Clinical characteristics of occluded culprit arteries and collaterals in patients with non-ST-segment elevation myocardial infarction and impact on clinical outcomes

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Abstract. The presence of an occluded culprit artery or collaterals in non-ST-segment elevation myocardial infarction (NSTEMI) is relatively common; however, limited data are available regarding their clinical significance. The aim of the current study was to determine the clinical characteristics of occluded culprit arteries and coronary collaterals in patients with NSTEMI and their impact on patient outcomes. A total of 345 patients diagnosed with NSTEMI via coronary angiography between February 2006 and May 2013 were evaluated in the present study. Patient demographics, procedural characteristics and clinical outcomes of patients were analyzed according to the presence of an occluded culprit artery and coronary collaterals. A total of 78 (22.6%) and 166 patients (48.1%) exhibited an occluded artery and coronary collaterals, respectively. The left anterior descending artery is a more common location of culprit arteries in patients with NSTEMI with patent artery (NSTEMIPA) and distal parts of the artery are more common location of culprit arteries in patients with NSTEMI with occluded arteries (NSTEMIOA). Patients with NSTEMIOA exhibited higher peak creatine kinase-MB (CKMB) and troponin-I levels compared with patients that had NSTEMIPA. The presence of coronary collaterals is associated with a lower mean left ventricular ejection fraction, higher regional wall motion score index and extensive coronary artery disease. However, the clinical outcomes of patients with collaterals did not differ, irrespective of the presence of an occluded culprit artery or coronary collaterals. In the current study, ~25% of patients with NSTEMI had an occluded culprit coronary artery whereas 50% of patients with NSTEMI had coronary collaterals. The presence of an occluded artery and/or coronary collaterals did not affect clinical outcomes. Further studies are required to evaluate the long-term prognostic impact of an occluded artery and collaterals.

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Introduction

Acute coronary syndromes refer to the array of clinical signs and symptoms produced by acute myocardial ischemia and share common pathophysiologic origins related to the instability and rupture of atherosclerotic vulnerable plaques (1). Unstable angina and non-ST-segment elevation myocardial infarction (NSTEMI) are primarily differentiated by whether the ischemia is prolonged enough to lead to structural myocardial damage and the release of detectable markers of myocardial injury, including troponin-I, troponin-T or creatinine kinase MB(CKMB) (1). The diagnosis of ST-segment elevation myocardial infarction (STEMI) and NSTEMI is dependent on symptoms, including consistent chest pain with myocardial ischemia, and ST-segment depression or T-wave inversion on the electrocardiogram (ECG) (2). Although patients with NSTEMI and STEMI share similar cardiac risk factors, their angiographic features and clinical outcomes are distinct and warrant different management strategies. For example, STEMI is characterized by complete occlusion of the culprit artery and immediate treatment such as primary coronary percutaneous intervention and large ventricular remodeling is necessary. Furthermore, STEMI is associated with poor clinical outcomes (3,4). However, NSTEMI is characterized by incomplete occlusion of the culprit artery and patients with NSTEMI are usually treated with less urgency and the clinical courses are typically less severe than those with STEMI (4-6). Notably, it has been hypothesized that the reason for the poor clinical outcomes associated with STEMI is due to total occlusion of the culprit artery (3). Previous studies have demonstrated that ~25% of patients with NSTEMI harbor occluded culprit arteries and exhibit angiographic features similar to those with STEMI (3-7); however, the clinical significance of total occluded culprit artery in NSTEMI has not been fully evaluate.

It has also been demonstrated that the presence of collaterals has beneficial effects on the infarct size, coronary microcirculation, myocardial viability, ventricular function and ventricular aneurysm formation following acute coronary occlusion in patients with STEMI (8-11). However, to the best of our knowledge, the effect of coronary collaterals in patients with NSTEMI undergoing early invasive management remains unknown.

Therefore, the current study investigated the clinical characteristics and the significance of occluded culprit arteries and coronary collaterals in patients with NSTEMI.

Patients and methods

Study population. Of 400 patients diagnosed with NSTEMI, 345 (86.2%) who underwent coronary angiography between June 2006 and May 2013 were evaluated at Kyung Hee University Hospital at Gangdong (Seoul, Korea). A total of 55 patients who were not subjected to coronary angiography were excluded from the present study. Patients with elevated levels of creatine kinase-MB (CKMB) or troponin-I, but without angiographic evidence of total or subtotal occlusion of a culprit artery were excluded from the current study. The decision to perform coronary angiography was made at the physician's discretion and was based on patient medical history and clinical status. Basic demographics, procedural characteristics and clinical outcomes, including bleeding complications were compared between patients in the two groups.

Coronary angiograms were reviewed independently by two different physicians to locate the culprit artery and the presence of angiographic collaterals. Basic demographics, procedural characteristics and clinical outcomes were compared according to the occluded culprit artery and coronary collaterals. The current study was a retrospective analysis; therefore, patients were not required to give informed consent.

Intervention procedure. Drug-eluting or plain balloons were used in percutaneous coronary intervention (PCI) when the culprit artery diameter was <2.5 mm. Stents were implanted when the culprit artery diameter was ≥2.5 mm. Drug-eluting stents were exclusively used. Stent implantation was performed following standard techniques and stents were selected by the practitioner. Complete lesion coverage and angiographic optimization were recommended with <20% residual stenosis by a visual estimate. During the procedure, all patients received a bolus of 100 IU/kg heparin, with a repeated bolus of 3,000 IU heparin to maintain an activated clotting time ≥300 sec. All patients were treated with 100 mg/day aspirin indefinitely and 75 mg clopidogrel or 100 mg ticagrelor twice a day for ≥12 months after PCI.

Definition. NSTEMI was defined as the appearance of typical chest pain 12 h prior to admission, with elevated CKMB (≥5 ng/ml) or troponin-I (≥0.05 ng/ml) and without ST-segment elevation on an ECG >0.2 mV from baseline at admission. The culprit lesion was independently determined at angiography by two different physicians. The culprit artery was determined as exhibiting evidence of a complex lesion suggestive of acute plaque rupture, including an intraluminal filling defect, ulcer with overhanging edges, extraluminal contrast, dissection, multiple irregularities within the artery, or acute occlusion. An occluded artery was defined as a lesion with 100% stenosis and a Thrombolysis In Myocardial Infarction (TIMI) (12) flow 0. Chronic kidney disease was defined as serum creatinine >1.4 mg/dl. A quantitative assessment of left ventricular systolic function was performed using the modified biplane Simpson method (13) to calculate ejection fraction. Left ventricular dysfunction was defined as an ejection fraction <40% on echocardiography. The Wall motion score index (WMSI) was calculated using a 16-segment model recommended by the American Echocardiography Association (14). The regional wall motion score index (RWMSI) was calculated as the sum of motion scores divided by the number of visualized segments. A regional wall motion score was applied to each myocardial segment as follows: 1, normal contraction; 2, hypokinetic contraction; 3, akinetic contraction and 4, dyskinetic contraction. Higher scores indicated a more severe wall motion abnormality (15).

Statistical analysis. Data were expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. Continuous variables were compared using an unpaired Student's t-test and categorical variables were compared using a χ^2 test. $P<0.05$ was considered to indicate a statistically significant difference. Data analyses were performed using SPSS version 12.5 (SPSS, Inc., Chicago, IL, USA). To reduce the effect of selection bias and possible confounders, adjustment for significant differences in the baseline characteristics of patients was performed with propensity score matching (16). All baseline characteristics of patients indicated in 2.s I, II, III, IV and V were matched by the variables that exhibited differences in the overall population. Kaplan-Meier curves for overall survivals and event-free survivals were constructed according to the presence of collaterals. Univariate and multivariate analyses for statistically significant variables ($P<0.05$) were performed regarding mortality at 12 months.

Results

Baseline characteristics in patients with NSTEMI with occluded artery (NSTEMIOA; n=86) and in those with NSTEMI with patent artery (NSTEMIPA; n=261) are presented in Table I. The incidence of NSTEMIOA was 22.6%. Patients with NSTEMIOA exhibited a significantly higher level of peak CKMB and troponin-I compared with those in the NSTEMIPA group (89.0±85.7 vs. 52.0±78.1, $P<0.001$ and 6.6±9.7 vs. 3.5±7.2; $P=0.008$, respectively). There were no significant differences between other baseline clinical characteristics. Angiographic and procedural characteristics are presented in Table II. Patients with NSTEMIPA more commonly exhibited involvement of the left anterior descending artery (LAD) than those with NSTEMIOA (49.4 vs. 25.6%, respectively; $P<0.001$). However, distal artery involvement was more common in those with NSTEMIOA (38.4 vs. 22.4%; $P=0.005$). Following propensity score matching for the entire cohort, 58 matched pairs of patients were identified. There were no significant differences in the clinically relevant variables between patients in the

Table I. Baseline characteristics of patients with or without an occluded artery.

Characteristics	Overall population			Propensity-score matched population		
	NSTEMI with occluded artery (n=78)	NSTEMI with patent artery (n=267)	P-values	NSTEMI with occluded artery (n=58)	NSTEMI with patent artery (n=58)	P-values
Age, years	62.1±13.2	65.2±12.6	0.067	60.0±12.7	62.2±12.5	0.331
Males, (%)	51 (65.3)	185 (69.2)	0.514	41(70.6)	39 (67.2)	0.688
Height, cm	162±9	163±9	0.392	162±10	164±9	0.320
Weight, kg	64.5±13.4	64.8±11.9	0.849	66.1±14.1	65.1±12.0	0.696
BMI	24.3±3.4	24.1±3.8	0.793	24.8±3.4	24.0±3.3	0.192
Hypertension, (%)	41 (52.5)	168 (62.9)	0.100	28 (48.2)	35 (60.3)	0.192
Diabetes (%)	22 (28.2)	95 (35.5)	0.226	15 (25.8)	14 (24.1)	0.830
Smoking (%)	44 (56.4)	159 (59.5)	0.704	36 (62.0)	33 (56.8)	0.570
Dyslipidemia (%)	14 (17.9)	43 (16.1)	0.700	9 (15.5)	12 (20.6)	0.469
Previous PCI (%)	4 (5.1)	21 (7.8)	0.613	0	4 (6.8)	0.119
Previous CABG (%)	0 (0)	1 (0.3)	0.588	0	1 (1.7)	0.315
Peripheral artery disease (%)	1 (1.2)	2 (0.7)	0.538	1 (1.7)	0	0.315
Chronic kidney disease (%) (Creatinine >1.4 mg/dl)	6 (7.6)	31 (11.6)	0.428	4 (6.8)	5 (8.6)	0.729
Congestive heart failure (%)	2 (2.5)	9 (3.3)	0.721	1 (1.7)	1 (1.7)	0.752
Cerebrovacular disease, (%)	6 (7.6)	39 (14.6)	0.111	4 (6.8)	8 (13.7)	0.361
ECG finding, (%)			0.885			0.784
ST depression	27 (11.5)	87 (13.1)	0.737	18 (31.3)	18 (31.3)	0.579
T-wave inversion	21 (25.6)	69 (25.0)	0.848	16 (27.5)	13 (22.4)	0.520
No change	30 (38.4)	111 (41.5)	0.623	24 (41.3)	27 (46.5)	0.575
Killip class (%)			0.371			0.606
I	62 (79.8)	214 (80.1)	0.898	48 (82.7)	45 (77.5)	0.485
II	3 (3.8)	2 (0.7)	0.078	3 (5.1)	1 (1.7)	0.309
III	8 (10.2)	30 (11.2)	0.808	5 (8.6)	7 (12.0)	0.542
IV	5(6.4)	21(7.8)	0.668	2 (3.4)	5 (8.6)	0.242
LVEF, %	55.8±11.1	56.7±11.9	0.547	56.7±11.0	55.0±12.5	0.678
LVEF <40% at index echocardiogram	8 (10.2)	23 (8.6)	0.655	5 (8.6)	7 (12.0)	0.762
RWMSI	1.42±0.33	1.32±0.36	0.038[a]	1.39±0.30	1.39±0.36	0.993
Heart rate at admission, bpm	78±19	80±21.4	0.510	75±17	80±20	0.147
Systolic blood pressure at admission, mmHg	131±25	138±29	0.068	131±24	133±29	0.736

Table I. Continued.

Characteristics	Overall population			Propensity-score matched population		
	NSTEMI with occluded artery (n=78)	NSTEMI with patent artery (n=267)	P-values	NSTEMI with occluded artery (n=58)	NSTEMI with patent artery (n=58)	P-values
Diastolic blood pressure at admission, mmHg	80±14	79±15	0.599	80±14	78±16	0.443
CKMB, at admission, mg/dl	31.6±43.6	19.4±42.7	0.029a	35.1±14.3	26.5±42.8	0.308
CKMB, at peak, mg/dl	89.0±85.7	52.0±78.1	<0.001a	96.5±90.4	85.6±99.4	0.541
Troponin-I, at admission, mg/dl	6.6±9.7	3.5±7.2	0.002[a]	7.5±10.9	5.5±9.0	0.282
Time from admission to angiography within 24 h (%)	60 (76.9)	214 (80.1)	0.681	45 (77.5)	46 (80.3)	0.821
Medication (%)						
Aspirin	73 (93.5)	249 (93.2)	0.872	57 (98.2)	56 (96.5)	0.559
Thienopyridine	74 (94.8)	252 (94.3)	0.940	57 (98.2)	55 (94.8)	0.309
Statins	73 (93.5)	246 (92.1)	0.668	54 (94.8)	53 (91.3)	0.729
Beta-blocker	25 (32.0)	52 (19.4)	0.833	40 (68.9)	34 (58/6)	0.246
ACEi or ARB	53 (67.9)	199 (74.5)	0.250	40 (68.9)	43 (74.1)	0.537

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. [a]P<0.05; NSTEMI, non-ST-segment elevation myocardial infarction; BMI, body mass index; PCI, percutaneous coronary intervention; ECG, electrocardiogram; RWMSI, Regional wall motion score index; CABG, coronary artery bypass graft; LBBB, left bundle branch block; LVEF, left ventricular ejection fraction; CKMB, creatine kinase MB; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

Table II. Angiographic characteristics with or without an occluded artery.

Characteristics	Overall population			Propensity-score matched population		
	NSTEMI with occluded artery (n=78)	NSTEMI with patent artery (n=267)	P-values	NSTEMI with occluded artery (n=58)	NSTEMI with patent artery (n=58)	P-values
Lesion characteristics						
Culprit coronary vessel (%)						
Left anterior descending	20 (25.6)	132 (49.4)	<0.001[a]	14 (24.1)	17 (29.3)	0.529
Left circumflex	24 (30.7)	60 (22.4)	0.133	22 (37.9)	18 (31.3)	0.435
Right coronary	33 (42.3)	67 (25.0)	0.003[a]	21 (36.2)	22 (37.9)	0.848
Left main	1 (1.2)	8 (3.3)	0.690	1(1.7)	1(1.7)	0.752
Culprit location (%)						
Proximal	31 (39.7)	116 (43.4)	0.561	25 (43.1)	25 (43.1)	0.887
Middle	17 (21.7)	91 (34.0)	0.040[a]	12 (20.6)	22 (37.9)	0.041
Distal	30 (38.4)	60 (22.4)	0.005[a]	21 (36.2)	11 (18.9)	0.038
Number of diseased vessels (%)						
Single	33 (42.3)	88 (32.9)	0.128	25 (43.1)	27 (46.5)	0.709
Double	21 (31.3)	67 (25.0)	0.744	17 (29.3)	19 (32.7)	0.688
Triple	24 (30.7)	112 (41.9)	0.076	16 (27.5)	12 (20.6)	0.385
Collaterals	54 (69.2)	78 (29.2)	<0.001[a]	40 (68.9)	40 (68.9)	0.579
Revascularization	76 (97.4)	260 (97.3)	0.978	58 (100)	58 (100)	0.996
Successful PCI (%)	69 (88.4)	249 (93.2)	0.305	58 (100)	58 (100)	0.996
Post-PCI TIMI 3 (%)	71 (91.8)	257 (96.2)	0.221	54 (93.1)	55 (94.8)	0.697
Quantitative coronary angiography						
Reference vessel diameter, mm	2.8±0.5	2.9±1.2	0.339	2.8±0.4	3.1±0.4	0.448
Stent length, mm	21.8±7.9	22.0±7.7	0.800	21.6±8.0	23.9±8.3	0.128
Stent diameter, mm	2.7±0.5	2.8±0.3	0.067	2.7±0.5	2.7±0.3	0.836
Number of stents	1.2±0.7	1.3±0.6	0.068	1.3±0.6	1.4±0.6	0.231

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. [a]P<0.05. NSTEMI, non-ST-segment elevation myocardial infarction, PCI, percutaneous coronary intervention; TIMI, Thrombolysis In Myocardial Infarction.

Table III. Clinical outcomes of an occluded artery in patients over 12 months.

Clinical characteristics	Overall population			Propensity-score matched population		
	NSTEMI with occluded artery (n=78)	NSTEMI with patent artery (n=267)	P-values	NSTEMI with occluded artery (n=58)	NSTEMI with patent artery (n=58)	P-values
30-day outcomes (%)	4 (3.0)	22 (8.1)	0.415	1 (1.7)	2 (3.4)	0.559
Mortality, 30 days	4 (3.0)	21 (7.8)	0.619	1 (1.7)	2 (3.4)	0.559
Stroke, 30 days	0	1 (0.3)	0.588	0	0	
12-month outcomes (%)	11 (14.1)	67 (25.0)	0.072	6 (10.3)	12 (20.6)	0.124
Mortality, 12 months	5 (6.4)	30 (11.2)	0.287	1 (1.7)	2 (3.4)	0.559
MI, 12 months	2 (2.5)	11 (3.7)	0.526	1 (1.7)	2 (3.4)	0.559
Stroke, 12 months	3 (3.8)	5 (1.8)	0.308	2 (3.4)	0	0.496
Readmission for cardiac cause, 12 months	5 (6.4)	39 (14.6)	0.056	2 (3.4)	8 (13.7)	0.094

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. NSTEMI, non-ST-segment elevation myocardial infarction; MI, myocardial infarction.

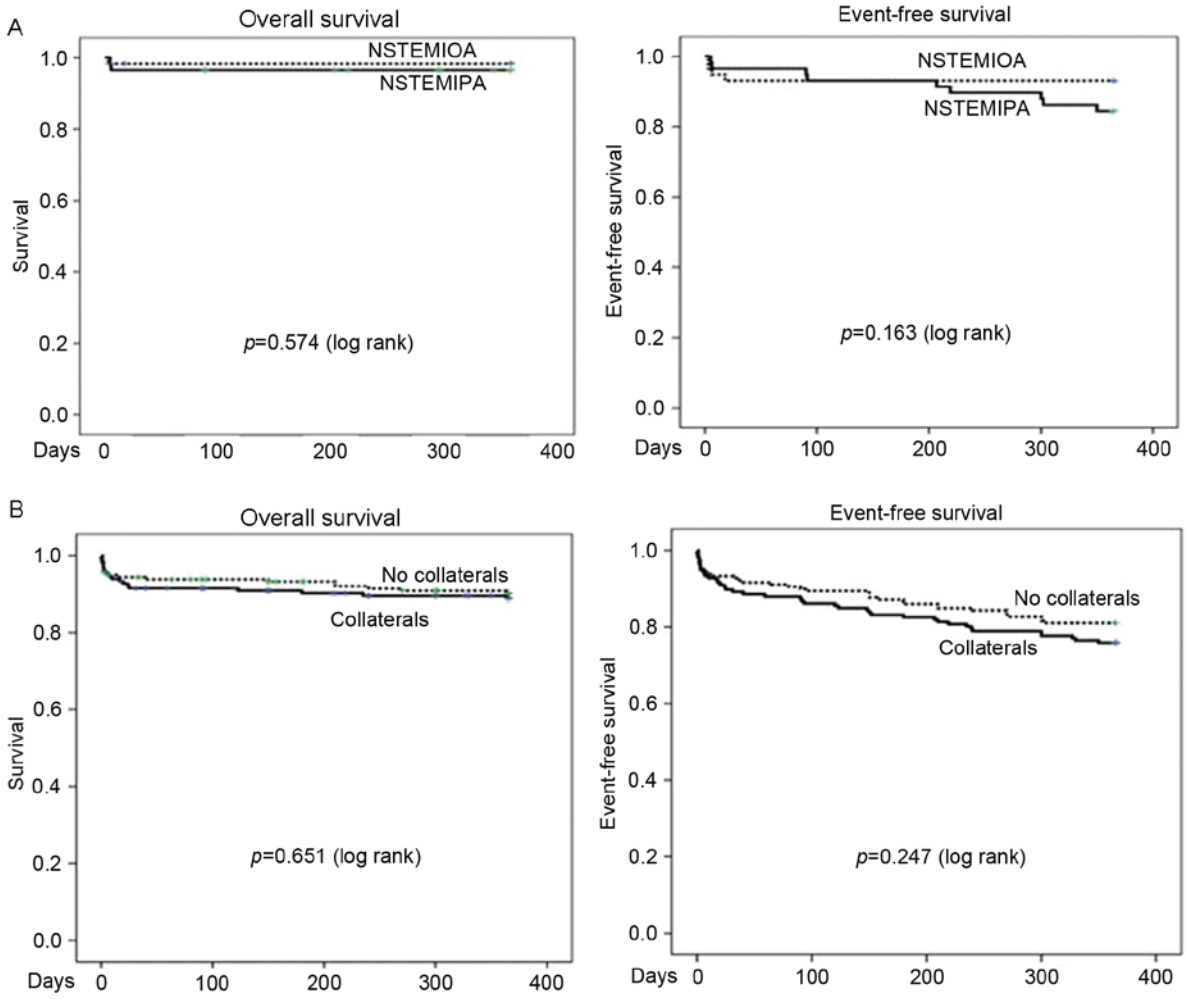

Figure 1. Kaplan-Meier curves for overall survivals and event-free survivals according to the presence of absence collaterals. (A) matched propensity-score and (B) population overall population were indicated.

two groups, apart from the location of the culprit artery (P=0.048; Table II). There were no significant differences of clinical outcomes between the groups at 30 days and 1 year of follow-up (Table III). Kaplan-Meier curves indicated that overall survival rates and event-free survival did not differ significantly between patients with NSTEMIPA and those with NSTEMIOA (Fig. 1).

Collaterals were present in 166 patients (48.1%). Baseline characteristics of these patients are present in Table IV. The presence of coronary collaterals was associated with significantly lower mean left ventricular ejection fraction (LVEF), mean LVEF <40% and higher RWMSIs at index admission (P=0.004; P=0.005 and P<0.001, respectively). There were no other significant differences regarding clinical variables between the two groups. Angiographic and procedural characteristics are presented in Table V. The presence of collaterals was significantly higher in the right coronary artery (RCA; P=0.003) and in patients with triple vessel artery disease (P=0.001). By contrast, there was a higher incidence of single vessel disease in patients with NSTEMI patients that did not have collaterals (P=0.001). Pre-PCI TIMI 0 was more common in patients with collaterals (P<0.001). In quantitative coronary analysis, patients with collaterals exhibited a smaller minimal luminal diameter (P=0.009), severe diameter stenosis (P=0.002), a longer stent length (P=0.013) and a smaller stent diameter (P=0.009), compared with patients with NSTEMI but did not exhibit collaterals.

Following propensity score matching for the entire cohort, 120 matched pairs of patients were identified. There were no significant differences regarding clinically relevant variables between patients in the two groups, apart from the culprit coronary artery (P=0.014), pre-PCI TIMI 0 (P=0.001) and CKMB levels (Tables V and VI).

There were no significant differences in clinical outcomes between patients with collaterals and those without collaterals at 30 days and 1 year of clinical follow-up (Table VI). Kaplan-Meier curves indicated that survival rates and event-free survival between the two groups did not differ significantly within 1 year (Fig. 1B).

Univariate analysis indicated that patient age, type of ECG at admission, weight, hypertension, Killip class, LVEF at index admission, RWMSI at admission, LAD as the culprit location and triple vessel disease were associated with mortality at 12 months. Multivariate analysis indicated that age [odds ratio (OR)=1.165, 95% confidence interval (CI)=1.053-1.290, P=0.003], LAD as the culprit location (OR=20.359, 95% CI=1.528-271.190, P=0.023) and

Table IV. Baseline characteristics according to presence of collaterals.

	Overall population			Propensity-score matched population		
Characteristics	Collaterals (n=166)	No collaterals (n=179)	P-values	Collaterals (n=120)	No collaterals (n=120)	P-values
Age, years	65.2±12.8	63.8±12.7	0.326	60.0±13.0	65.4±12.1	0.005[a]
Males (%)	110 (60.2)	126 (70.3)	0.492	83 (69.1)	84 (70.0)	0.888
Height, cm	162±9	163±8	0.465	162±10	163±8	0.501
Weight, kg	64.5±12.9	64.9±11.6	0.798	66.5±14.4	64.7±11.7	0.360
BMI	24.4±4.1	24.2±3.4	0.801	24.9±3.5	24.0±4.0	0.890
Hypertension (%)	65 (39.1)	71 (39.6)	0.923	73 (60.8)	73 (60.8)	0.553
Diabetes (%)	108 (65.0)	120 (67.0)	0.698	39 (32.5)	42 (35.0)	0.682
Smoking (%)	84 (50.6)	119 (66.4)	0.003	56 (46.6)	64 (53.3)	0.302
Dyslipidemia (%)	32 (19.2)	25 (13.9)	0.826	97 (80.8)	102 (85.0)	0.391
Previous PCI (%)	17 (10.2)	9 (5.0)	0.145	7 (5.8)	8 (6.6)	0.587
Previous CABG (%)	1 (0.6)	0	0.481	1 (0.8)	0	0.316
Peripheral artery disease (%)	0	3 (1.6)	0.249	0	2 (1.6)	0.498
Chronic kidney disease (%) (Creatinine >1.4 mg/dl)	19 (11.4)	18 (10.0)	0.677	14(11.6)	11 (9.1)	0.526
Congestive heart failure (%)	5 (3.0)	6 (3.3)	0.858	4 (3.3)	5 (4.1)	-0.734
Cerebrovacular disease (%)	20 (12.0)	25 (13.9)	0.597	16 (13.3)	15 (12.5)	0.847
Killip class (%)						
I	126(75.9)	150 (83.7)	0.067	93 (77.5)	104 (86.6)	0.064
II	3 (1.8)	2 (1.1)	0.592	3 (2.5)	1 (0.8)	0.313
III	22 (13.2)	16 (8.9)	0.201	15 (12.5)	11 (9.1)	0.406
IV	15 (9.0)	11 (6.1)	0.309	9 (7.5)	4 (3.3)	0.154
Electrocardiogram						
ST-depression	63 (37.9)	51 (28.4)	0.062	45 (37.5)	33 (27.5)	0.098
T-wave inversion	43 (25.9)	47 (26.2)	0.940	46 (38.3)	56 (46.6)	0.192
No change	60 (36.1)	81(45.2)	0.086	29 (24.1)	31 (25.8)	0.766
LVEF (%)	57.5±10.8	62.6±8.5	0.004[a]	55.2±12.4	57.4±11.0	0.143
LVEF <40% at index echocardiogram	22 (13.2)	9 (5.0)	0.005[a]	17 (14.1)	9 (7.5)	0.097
RWMSI	1.43±0.38	1.27±0.32	<0.001[a]	1.38±0.28	1.34±0.38	0.394
Heart rate at admission, bpm 0	81±21	79±21	0.340	75±17	79±19	0.124
Systolic blood pressure at admission, mmHg	136±28	137±29	0.704	131±24	139±30	0.067

Table IV. Continued.

Characteristics	Overall population			Propensity-score matched population		
	Collaterals (n=166)	No collaterals (n=179)	P-values	Collaterals (n=120)	No collaterals (n=120)	P-values
Diastolic blood pressure at admission, mmHg	79±15	79±15	0.996	80±14	79±16	0.595
CKMB, at admission, mg/dl	17.9±26.7	26.0±53.9	0.085	35.7±48.0	14.0±26.1	<0.001[a]
CKMB, at peak, mg/dl	52.2±70.0	67.7±90.0	0.080	99.5±91.5	46.1±69.7	<0.001[a]
Troponin-I, at admission, mg/dl	4.4±7.7	4.0±8.1	0.600	7.3±10.3	2.8±6.0	<0.001[a]
Time from admission to angiography within 24 h, (%)	135 (81.3)	141 (78.7)	0.553	101 (84.1)	97 (80.8)	0.497
Medications						
Aspirin	156 (93.9)	167 (93.2)	0.460	98 (81.6)	93 (77.5)	0.130
Thienopyridines	156 (93.9)	170 (94.9)	0.652	109 (90.8)	107 (89.1)	0.335
Statins	154 (92.7)	165 (92.1)	0.835	112 (93.3)	113 (94.1)	0.790
Beta blocker	103 (62.0)	118 (75.9)	0.550	108 (90.0)	102 (85.0)	0.242
ACEi or ARBs	121 (71.5)	131 (73.1)	0.752	94 (78.3)	97 (80.8)	0.722

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. [a]P<0.05. NSTEMI, non-ST-segment elevation myocardial infarction; BMI, body mass index; RWMSI, Regional wall motion score index; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; LVEF, left ventricular ejection fraction; CKMB, creatine kinase MB; ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

Table V. Angiographic characteristics according to the presence of collaterals.

	Overall population			Propensity-score matched population		
Characteristics	Collaterals (n=166)	No collaterals (n=179)	P-values	Collaterals (n=120)	No collaterals (n=120)	P-values
Lesion characteristics						
Culprit coronary vessel (%)						
Left anterior descending	65 (39.1)	87 (48.6)	0.083	51 (42.5)	62 (51.6)	0.196
Left circumflex	34 (20.4)	50 (27.9)	0.132	43 (35.8)	21 (17.5)	0.001
Right coronary	61 (36.7)	39 (21.7)	0.003[a]	25 (20.8)	36 (30.0)	0.103
Left main	6 (3.6)	3 (1.6)	0.259	1 (0.8)	1 (0.8)	0.751
Culprit location (%)						
Proximal	67 (40.3)	80 (44.6)	0.416	44 (36.6)	55 (45.8)	0.149
Middle	52 (31.3)	56 (31.2)	0.994	44 (36.6)	38 (31.6)	0.414
Distal	47 (28.3)	43 (24.0)	0.364	32 (26.6)	27 (22.5)	0.454
Number of diseased vessel (%)						
Single	43 (25.9)	78 (43.5)	0.001[a]	101 (84.1)	97 (80/8)	0.497
Double	42 (25.3)	46 (25.6)	0.933	15 (12.5)	19 (15.8)	0.459
Triple	81 (48.7)	55 (30.7)	0.001[a]	4 (3.3)	4 (3.3)	0.701
Revascularization	164 (98.7)	172(96.0)	0.177	120 (100)	120 (100)	0.951
Successful PCI (%)	153 (92.1)	165 (92.1)	0.295	120 (100)	120 (100)	0.951
Pre-PCI TIMI 0 (%)	55 (33.1)	23 (12.8)	<0.001[a]	38 (31.6)	16 (13.3)	0.001[a]
Post-PCI TIMI 3 (%)	77 (91.6)	214 (99.0)	0.221	112 (93.3)	112 (93.3)	0.608
Quantitative coronary angiography						
Reference vessel diameter, mm	2.9±1.5	2.8±0.4	0.669	2.8±0.4	2.8±0.3	0.951
Minimal luminal diameter, mm	0.37±0.52	0.53±0.55	0.009[a]	0.49±0.47	0.53±0.49	0.103
Diameter stenosis (%)	90.2±12.2	85.9±11.4	0.002[a]	91.5±11.3	88.2±10.4	0.157
Stent length, mm	23.1±7.8	20.9±7.5	0.013	20.8±7.7	22.3±7.6	0.277
Stent diameter, mm	2.7±0.3	2.8±0.4	0.009[a]	2.7±0.5	2.8±0.3	0.227
Number of stents	1.3±0.7	1.3±0.6	0.222	1.3±0.6	1.4±0.6	0.208

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. [a]P<0.05. NSTEMI, non-ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; TIMI, Thrombolysis In Myocardial Infarction.

hypertension (O=10.407, 95% CI=1.072-101.063, P=0.043) were independent predictors for patient mortality at 12 months (data not shown).

Discussion

In the present study, 25% of patients with NSTEMI exhibited occluded arteries, whereas 50% of patients with NSTEMI exhibited coronary collaterals. Patients with NSTEMI with occluded arteries exhibited higher peak biochemical markers and culprit lesions were located in non-LAD or distal coronary arteries. The results of the current study demonstrated that NSTEMI with collaterals have a lower mean LVEF, higher RWMSI and more severe and extensive coronary artery disease on angiography, including multivessel disease, pre-PCI TIMI 0, longer stent length and a smaller diameter, compared with patients that have NSTEMI without collaterals. However, the clinical outcomes of patients were similar irrespective of the presence of an occluded culprit artery or coronary collaterals.

The presence of an occluded culprit artery may be associated with an increase in mortality and morbidity, as total artery occlusion is associated with the risk of extensive myocardial injury and may lead to poor clinical outcomes. Previous studies have demonstrated that patients with NSTEMIOA not only have a higher unadjusted rate of mortality at 6-24 months follow-up (7,17,18), but also exhibit a higher incidence of heart failure (4) and poor LVEF (5) than those with NSTEMIPA. However, the results of the current study did not identify any differences between these two groups of patients regarding clinical outcomes. Although patients with occluded culprit arteries have significant disadvantages (19) compared with those that have non-occluded arteries, the mixed results regarding clinical outcomes in the current study may be explained by several factors. Firstly, the treatment of NSTEMI has markedly improved due to the use of drug-eluting stents and development of novel medicines, including glycoprotein IIb/IIIa inhibitors. An older study identified positive clinical outcomes (6); however, more recent studies have identified

Table VI. Clinical outcomes of collaterals over 12 months.

	Overall population			Propensity-score matched population		
Clinical characteristics	Collaterals (n=166)	No collaterals (n=179)	P-values	Collaterals (n=120)	No collaterals (n=120)	P-values
30-day outcomes	14 (8.4)	12 (6.6)	0.543	3 (2.5)	3 (2.5)	0.658
Mortality, 30 days	14 (8.4)	11 (6.1)	0.691	3 (2.5)	2 (1.6)	0.651
Stroke, 30 days	0	1 (0.5)	0.335	0	1 (0.8)	0.316
12-month outcomes	40 (24.0)	34 (18.9)	0.249	29 (24.1)	30 (25.0)	0.881
Mortality, 12 months	18 (10.0)	17 (9.4)	0.723	5 (4.1)	6 (5.0)	0.758
MI, 12 months	6 (3.6)	7 (3.9)	0.885	3 (2.5)	6 (5.0)	0.499
Stroke, 12 months	5 (3.0)	3 (1.6)	0.410	4 (3.3)	2 (1.6)	0.684
Readmission, 12 months	23 (13.8)	22 (12.2)	0.666	17 (14.1)	16 (13.3)	0.851

Data are expressed as the mean ± standard deviation for continuous variables and frequencies for categorical variables. MI, myocardial infarction.

mixed results (4,17,20). Secondly, the culprit artery in patients with NSTEMIOA is more frequently located in a non-LAD or a distal area in the present study, which may reduce its adverse effect on patients.

Furthermore, it has been demonstrated that collaterals in STEMI exert a protective, beneficial effect (7-10). However, few published studies have examined the clinical impacts of collaterals in NSTEMI and the results of previous studies have been controversial (21-24). Kloepfer *et al* (25) prospectively compared the clinical characteristics and outcomes in patients with NSTEMI with and without collaterals. The results indicated that those with collaterals had more severe and extensive coronary artery disease and poorer clinical outcomes. In another study, patients with NSTEMIOA that had collaterals exhibited better clinical outcomes compared with NSTEMIOA patients that did not have collaterals (26). However, this study was limited; for example, patients with NSTEMIPA that also had collaterals were excluded. In the present study, the presence of collaterals was associated with more extensive coronary artery disease and a lower LVEF; however, the clinical outcomes of patients with NSTEMI with and without collaterals were similar. It remains unknown why the presence of coronary collaterals in patients with NSTEMI is not as protective as in STEMI. It was hypothesized that in cases of STEMI, which progresses rapidly within minutes or hours due to abrupt plaque rupture, collateral circulation may protect the myocardium distal to the total occlusion site from fatal ischemia. However, in terms of NSTEMI, the presence of collateral vessels only explains long-standing severe extensive disease rather than the protection they confer against abrupt myocardial ischemia. However, further studies are required to test this hypothesis.

The current study was limited in several ways. Firstly, the current study was a retrospective, single-center study. Secondly, locations of the culprit artery lesions were independently determined by two physicians without central adjudication and therefore may be subject to bias, particularly regarding patients with multivessel disease. Thirdly, ~15% of patients in the current study did not undergo coronary angiography due to patients' refusal or poor clinical conditions. Despite these limitations, the results of the current study suggest that the presence of occluded culprit arteries and coronary collaterals in patients with NSTEMI are clinically insignificant. A large, multicenter study is required to evaluate the prognostic impact of occluded culprit arteries.

In conclusion, the current study demonstrated that NSTEMIOA is associated with the involvement of non-LAD and distal arteries. NSTEMI with collaterals is associated with a lower mean LVEF, as well as more severe and extensive coronary artery disease. However, the presence of an occluded culprit artery or coronary collaterals does not significantly affect the clinical outcomes of patients NSTEMI over a 12-month period. Further studies are required to evaluate the long-term prognostic impact of an occluded artery and collaterals.

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Availability of data and materials

The dataset used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author contribution

PCB designed the study and approved the final version to be published. KDH and HHJ were involved drafting of the manuscript. JES, CJM, SSI, KCJ, KDH and HHJ collected and analyzed the data. All authors reviewed the initial manuscript closely and revised it critically for important intellectual content.

Ethics approval and consent to participate

Not applicable.

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Competing interests

The authors declare that they have no competing interests.

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