The presence of collateral was strongly associated with presence of preexisting angina (p=0.007) and delayed presentation to hospital (p= 0.04). Coronary collateral was more common in non-diabetics, non-anterior wall STEMI and those with mutivessel disease. Compared with the patients without collateral supply, those who had collateral had fewer incidence of in-hospital heart failure (p=0.03) and post MI pericarditis (p=0.04).

Conclusion: In STEMI, development or recruitment of early collateral supply to the infarct related artery was associated with lower rates of heart failure, post MI pericarditis, cardiogenic shock, hospital stay and in-hospital deaths. At 1 month, patients with collateral supply had fewer angina recurrence, reinfarcton and stent thrombosis.

Keywords: ST elevation Myocardial infarction, Primary PCI, Early Coronary collateral circulation

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Introduction

Myocardial infarct size is the single most important variable affecting the outcomes in STEMI. Early recruitment of the collaterals to the infarct related artery during STEMI decreases the infarct size and has favorable effect on the short and long term outcomes. Coronary collaterals are pre-existing small arterial interconnections that enlarge to functionally relevant conduction vessels and they provide a bypass for alternative blood supply. It can develop within minutes in case of STEMI. Well-formed collaterals have beneficial effect on ventricular function, ventricular aneurysm formation, mechanical complications like free wall rupture/ventricular septal rupture and QT interval. This contributes to the reduced mortality in patients with a well-developed coronary collateral circulation.[1-7] We sought to investigate the impact of these early collateral circulation on clinical outcomes in STEMI patients who underwent Primary PCI.

Methods

This study was a single centre, prospective observational study. 106 consecutive patients with STEMI who met inclusion criteria were enrolled from May 2019 to April 2020 into the study.

Inclusion criteria were all patients aged 18 years or more with STEMI taken for primary PCI. Exclusion criteria included patients with known chronic total occlusion of any vessel, patients undergoing recue PCI, patients taking G-CSF or other angiogenic therapy and patients with un-interpretable CAG.

Collateral circulation was assessed visually during coronary angiography and classified according to Rentrop score.[8]

RENTROP SCORE:

0: absent contrast filling of collateral connections

1: contrast filling of collaterals up to the side-branch of the recipient artery

2: partial contrast filling of the epicardial main branch of the recipient artery
3: complete contrast filling of the epicardial main branch of the recipient artery

Follow up was done after 1 month of primary PCI. Written informed consent was taken from each patient and the study had ethical clearance from the IRB board.

Data were compiled, edited and checked to maintain consistency. Repetitions and omissions of data were corrected before coding and entering them in MS. Excel. Recorded data were then exported to SPSS V 25 for further statistical analysis. Descriptive statistics such as Mean ± SD or median (range) depending upon the distribution for continuous variables and frequency (percentage) for categorical variables were computed. The association between two categorical variables was assessed using Chi-squared test.

Independent sample t-test was used to compare means and non-parametric Mann-Whitney U test to compare medians of different continuous variables between patients with and without collateral circulation. Predictors of collateral circulation development was analyzed using binary logistic regression. The complications and outcomes between the two groups was compared using Fisher's exact test. The results were considered statistically significant if $p<0.05$.

Results

Among the 106 patients included, 56(53%) patients did not have angiographically visible collateral circulation, from here on labeled Group A. In the remaining 50 patients (47%, group B), we found some collateral filling of the infarct related artery (Rentrop score 1 in 22% patients, score 2 in 20% patients and score 3 in 5% patients).

Table 1: Baseline clinical characteristics

Characteristics	Patients without collateral circulation (Group A) (n = 56)	Patients with collateral circulation (Group B) (n = 50)	P-value
Age (years), mean ± SD	57.6 ± 14.8	56.4 ± 14.3	0.669
Sex, n (%)			
Male	40 (71.4)	36 (72.0)	0.948
Female	16 (28.6)	14 (28.0)	
Duration of symptoms (h), median (min – max)	4 (0.5 – 120)	7 (0.5 – 96)	0.04
Smoking, n (%)			
Yes	32 (57.1)	28 (56.0)	0.89
HTN, n (%)	22 (39.3)	20 (40.0)	0.95
Previous angina, n (%)			
Yes	13 (23.2)	24 (48.0)	0.07
Previous MI, n (%)			
Yes	1 (1.8)	1 (2.0)	0.93
Previous PCI, n (%)			
Yes	1 (1.8)	0 (0.0)	0.34
Previous CABG, n (%)			
No	56 (100.0)	50 (100.0)	0.89
DM, n (%)			
Yes	17 (30.4)	8 (16.0)	0.07
CKD, n (%)			
Yes	1 (1.8)	2 (4.0)	0.49
Dyslipidemia, n (%)			
Yes	6 (10.7)	4 (8.0)	0.57
PAD, n (%)			
No	56 (100.0)	50 (100.0)	0.91
Previous stroke/ TIA, n (%)			
Yes	1 (1.8)	0 (0.0)	0.34
Family history of premature CAD, n (%)			
Yes	1 (1.8)	3 (6.0)	0.25

Table 2: Clinical and CAG characteristics of the two groups

Characteristics	Patients without collateral circulation (n = 56)	Patients with collateral circulation (n = 50)	P-value
Killip class, n (%)			
Class I	39 (69.7)	38 (76.0)	
Class II	3 (5.3)	4 (8.0)	
Class III	3 (5.3)	0 (0.0)	
Class IV	11 (19.7)	8 (16.0)	
Baseline LVEF (%)	30 (20 – 60)	30 (15 – 60)	0.20
Door-to-wire time (min)	65 (20 – 125)	80 (20 – 325)	0.06
Culprit vessel			
LAD	31 (55.4)	22 (44.0)	
LCx	8 (14.3)	4 (8.0)	
RCA	15 (26.8)	23 (46.0)	
Other vessels	2 (3.6)	1 (2.0)	
Dominance			
Right	46 (82.1)	47 (94.0)	
Left	9 (16.1)	2 (4.0)	
Codominant	1 (1.8)	1 (2.0)	
CAG result			
SVD	27 (48.2)	22 (44.0)	
DVD	17 (30.4)	19 (38.0)	
TVD	12 (21.4)	9 (18.0)	
Successful PCI¥	98%	98%	

¥: TIMI flow grade ≥2 in the infarct-related artery with residual stenosis<50%

Table 3: Characteristics of collateral circulation (n = 50)

Characteristics	Number (%)
Rentrop class	
1	24 (48.0)
2	21 (42.0)
3	5 (10.0)
Collateral donor vessel	
RCA	26 (52.0)
LAD	6 (12.0)
LCx	5 (10.0)
LAD and LCx	13 (26.0)
Collateral recipient	
RCA	23 (46.0)
LAD	22 (44.0)
LCx	4 (8.0)
RI	1 (2.0)

In Hospital Outcomes: The clinical outcomes and complications that occurred in both study groups are shown in Table 5. Of the 15 patients (14%) who died during the hospital stay, 10 (17.9%) were from group A and 5 (10%) from group B (p=0.25). No linear association was observed between collateral grades and in-hospital mortality. Mortality rates in Rentrop score 0, 1 and 2/3 were 17.9%, 4.2% and 15.4%, p=0.3

Characteristics	Patients without collateral circulation (Group A)	Patients with collateral circulation (Group B)	p-value
In-hospital complications			
Heart failure	29 (51)	19 (20.0)	0.03
Cardiogenic shock	14 (25.0)	9 (18.0)	0.2
Heart block	6 (10.7)	12 (24.0)	0.08
Tachyarrhythmia	9 (16.1)	6 (12.0)	0.12
LV apical clot	-	3 (6.0)	0.09
Pericarditis	9 (16.1)	2 (4.0)	0.04
Stroke	1 (1.8)	1 (2.0)	0.34
AKI	2 (3.6)	1 (2.0)	0.23
Surgical site complication (pseudoneurysm)	-	1 (2.0)	0.11
Stent thrombosis	2 (3.6)	-	0.07
Hospital stay (days)	6.5 (2 – 32)	6 (3 – 22)	0.34
In-hospital mortality	10 (17.9)	5 (10.0)	0.25
LVEF (%)			
Baseline	30 (20 – 60)	30 (15 – 60)	0.20
At discharge	40 (20 – 60)	43 (20 – 65)	0.50

Table 5: In-hospital outcomes and complications between the two groups

Cardiogenic shock was the most frequent cause of mortality, accounting for 65% of deaths. Cardiogenic shock developed more often in patients from group A than in patients from group B (25% vs 18%, p= 0.2). In group A, 11(78.6%) of the 14 patients who experienced cardiogenic shock were already in shock before PTCA, whereas in group B only 1 of 9 patients had shock before PTCA.

Outcomes at 1 month:

Characteristics	Patients without collateral circulation(%)	Patients with collateral circulation(%)	p-value
Outcome at 1 month			
No complications	33 (71.7)	32 (71.1)	0.23
Readmission	7 (15.2)	8 (17.7)	0.04
Re-infarction	4 (8.7)	1 (2.2)	0.03
Death	2 (4.3)	1 (2.2)	0.34
Complications at 1 month			
Heart failure	8	10	0.27
Angina recurrence	5	2	0.11
LV apical clot	-	1	0.19
MI	-	1	0.18
Paroxysmal AF	-	1	0.18
LVEF (%)	46.5 (23-60)	50 (20-65)	0.93

Table 6: Outcome at 1 month (Out of 91 patients); 15/106 had in-hospital mortality

On follow up at 1 month, there were 3 deaths, 2 in Group A and 1 in Group B. In group A, there was higher rates of reinfarction (4 patients vs 1 patient, p=0.03). Rate of readmission was higher in group B (p=0.04).

Heart failure was the commonest complication during follow up occurring in 20% of total patients. It was distributed evenly in patients of both groups. There was no difference in terms of LVEF at 1 month between the groups.

Discussion

Numerous studies and two large meta-analysis have shown that the presence of early coronary collaterals is associated with fewer number of complications and mortalities.[1-7,12]

This study showed higher incidence of collateral development after acute STEMI(47%) as compared to 36% and 23% in other major studies of STEMI done by Perez-Castellano et al[6] and Antoniucci et al[11] respectively. The recent meta analysis which included 10,411 patients showed the incidence of collateral to be 23.6%.[5] The higher incidence in this study may be attributed to the delay in coronary angiography as we know that the incidence of collaterals increases with time as shown by Schwartz et al.[12] This delay in angiography was mainly contributed by the delay in presentation of the patient to the hospital after symptom onset in group B as compared to group A (4 hours vs. 7 hours, p= 0.04). There was no significant difference in door to wire time between the two groups. Similar significant association between longer duration of symptoms of MI and coronary collateral recruitment has been shown in other studies.[2,3]

Multivessel disease was more common in group B (56% vs 51.8%, p 0.664) similar to other studies.

Cardiogenic shock was more common in group A (25% vs 18%, p=0.2). It is consistent finding across multiple studies and meta analysis. This difference in the two groups can be explained by the smaller infarct size in group B patients.

In-hospital outcomes and complications: The total in-hospital mortality was 15(14.1%). This is much higher than the previous studies done in Nepal which showed the mortality rate of 3.98%and 7.5%.[9,10] This may be because of the fact that the proportion of patients in cardiogenic shock was higher in this study. The number of patients with heart failure and Post MI pericarditis in group B was lower than in group A, similar to other studies.

Outcome at one month: There was no significant difference in terms of LVEF at discharge or at 1 month between the groups (46.5% in group A vs 50% in group B, p=0.93).

Limitations

Our study is a single-center observational study with a relatively small sample size. A short follow up period of one month and reliance on visual estimation rather than use of physiological measurements like Coronary Flow Index by Doppler flow wires or pressure method to access collateral circulations are other limitations of this study.

Conclusion

Early development of coronary collateral circulation after STEMI is found in nearly 47% of patients. Its incidence increases with time duration of MI. Coronary collaterals are more common in patients with previous history of angina and who are non-diabetics. Very well developed collaterals of Rentrop score 3 is uncommon in STEMI. The group of patients with early coronary collaterals had significantly lower incidence of heart failure during admission, post MI pericarditis and reinfarction at 1 month.

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