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Impact of the origin of the collateral feeding donor artery on short-term mortality in ST-elevation myocardial infarction with comorbid chronic total occlusion

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ABSTRACT

Background: Patients with ST-elevation myocardial infarction (STEMI) and multi-vessel disease (MVD) have higher mortality, especially with comorbid chronic total occlusion (CTO). The origin of collateral flow to the CTO segment has not been studied in regard to short-term mortality.
This study examined the impact of collateral feeding donor arteries from an infarct-related artery (IRA) or non-IRA to the comorbid CTO segment in regard to STEMI short-term mortality.
Methods: Data from 760 consecutive STEMI patients who underwent primary percutaneous coronary intervention were obtained retrospectively from medical records. The number of vessels involved and origin of the collateral feeding donor artery were evaluated using angiograms from the primary percutaneous coronary intervention. The study population was divided into patients with: single-vessel disease (SVD) ($n = 483$), MVD without CTO ($n = 208$), and MVD with CTO ($n = 64$). All CTO segments had collateral flow from an IRA ($n = 23$) or non-IRA ($n = 46$). All-cause mortality (30-day) was analyzed.
Results: Compared to SVD and MVD without CTO, MVD with comorbid CTO had a higher mortality (5.4% vs. 15.9% vs. 24.6%, $P < 0.0001$, respectively). Of patients with CTO, those with collateral flow from the IRA had significantly higher mortality than the non-IRA group (52.2% vs. 10.9%, $P < 0.0001$). Collateral flow from the IRA was extracted as an independent predictor associated with 30-day all-cause mortality using a multivariate Cox proportional hazards model (hazard ratio 4.71, 95% confidence interval 1.60–14.2, $P = 0.0005$).
Conclusions: The origin of the collateral donor artery from the IRA had an impact on short-term mortality in STEMI patients with comorbid CTO lesions.

1. Introduction

Primary percutaneous coronary intervention (PCI) has improved the outcomes of ST-elevation myocardial infarction (STEMI) patients. However, there are still STEMI patients with fatal outcome despite prompt revascularization. It is well known that multi-vessel disease (MVD) has a higher risk than single-vessel disease (SVD) [1,2]. In patients with MVD, a comorbid chronic total occlusion (CTO) lesion in a non-infarct related artery (IRA) was reported as a strong factor for higher mortality rate [3]. STEMI with comorbid CTO in a non-IRA has a broad ischemic area, which may result in vital shock or cardiopulmonary arrest at onset [3–5].

The CTO segment usually receives blood supply from a collateral feeding donor artery. If acute occlusion occurs in this collateral feeding donor artery, the area of myocardial damage is considered a double-vessel simultaneous occlusion. In contrast, if it occurs in a non-collateral donor artery, the area of damage is not as broad as seen with single-vessel occlusion. The difference in myocardial injury area may have a relationship to short-term mortality rate; however, this has not been proven.

The purpose of the present study is to assess the impact of the origin of the collateral feeding donor artery from the IRA or non-IRA to the comorbid CTO segment on short-term mortality of patients with STEMI and CTO.

Abbreviations: PCI, percutaneous coronary intervention; STEMI, ST-elevation myocardial infarction; MVD, multi-vessel disease; SVD, single vessel disease; CTO, chronic total occlusion; IRA, infarct-related artery; CABG, coronary artery bypass graft; HDL, high-density lipoprotein; eGFR, estimated glomerular filtration rate; BNP, brain natriuretic peptide; IABP, intra-aortic balloon pump; PCPS, percutaneous cardiopulmonary support.

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2. Methods

2.1. Study design and population

To assess the impact of the origin of the collateral feeding donor artery on short-term mortality of STEMI with CTO, STEMI patients who underwent primary PCI within 24 h of symptom onset, and whose clinical course could be tracked after 30 days were extracted from medical records from December 2005 to February 2015 in Tokai University School of Medicine. A total of 760 STEMI patients who matched the above criteria were analyzed in this study. Baseline coronary angiography was evaluated in terms of the number of vessels involved and the presence or absence of CTO lesions aside from the culprit STEMI lesion, and the study population was divided into SVD (n = 483), MVD without CTO (n = 208), and MVD with CTO (n = 69). Moreover, patients who had MVD with CTO were divided into two groups according to the origin of the collateral feeding donor artery (from the IRA or not), with an IRA group (n = 23) and a non-IRA group (n = 46). Thirty-day mortality was analyzed across four groups (SVD, MVD without CTO, IRA, and non-IRA) or two groups (IRA and non-IRA).

Exclusion criteria included the following: patients who did not undergo primary PCI in the culprit STEMI lesion, patients with a coronary artery bypass graft (CABG) performed as the primary revascularization strategy rather than PCI, and patients with CTO lesions already protected by bypass grafts.

2.2. PCI procedure and definitions

Patients presenting within 24 h of symptom onset with electrocardiographic findings on arrival showed persistent ST-segment elevation >1 mm in two contiguous leads, and new or presumed new left bundle branch block were defined as having acute STEMI [6]. The final diagnosis was confirmed by emergency coronary angiography and was followed by primary PCI in the culprit lesion in all patients. The decision was at the discretion of experienced PCI operators.

The origin of the collateral feeding donor artery supply to the CTO segment was evaluated at the initial and final angiogram in primary PCI by experienced PCI operators, and it provided a warrant for grouping by IRA or non-IRA.

All patients received dual antiplatelet therapy before PCI, and those already taking aspirin or thienopyridine derivatives (clopidogrel or ticlopidine) were not re-loaded immediately before this procedure. Bolus heparin (100 U/kg of body weight) was administered. Unfractionated heparin was added to maintain an activated clotting time >250 s during the PCI procedure.

Significant coronary artery disease was defined as >70% stenosis in a main epicardial coronary artery in at least one angiographic evaluation view [7,8]. A CTO was defined as a complete occlusion of the coronary vessel with TIMI flow grade of 0 or 1 present for an estimated duration of more than 3 months based on comprehensive judgment by various examinations [9].

Coronary flow on angiography was determined based on the definition of TIMI flow grade [10]. Myocardial perfusion was evaluated using myocardial blush grade [11]. The grading of collateral flow to CTO segment was determined according to Retrop grade. [12].

Angiographic success in revascularization of the culprit lesion of STEMI was defined as a residual stenosis of <30%, final TIMI flow grade > 2, without major side branch loss of >1.5 mm in diameter, flow-limiting dissection, or angiographic thrombus [13].

2.3. Statistical analysis

Numerical factors with normal distribution are shown as averages ± standard deviation. Student's t-test was used to determine statistically significant differences in quantitative variables with normal distribution between two different groups. Analysis of variance was performed to compare numerical parameters among groups (SVD vs. MVD without CTO vs. IRA vs. non-IRA). Pearson's Chi-square test was applied to determine differences among the categorical variables. Numerical factors with skewed distribution are shown as medians (interquartile range). Wilcoxon rank-sum test was used to determine statistically significant differences in quantitative variable with skewed distribution between groups. Kruskal–Wallis one-way analysis of variance was used to compare across more than three groups. Fisher's exact test was applied to determine differences between categorical variables.

Survival analysis was displayed as survival curves according to the Kaplan–Meier method, and their comparison by log-rank statistics.

To estimate the independent predictors for deaths within 30 days of the event, multivariable Cox proportional hazards models were used. For selection of significant covariates, a backward stepwise selection procedure was adopted to identify covariates associated with 30-day death by univariable Cox proportional hazards models with stepwise

Table 1
Baseline characteristics.

	Overall (n = 760)	SVD (n = 483)	MVD without CTO (n = 208)	MVD with CTO (n = 69)		P value; overall	P value; IRA vs. non-IRA
				IRA (n = 23)	Non-IRA (n = 46)		
Age, years	66.3 ± 12.5	65.2 ± 12.6	68.6 ± 12.3	68.6 ± 13.1	66.8 ± 12.3	0.6532	0.5660
Male	595 (78.3%)	385 (79.7%)	158 (76.0%)	17 (73.9%)	35 (76.1%)	0.8085	0.8434
Height, cm	162.3 ± 8.6	162.6 ± 8.5	161.6 ± 8.7	163.7 ± 8.5	161.2 ± 9.5	0.3651	0.3237
Weight, kg	63.0 ± 12.8	63.6 ± 12.7	61.4 ± 12.8	65.5 ± 16.0	63.6 ± 13.0	0.1870	0.6049
Current smoking	277 (36.4%)	190 (39.3%)	66 (31.7%)	7 (30.4%)	14 (30.4%)	0.3633	0.6576
Diabetes mellitus	277 (36.4%)	145 (30.0%)	96 (46.2%)	14 (60.9%)	22 (47.8%)	<0.0001	0.3066
Insulin	45 (5.9%)	17 (3.5%)	20 (9.6%)	3 (13.0%)	5 (10.9%)	0.0026	0.7903
Dyslipidemia	529 (69.6%)	329 (68.1%)	146 (70.2%)	18 (78.3%)	36 (78.3%)	0.3941	1.00
Hypertension	583 (76.7%)	360 (74.5%)	163 (78.4%)	21 (91.3%)	39 (84.8%)	0.1107	0.4483
Family history	102 (13.4%)	69 (14.3%)	24 (11.5%)	2 (8.7%)	7 (15.2%)	0.6788	0.4483
Prior CABG	4 (0.5%)	2 (0.4%)	2 (1.0%)	0	0	0.7449	
Prior stroke	83 (10.9%)	46 (9.5%)	22 (10.6%)	7 (30.4%)	8 (17.4%)	0.0075	0.2156
Hemodialysis	13 (1.7%)	6 (1.2%)	6 (2.9%)	1 (4.4%)	0	0.2522	0.1543
Hemoglobin, mg/dL	14.1 ± 2.2	14.4 ± 2.1	13.5 ± 2.4	14.5 ± 2.6	13.7 ± 2.4	0.2462	0.1559
LDL cholesterol, mg/dL	122.8 ± 40.4	122.7 ± 38.6	120.9 ± 40.1	119.7 ± 46.5	134.6 ± 54.7	0.2284	0.2712
HDL cholesterol, mg/dL	49.7 ± 15.0	51.0 ± 15.2	48.4 ± 14.7	40.5 ± 13.3	46.1 ± 12.3	0.0011	0.0940
Triglyceride, mg/dL	93 (55–152.75)	90 (55–156)	90 (54.5–145)	92 (55–156)	107 (54–175.5)	0.5481	0.6781
Serum creatinine, mg/dL	1.1 ± 1.1	1.1 ± 1.1	1.2 ± 1.2	1.4 ± 1.2	1.0 ± 0.3	0.2875	0.0339
Estimated GFR, mL/min/1.73 m^2	63.4 ± 23.2	65.7 ± 23.2	60.3 ± 24.4	49.8 ± 18.3	60.7 ± 16.3	0.0007	0.0146
BNP, pg/dL	65.75 (22.7–200.8)	52 (20.4–159.6)	83.6 (25.2–234.2)	174.65 (71.5–877.6)	125.3 (38.2–267)	0.0044	0.2693

CTO = chronic total occlusion; IRA = infarct-related artery; CABG = coronary artery bypass graft; GFR = glomerular filtration rate; BNP = brain natriuretic peptide; HDL = high-density lipoprotein; LDL = low-density lipoprotein; MVD = multi-vessel disease.