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Complete revascularization based on angiography derived fractional flow reserve versus incomplete revascularization in patients with ST-segment elevation myocardial infarction

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Abstract

Background: *Nearly half of ST-segment elevation myocardial infarction (STEMI) patients present with significant multivessel coronary artery disease, they are at high risk of subsequent adverse events. Whether complete revascularization guided by coronary angiography-derived fractional flow reserve (caFFR) further reduces such events risk is not fully investigated.*

Methods: *In this study, 367 consecutive STEMI patients who underwent successful primary percutaneous coronary intervention (PCI) were enrolled. caFFR of all three coronary vessels were measured, including 367 culprit vessels and 703 non-culprit vessels. Complete revascularization was defined as post-PCI caFFR > 0.8 of all three coronary vessels. The primary endpoint was major adverse cardiovascular events (MACE; a composite of cardiovascular death, non-fatal recurrent myocardial infarction, ischemia-driven revascularization and non-fatal stroke/transient ischemic attacks) during follow-up.*

Results: *At a median follow-up of 3.8 years, MACE had occurred in 39 patients of the 220 (17.7%) in the complete revascularization group as compared with 49 patients of the 131 (37.4%) in the incomplete revascularization group (hazard ratio 1.9; 95% confidence interval 1.2–3.0; p = 0.005). The incomplete revascularization in culprit vessels evaluated by caFFR showed the highest risk for MACE occurrence.*

Conclusions: *In STEMI patients with multivessel coronary artery disease, incomplete revascularization based on caFFR might contribute to identifying patients at high-risk.* (Cardiol J 2024; 31, 2: 226–234)

Keywords: ST-segment elevation myocardial infarction, primary percutaneous coronary intervention, complete revascularization, coronary angiography-derived fractional flow reserve, major adverse cardiovascular events

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Introduction

Despite primary percutaneous coronary intervention (PPCI) as the preferred reperfusion strategy in ST-segment elevation myocardial infarction (STEMI) patients, STEMI remains one of the leading causes of death around the world [1]. They are at a high risk of subsequent adverse events related to both the stented segment and non-culprit lesions beyond the stented segment [2]. It is reported that up to 40–50% STEMI patients present with significant multivessel coronary artery disease (MVD) [3]. Based on strong evidence, complete revascularization in STEMI patients with multivessel disease is recommended by current guidelines. However, optimal methods to evaluate the severity of non-culprit lesions and timing of revascularization have not been adequately investigated [4]. On the one hand, non-culprit lesions are often discovered incidentally during PPCI, and they may be severely stenotic but are not necessarily unstable. Routine revascularization in stable coronary artery plaques may not improve long-term prognosis [5]. In addition, even opening non-culprit artery at a staged procedure in the subacute STEMI phase, repeated invasive procedures and the associated risks are potential obstacles. On the other hand, DANAMI--3-PRIMULTI [6] and Compare-Acute trial [7] showed that fractional flow reserve (FFR)-guided complete revascularization of non-infarct-related lesions in the acute phase of PPCI improved clinical outcomes compared with treatment of the infarct--related artery (IRA) only.

Although FFR measurement has been the gold standard in assessing functional severity of the epicardial coronary stenosis, it is far from widely used in STEMI patients. In terms of additional non-culprit vessel wire manipulation and the administration of adenosine, it is inconvenient to carry out FFR measurement during PPCI. The coronary angiography-derived FFR (caFFR), without using invasive pressure-wire measurement and hyperemic stimulus, overcomes these constraints and shows high diagnostic accuracy by using wire--derived FFR as the reference standard [8].

In this study, the aim was to use a noninvasive method of caFFR to explore the incremental value of complete revascularization over only culprit-vessel revascularization among STEMI patients in long-term prognosis.

Methods

The data are available to other researchers on reasonable request from the corresponding author.

Study design

This was a retrospective cohort study conducted at the Peking University First Hospital. STEMI patients who underwent PPCI between January 1, 2015 and December 31, 2020 were consecutively enrolled. The STEMI diagnosis was based on the fourth universal definition of myocardial infarction (MI) [9]. The PPCI was the preferred reperfusion strategy in patients within 12 h of symptom onset or > 12 h with evidence of ongoing ischemia and was performed expeditiously by an experienced team. Patients were excluded if they had been scheduled for coronary artery bypass grafting (CABG) after angiography; had an angiographic image that could not measure caFFR of culprit vessels; lack of adequate angiograms of non-culprit vessels. The STEMI culprit vessels were determined by identifying intraluminal thrombus embolization on angiography, ischemic electrocardiography changes, and/or wall motion abnormalities on echocardiography. All patients received evidence-based medical management adherence to guidelines. Clinical data were extracted from electronic medical records by trained physicians using a standardized data collection form. This study was approved by the institutional review board of the Peking University First Hospital and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline [10].

caFFR measurement

Detailed measurements of caFFR have been previously described [8]. In brief, the caFFR was calculated by validated software (FlashAngio, Rainmed, China). To calculate caFFR, at least two angiographic projections separated by ≥ 30° without vessel overlap are required. Flow velocity (V') and mean aortic pressure (Pa') were used by a proprietary computational pressure-flow dynamics method to solve the Navier-Stokes equation, computing a pressure drop (ΔP) along the generated mesh of the coronary artery as FFR = = (Pa'-ΔP)/Pa' [8]. All three main coronary arteries were measured caFFR if possible. The caFFR was computed in the equation above by researchers in an independent institution blinded to the patients' clinical data. In this study, all three main coronary arteries were defined of caFFR indexes > 0.8 as complete functional complete revascularization, otherwise, any artery of caFFR ≤ 0.8 was deemed as an incomplete revascularization. If patients with MVD underwent staged PCI in non-IRA, the caFFR value that performed in the staged PCI was used. The "tips and tricks" of caFFR measurements is provided in the **Supplementary material**.

Clinical outcomes

The primary end point of the study was the major adverse cardiovascular events (MACE; a composite of cardiovascular death, nonfatal recurrent MI, ischemia-driven revascularization and nonfatal stroke/transient ischemic attacks [TIA]) during follow-up. The secondary end points were all-cause death and individual parts of the primary end point. The definitions for cardiovascular outcomes are according to the uniform standard [11]. Cardiovascular death included any death resulting from cardiovascular causes. Nonfatal recurrent MI was defined based on evidence of myocardial necrosis combined with supporting myocardial ischemia presentation. The ischemia-driven revascularization was defined as a revascularization procedure with clinical ischemia evidence, including recurrent angina or positive test. Non-fatal stroke/TIA is defined as episodes of neurological dysfunction caused by cerebrovascular injury with or without acute infarction. The safety endpoint was in-hospital bleeding events classified according to the Bleeding Academic Research Consortium (BARC) types 2, 3, and 5 [12]. The follow-up clinical outcomes were obtained from telephone interviews and electronic medical record systems by January 2022. The standardized telephone interviews were conducted by trained physicians, who were blinded to the results of the caFFR measurements. If patients reported that they had been hospitalized, their hospital records were consulted and recorded. Clinical and safety end points were verified by other blinded adjudication physicians.

Statistical analysis

Continuous variables were presented as mean ± standard deviation and compared using the Student *t* test when normally distributed or as median (interquartile range) and compared with the Wilcoxon rank sum test when with skewed distribution. For categorical variables, data were reported as numbers and percentages and compared using the χ^2 test or Fisher exact test as appropriate. Cumulative incidences of the MACE outcome and each component of MACE (cardiovascular death, nonfatal recurrent MI, ischemia-driven revascularization and nonfatal stroke/TIA) through follow-up were estimated using cause-specific hazards models by treating non-cardiac death as competing events, differences were evaluated using the Gray test. Parameters showing clinical significance and significant statistical associations ($p < 0.01$) with MACE in univariable analysis were included into the multivariable model. The adjusted model included age, sex, diabetes, hypertension, creatine kinase-MB peak value, symptom onset to reperfusion time, estimated glomerular filtration rate, low-density lipoprotein cholesterol. A two-sided alpha level of 0.05 was considered as statistically significant. All statistical analyses were conducted using Stata software, version 16.0 (StataCorp).

Results

Patients and baseline characteristics

Overall, there were 512 STEMI patients in Peking University First Hospital who received PPCI from January 2015 to December 2020. Patients requiring CABG after coronary angiography (5 patients) were excluded, caFFR could not be measured (59 patients), lacking adequate angiographic imaging of non-culprit vessels (81 patients). Finally, 367 patients with STEMI underwent PPCI were included in the study (Fig. 1). Table 1 summarizes the baseline characteristics of the STEMI patients enrolled in the study. Among them, 359 (97.8%) patients' culprit lesions were treated with stent implantation, and 8 (2.2%) patients only received thrombus aspiration. There were 71 (19.3%) patients who underwent staged revascularization of non-IRA lesions in the acute setting of STEMI. The average number of stents were 1.3 ± 0.7. The left anterior descending was the most frequently interrogated vessel (49.6%).

Assessment of caFFR

In total, 367 STEMI patients with 367 culprit vessels and 703 non-culprit vessels finally included in the study. There were 133 (36.2%) patients presented with MVD. Based on the post-PCI caFFR, 232 (63.2%) patients were distinguished with functional complete revascularization (all three main coronary vessels post-PCI caFFR > 0.8) and 135 (36.8%) with incomplete revascularization (any coronary vessels post-PCI caFFR ≤ 0.8). Most culprit vessels (94.0%) reached functional revascularization (post-PCI caFFR > 0.8), and 68.4% patients post-PCI caFFR more than 0.9 after PPCI. In non-culprit vessels, the proportions were 88.2% and 73.7%, respectively. Baseline characteristics did not differ significantly among the groups (Table 1). Moreover, there were 22 (6.0%) patients post-PCI caFFR of culprit vessels below 0.8. The median post-PCI caFFR value of culprit vessels was 0.93 (0.90–0.95).

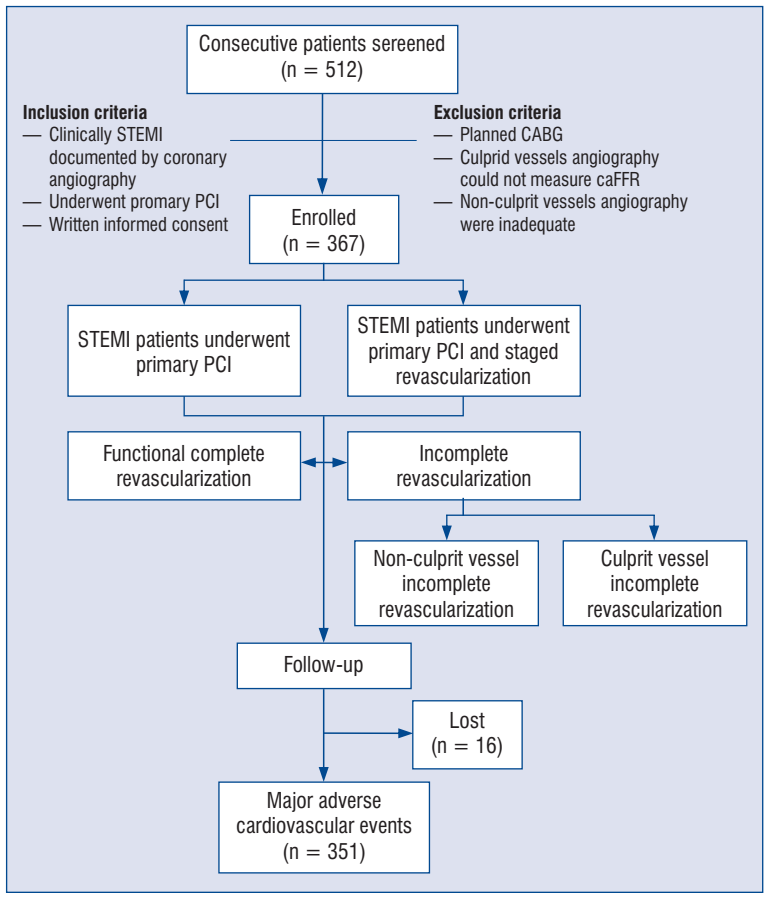

Figure 1. Flowchart for the study; CABG — coronary artery bypass grafting; caFFR — coronary angiography-derived fractional flow reserve; PCI — percutaneous coronary intervention; STEMI — ST-segment elevation myocardial infarction.

Long-term clinical outcome

The median follow-up duration was 3.8 (2.3–5.5) years. No difference in outcomes for safety endpoints between functional complete revascularization and incomplete revascularization group were recorded (**Suppl. Table 2**). The BARC ≤ 2 bleeding events had occurred in 2 (0.86%) and 0 patients, respectively (p = 0.534), and there were no BARC 3 or 5 bleeding events in both groups. During follow-up, 16 (4.4%) patients were lost, and 88 (25.1%) patients experienced MACEs (Table 2). The cumulative incidence of patient-oriented MACEs was significantly higher in the incomplete revascularization group when compared with the functional complete revascularization group (37.4% vs. 17.7%, respectively), mainly driven by an apparent difference in the occurrence of nonfatal recurrent MI (Fig. 2). Patients presented with incomplete revascularization suffered from a two-fold increase in the risk of MACEs (hazard ratio [HR] 1.9; 95% confidence interval [CI] 1.2–3.0; p = 0.005), after adjusted for age, sex, diabetes, hypertension, creatine kinase-MB peak value, symptom onset to reperfusion time, estimated glomerular filtration rate, and low-density lipoprotein cholesterol (Fig. 3A). Notably, patients with culprit vessel incomplete revascularization showed the worst prognosis (**Suppl. Table 1**, Fig. 3B).

In addition, among patients who underwent staged revascularization in the acute setting of STEMI, caFFR of non-IRAs was also measured and grouped complete revascularization based on post-staged PCI caFFR. There were 5 patients who underwent PCI of non-culprit lesions as a single-stage procedure, and 51 patients underwent PCI of non-culprit lesions as a staged procedure. The results remained unchanged after reanalysis. The complete revascularization predicted better outcomes compared to incomplete revascularization (11.9% vs. 29.9%, HR 2.14; 95% CI 1.26–3.65; p = 0.005) after adjusted for age, sex, diabetes, hypertension, creatine kinase-MB peak value, symptom onset to reperfusion time, estimated glomerular filtration rate and low-density lipoprotein cholesterol (Table 3).

Table 1. Patients' baseline characteristics.

Clinical characteristics	Overall (n = 367)	Functional complete revascularization (n = 232)	Incomplete revascularization (n = 135)	P
Male sex	300 (81.7%)	197 (84.9%)	103 (76.3%)	0.039
Age [year]	63.0 ± 12.8	61.9 ± 13.0	64.4 ± 13.4	0.088
Body mass index [kg/m^2]	25.2 ± 3.5	25.5 ± 3.4	24.6 ± 3.7	0.019
Diabetes mellitus	105 (28.6%)	53 (22.8%)	52 (38.5%)	0.001
Hypertension	224 (61.0%)	136 (58.6%)	88 (65.2%)	0.214
Dyslipidemia	117 (31.9%)	77 (33.2%)	40 (29.6%)	0.480
Previous or current smoker	245 (66.8%)	165 (71.1%)	80 (59.3%)	0.020
Previous MI	20 (5.4%)	14 (6.0%)	6 (4.4%)	0.518
Previous PCI	31 (8.4%)	24 (10.3%)	7 (5.2%)	0.087
Previous CABG	0	0	0	/
Peripheral artery disease	15 (4.1%)	9 (3.9%)	6 (4.4%)	0.792
History of CHF	1 (0.3%)	0	1 (0.7%)	0.368
Chronic kidney disease	10 (2.7%)	2 (0.9%)	8 (5.9%)	0.006
Previous stroke/TIA	40 (10.9%)	23 (9.9%)	17 (12.6%)	0.427
Systolic BP [mmHg]	119.7 ± 20.8	122.8 ± 19.3	114.3 ± 22.2	<0.001
Diastolic BP [mmHg]	71.2 ± 13.7	73.9 ± 13.1	66.7 ± 13.7	<0.001
Heart rate [bpm]	78.7 ± 16.3	78.1 ± 14.2	79.9 ± 19.5	0.334
Killip class:				0.154
I	297 (80.9%)	192 (83.1%)	104 (77.0%)	
II-IV	40 (19.1%)	39 (16.9%)	31 (23.0%)	
Laboratory tests				
Leukocyte [10^9/L]	10.2 ± 3.5	10.2 ± 3.7	10.3 ± 3.0	0.748
Hemoglobin [g/L]	141.3 ± 18.3	143.4 ± 16.6	137.7 ± 20.5	0.007
Platelet [10^9/L]	207.0 (173.8–253.0)	220.7 ± 133.3	225.2 ± 72.9	0.717
eGFR [mL/min/1.73 m^2]	74.6 ± 21.2	76.1 ± 19.4	72.1 ± 23.7	0.135
Blood glucose [mmol/L]	7.6 (6.2–9.7)	7.3 (6.0–9.5)	8.2 (6.6–10.6)	0.010
Triglyceride [mmol/L]	1.4 (1.0–2.1)	1.3 (1.0–2.2)	1.4 (0.9–2.1)	0.978
Total cholesterol [mmol/L]	4.5 ± 1.2	4.4 ± 1.1	4.5 ± 1.3	0.312
LDL cholesterol [mmol/L]	2.7 ± 0.8	2.7 ± 0.8	2.8 ± 0.8	0.264
HDL cholesterol [mmol/L]	1.0 ± 0.2	1.0 ± 0.2	1.0 ± 0.3	0.905
CK-MB peak value [ng/mL]	237.0 (110.6–397.7)	240.0 (109.9–404.1)	235.5 (109.4–385.5)	0.176
Procedural characteristics				
Infarct-related vessel:				< 0.001
Left anterior descending	182 (49.6%)	134 (57.8%)	48 (35.6%)	
Left circumflex artery	42 (11.4%)	27 (11.6%)	15 (11.1%)	
Right coronary artery	143 (39.0%)	71 (30.6%)	72 (53.3%)	
Radial artery access	328 (89.4%)	216 (93.1%)	112 (83.0%)	0.002
Thrombus aspiration	154 (42.0%)	103 (44.4%)	51 (37.8%)	0.215
Symptom onset to reperfusion time [h]	4.5 (3.0–7.6)	4.4 (2.9–7.6)	4.6 (3.1–8.0)	0.308
Stent implantation numbers	1.3 ± 0.7	1.3 ± 0.6	1.4 ± 0.7	0.205
Intra-aortic balloon pump	17 (4.6%)	4 (1.7%)	13 (9.6%)	0.001
Medication at hospital discharge				
ASA	360 (99.4%)	229 (99.6%)	131 (99.2%)	1.000
Ticagrelor	110 (30.0%)	73 (31.7%)	37 (28.0%)	0.460
Clopidogrel	253 (68.9%)	158 (68.1%)	95 (72.0%)	0.513
Statins	360 (99.4%)	228 (99.1%)	132 (100.0%)	0.535
Beta-blocker	313 (86.5%)	201 (87.4%)	112 (84.9%)	0.325
ACEI/ARB	296 (81.8%)	198 (86.1%)	98 (74.2%)	0.005

Data are presented as median (interquartile range), number (%), or mean ± standard deviation; ACEI/ARB — angiotensin converting enzyme inhibitors/angiotensin receptor blocker; ASA — acetylsalicylic acid; BP — blood pressure; CABG — coronary artery bypass grafting; CHF — chronic heart failure; CK-MB — creatine kinase-MB; eGFR — estimated glomerular filtration rate; HDL — high density lipoprotein; LDL — low density lipoprotein; MI — myocardial infarction; PCI — primary percutaneous coronary intervention; TIA — transient ischemic attacks

Table 2. Major adverse cardiovascular events during follow-up in functional complete revascularization vs. incomplete revascularization.

Follow-up	All patients				Adjusted model 1		Adjusted model 2	
	Functional complete revascularization (n = 220)	Incomplete revascularization (n = 131)	Unadjusted HR (95% CI)	P	Adjusted HR (95% CI)	P	Adjusted HR (95% CI)	P
Cardiovascular death	10 (4.5)	11 (8.4)	1.86 (0.79–4.39)	0.159	0.97 (0.31–3.08)	0.963	1.13 (0.38–3.36)	0.825
Nonfatal recurrent MI	2 (0.9)	11 (8.4)	9.02 (2.00–40.65)	0.004	10.58 (2.00–55.86)	0.005	4.59 (1.33–15.90)	0.016
Ischemia-driven revascularization	23 (10.5)	20 (15.3)	1.47 (0.81–2.69)	0.207	1.59 (0.83–3.03)	0.159	1.33 (0.54–3.32)	0.538
Stroke/TIA	5 (2.3)	7 (5.3)	2.27 (0.73–7.08)	0.156	1.97 (0.63–6.21)	0.246	1.90 (0.58–6.20)	0.288
MACE	39 (17.7)	49 (37.4)	2.26 (1.49–3.45)	< 0.001	1.91 (1.21–3.01)	0.005	1.86 (1.08–3.21)	0.025
All-cause death	18 (8.2)	22 (16.8)	2.12 (1.13–3.95)	0.019	1.55 (0.78–3.05)	0.208	1.91 (0.95–3.86)	0.070

Adjusted model 1 was adjusted for age, sex, diabetes, hypertension, creatine kinase-MB peak value, symptom onset to reperfusion time, estimated glomerular filtration rate, low-density lipoprotein cholesterol; The adjusted model 2 included age, sex, diabetes, hypertension, symptom onset to reperfusion time, estimated glomerular filtration rate, low-density lipoprotein cholesterol and intra-aortic balloon pump used; CI — confidence interval; HR — hazard ratio; MACE — major adverse cardiovascular events; MI — myocardial infarction; TIA — transient ischemic attacks

Figure 2. Major adverse cardiovascular events during follow-up; MI — myocardial infarction; TIA — transient ischemic attacks; the blue column represents functional complete revascularization group; the gray column represents incomplete revascularization group.

Figure 3. Cumulative incidence curves of the primary end point.

Table 3. Reanalysis of major adverse cardiovascular events during follow-up in functional complete revascularization vs. incomplete revascularization.

Outcomes	Functional complete revascularization (n = 260)	Incomplete revascularization (n = 107)	Crude HR (95% CI)	P	Adjusted HR (95% CI)	P
Cardiovascular death	10 (4.5)	11 (8.4)	2.83 (1.20–6.67)	0.017	1.36 (0.47–3.88)	0.569
Nonfatal recurrent MI	2 (0.9)	11 (8.4)	6.05 (1.86–19.65)	0.003	6.02 (1.72–21.05)	0.005
Ischemia-driven revascularization	23 (10.5)	20 (15.3)	1.54 (0.64–3.66)	0.334	1.42 (0.57–3.52)	0.455
Nonfatal stroke/TIA	5 (2.3)	7 (5.3)	2.62 (0.84–8.11)	0.096	2.14 (0.67–6.88)	0.201
MACEs	31 (11.9)	32 (29.9)	2.85 (1.74–4.67)	< 0.001	2.14 (1.26–3.65)	0.005
All-cause death	18 (8.2)	22 (16.8)	3.17 (1.70–5.91)	< 0.001	1.99 (1.01–3.94)	0.047

Adjusted for age, sex, diabetes, hypertension, creatine kinase-MB peak value, symptom onset to reperfusion time, estimated glomerular filtration rate, low-density lipoprotein cholesterol; CI — confidence interval; HR — hazard ratio; MACE — major adverse cardiovascular events; MI — myocardial infarction; TIA — transient ischemic attacks

Discussion

In this retrospective study, it was proved that functional incomplete revascularization guided by caFFR might contribute to identifying high-risk STEMI patients. The incomplete revascularization may have an adverse effect on long-term prognosis, especially in culprit vessels. After PPCI, there remain a few culprit vessels suffering from suboptimal function revascularization, and these patients are at the highest risk for MACEs, which was driven mainly by increased occurrence of recurrent MI. Although PPCI is the preferred reperfusion strategy for STEMI patients, the reality is that STEMI patients continue to be at a high risk of future adverse events related to both the culprit lesions and residual non-culprit lesions. These patients often have multivessel disease that cause the future acute events. However, the universal recognized revascularization strategy for non--culprit lesions has not been established. Several randomized clinical trials have shown that complete revascularization is beneficial compared to only culprit lesions revascularization [6, 7, 13–15]. In the COMPLETE trial [15], having randomized over 4000 STEMI patients with multivessel disease, proved that complete-revascularization strategy can lead to a significant reduction in the risk of cardiovascular death or new MI at a median follow-up of 3 years. The complete revascularization resulted in a 26% lower risk of a composite of death from cardiovascular causes or new MI, and nearly half the risk with a culprit-lesion-only PCI strategy in the composite of death from cardiovascular death, new MI and ischemia-driven revascularization. Regardless of when the non-culprit-lesion PCI was taken, the benefit of complete revascularization consistently existed.

In clinical practice, determining which lesions cause ischemia and warrant revascularization based on visual estimation from coronary angiography cannot accurately predict a lesions' functional severity. As a well-established technique in assessing the functional severity of coronary lesions, FFR is the preferred management strategy in patients with MVD [16]. The index of FFR ≤ 0.80 defines hemodynamically significant stenosis that requires revascularization with an accuracy of more than 90% [16]. In the FAME study, FFR-guided PCI strategy significantly reduced the rate of the primary endpoint (composite of death, MI, and repeat revascularization) at 1 year than angiography-guided PCI, as well as contrast agent and stents implantation [17]. Furthermore, the DANAMI-3-PRIMULTI

trial [6] and Compare-Acute trial [18], large randomized trials, showed that complete revascularization guided by FFR in STEMI patients with multivessel disease significantly reduced the risk of future MACE, even in the acute setting of PPCI. Recently, FRAME-AMI trial (NCT02715518) also proved that FFR-guided complete revascularization is superior to angiography-guided strategy in acute MI patients from East Asia. However, FFR has not been frequently used in patients with an acute coronary syndrome, mainly owing to concerns with additional procedural time and cost. Of note, FFR measurements required hyperemic conditions have a risk of morbidity from arrhythmia.

The caFFR, without using invasive pressure-wire measurement and hyperemic stimulus, overcomes these constraints and shows high diagnostic accuracy by using wire-derived FFR as the reference standard [8]. It has been confirmed that caFFR measurement is in good correlation and agreement with wire-based FFR both before and after PCI [8, 19–21]. Several studies proved that STEMI with multivessel disease patients can benefit from quantitative flow ratio-guided complete revascularization in the stages of acute MI [22–24]. However, few studies reported caFFR-guided strategy in STEMI patients. Although a prevalence of microvascular dysfunction in both culprit and non-culprit vessels questioning the accuracy of caFFR measurement in the STEMI acute setting, the index of caFFR might be overestimated. Thus, the cut-value of caFFR ≤ 0.8 is still useful and crucial for guiding additional revascularization.

In the present study, additional evidence is provided that complete revascularization is important for prognosis. Not only for providing information for non-culprit vessels revascularization strategy, but also for culprit vessels optimization treatment. Nearly 6% patients' culprit vessels in the current study did not reach functional complete revascularization after PPCI, and these patients have shown the worst prognosis in the long-term. Therefore, identifying these high residual risk patients by caFFR at index of PPCI and to further optimize outcome by additional procedures and intensive secondary prevention are clinically significant.

Limitations of the study

The present study has usual limitations inherent in retrospective studies. Some patients had to be excluded because of insufficient angiography to measure caFFR. Although confounding factors were adjusted for in the models as much as possible, potential unmeasured confounding factors may still exist. Moreover, STEMI patients may present with microvascular dysfunction in non-culprit vessels, a reduced caFFR accuracy due to microvascular dysfunction cannot be excluded.

Conclusions

In STEMI patients with MVD, caFFR-based incomplete revascularization may contribute to identifying patients at high-risk and take further comprehensive multiple interventions to improve prognosis as early as possible.

Conflict of interest: None declared

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