The effect of complete revascularization in patients with ST-segment elevation myocardial infarction with Killip class ≥ III

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Background: The effect of complete revascularization (CR) on high-risk patients with ST-segment elevation myocardial infarction (STEMI) has remains a controversial issue, especially on patients in a critical condition. The aim of this study was to explore the effect of CR on patients with STEMI with Killip class ≥ III.

Methods: From January 2008 to December 2014, 185 patients diagnosed with STEMI with Killip class ≥ III and multiple vessel coronary artery disease received primary percutaneous coronary intervention (PCI). Eighty-nine patients underwent culprit-only PCI, and the remaining 96 patients underwent immediate or staged PCI for CR. Out of the 96 patients in the CR group, 51 patients underwent immediate CR, and 45 patients underwent CR during the same hospitalization. Thirty-day and 1-year clinical outcomes were compared between the culprit-only PCI group and the CR group as well as between the immediate CR group and staged CR group.

Results: There was a trend toward a lower incidence of post-PCI acute kidney injury in the culprit-only PCI group when compared with the CR group (14.8% vs. 26.0%; P = 0.069). Thirty-day and 1-year cardiovascular mortality and all-cause mortality were similar between the culprit-only PCI group and CR group. Decreased 1-year cardiovascular mortality and all-cause mortality were noted in the staged CR group compared with the immediate CR group.

Conclusion CR was associated a higher possibility of post-PCI acute kidney injury and did not seem to improve 30-day or 1-year clinical outcomes. Patients undergoing staged CR during the same hospitalization had better clinical outcomes.

Keywords: cardiovascular mortality, complete revascularization, Killip class ≥ III, ST-segment elevation myocardial infarction

Introduction

It is increasingly common for patients who experienced ST-segment elevation myocardial infarction (STEMI) to be diagnosed with multivessel coronary artery disease (MVD). Patients with MVD have a relatively poor prognosis [1]. The optimal management protocol for patients with STEMI and MVD remains controversial. Currently, American College of Cardiology/American Heart Association guidelines suggests a class IIb recommendation (Level of Evidence B) for multivessel percutaneous coronary intervention (PCI), which can be treated by either as a single- or multi-stage procedure in STEMI patients [2]. The European Society of Cardiology provides Class IIa recommendation (Level of Evidence A) of routine revascularization for non-infarct related artery lesions and states that it should be considered in STEMI patients with MVD before hospital discharge [3]. Despite these guidelines, physicians need to consider the importance of individualizing care for each patient, balancing the anticipated benefits from multi-vessel PCI against its potential risks, especially in high-risk patients.

In patients with STEMI of the anterior wall, Killip class ≥ III, high serum levels of cardiac biomarker, and high global registry of acute coronary events risk scores are the risk factors for in-hospital and long-term prognoses [4]. Previous studies had demonstrated favorable outcomes in patients with STEMI and MVD who underwent multi-vessel PCI, but the study groups only included relatively stable patients [5–8]. On the other hand, cardiogenic shock is an important and serious complication of STEMI. Multi-vessel PCI performed at the time of primary PCI in patients with cardiogenic shock and MVD is generally considered an acceptable management strategy. However, one meta-analysis and the culprit lesion only...
PCI versus multivessel PCI in cardiogenic shock study did not support multi-vessel PCI for STEMI patients with cardiogenic shock [9,10]. Therefore, the outcome of complete revascularization in relatively stable patients and high-risk patients may be different. However, few studies have focused on STEMI patients in relatively critical condition. Therefore, we aimed to explore the effect of complete revascularization on high-risk patients with STEMI of Killip class ≥ III.

**Materials and methods**

**Patients and groups**

From January 2008 to December 2014, 185 patients were diagnosed with STEMI of Killip ≥ III and with MVD at our hospital. The patients who underwent coronary artery bypass graft for revascularization, had only one-vessel coronary artery disease, or with less than 70% stenosis of the non-culprit vessel were excluded. All charts were reviewed retrospectively. According to the different strategy of PCI, 89 patients were enrolled into the culprit-only PCI group, and 96 patients were enrolled into the complete revascularization group. In the complete revascularization group, 51 patients underwent multi-vessel PCI immediately and 45 patients underwent staged PCI during the same hospitalization.

The Institutional Review Committee on Human Research of our institution approved the study protocol.

**Definitions**

Definition of the myocardial infarction (MI) is in accordance with the most recent universal definition of MI [11]. Killip III describes individuals with frank acute pulmonary edema and Killip class IV describes individuals in cardiogenic shock or hypotension (measured as systolic blood pressure lower than 90 mmHg) and with evidence of peripheral vasoconstriction (oliguria, cyanosis, or sweating) [12]. Acute kidney injury (AKI) is defined as either an increase in serum creatinine concentration by ≥0.5 mg/dl compared to the admission value or a ≥25% relative rise in the serum creatinine concentration during the first 72 hours after the procedure [13]. Cardiovascular mortality is defined as death related to MI, cardiac arrhythmia, and heart failure. All-cause mortality is defined as death from any causes, including cardiovascular mortality, stroke, and sepsis.

**Study endpoints**

The primary endpoints of our study were 30-day cardiovascular mortality and all-cause mortality. The secondary endpoints were 1-year cardiovascular mortality and all-cause mortality.

**Statistical analysis**

Data were expressed as a mean ± SD for continuous variables, as counts and percentages for categorical variables and as median and interquartile range for non-normally distributed parameters. Continuous variables were compared using an independent samples t-test or Mann–Whitney U tests. Categorical variables were compared using a Chi-square statistic or the Kruskal–Wallis test. Univariate Cox regression analyses about 30-day cardiovascular mortality and 1-year cardiovascular mortality were performed to identify the impact of complete revascularization for the whole study population and different subgroups. Kaplan–Meier curves were plotted for 30-day cardiovascular mortality among all patients and in specific groups. Statistical analyses were performed using SPSS 22.0 (IBM Corp., Armonk., New York, USA). A P-value less than 0.05 was considered statistically significant.

**Results**

**Baseline characteristics**

(Table 1) The average age of the culprit-only PCI group was 64.0 ± 12 years, and 77.5% were male. The average age of the complete revascularization group was 65.0 ± 13 years and 77.1% were male. There was no significant difference in age or gender in these groups or between immediate complete revascularization and staged complete revascularization groups. Higher BMI was noted in the staged complete revascularization group when compared with the immediate complete revascularization group. There was no significant difference in prevalence of smoking, diabetes mellitus, hypertension, prior history of MI, prior history of stroke, and end-stage renal disease between culprit-only PCI group and complete revascularization group or between immediate complete revascularization group and staged complete revascularization group. Chest pain to emergency department transit time and reperfusion time was not significantly different between culprit-only PCI group and complete revascularization group or between immediate complete revascularization group and staged complete revascularization group. Within the complete revascularization group, a higher prevalence of anterior wall involvement was found in the immediate complete revascularization group when compared with the staged complete revascularization group (82.4% vs. 31.1%; P < 0.001). The prevalence of left main disease was a little higher in the complete revascularization group (vs. culprit-only PCI) and immediate complete revascularization (vs. staged) groups but it was not statistically significant.

Higher prevalence of extra-corpororeal membrane oxygenation (ECMO) support was noted in the immediate complete revascularization group but did not reach statistically significant difference when compared with the staged complete revascularization group. Less frequent beta-blocker use was noted in the immediate complete revascularization group when compared with the staged complete revascularization group (47.1% vs. 71.1%; P = 0.047). A trend towards reduced post-PCI AKI in culprit-only PCI group was found when compared with the complete revascularization group (14.8% vs. 26.0%; P = 0.069), and no difference was found in the incidence of post-PCI AKI.

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AKI between the immediate complete revascularization group and the staged complete revascularization group.

**Culprit and non-culprit vessel angiography and method of primary percutaneous coronary intervention**

(Table 2) When examining pre-PCI angiography, pre-PCI reference luminal diameter of culprit vessel was noted to be larger in the staged complete revascularization group when compared with the immediate complete revascularization group (2.88 ± 0.59 vs. 3.34 ± 0.67 mm; \( P = 0.001 \)). Pre-PCI thrombolysis in myocardial infarction flow, pre-PCI stenotic percentage, and pre-PCI minimal luminal diameter of culprit vessel was not any different between the culprit-only PCI group and complete revascularization group or between the immediate complete revascularization group and staged complete revascularization group. When reviewing post-PCI angiography, larger post-PCI reference luminal diameter of culprit vessel was noted in the staged complete revascularization group when compared with the immediate complete revascularization group (3.17 ± 0.55 vs. 3.46 ± 0.63 mm; \( P = 0.019 \)). Post-PCI thrombolysis in myocardial infarction flow, post-PCI stenotic percentage, and post-PCI minimal luminal diameter of culprit vessel was not different between the culprit-only PCI group and complete revascularization group or between the immediate complete revascularization group and staged complete revascularization group. The ratio of bare-metal stent use to drug-eluting stent use was similar between the culprit-only PCI group and complete revascularization group or between the immediate complete revascularization group and staged complete revascularization group. The stenotic percentage of non-culprit vessel showed no difference between the culprit-only PCI group and
complete revascularization group (82.45 ± 12.26% vs. 84.27 ± 11.09%; \(P = 0.279\)) or between the immediate complete revascularization group and staged complete revascularization group (85.36 ± 11.58% vs. 83.24 ± 10.62%; \(P = 0.330\)).

**Table 3 Thirty-day and 1-year clinical outcomes of patients with culprit-only percutaneous coronary intervention versus complete revascularization**

|                  | Culprit-only PCI (N=89) | All (N=96) | Immediate (N=51) | Staged (N=45) | \(P\)-value (culprit-only PCI vs. CR) | \(P\)-value (immediate vs. staged) |
|------------------|-------------------------|------------|------------------|---------------|--------------------------------------|-----------------------------------|
| **30-day outcome** |                         |            |                  |               |                                      |                                   |
| Cardiovascular mortality (%) | 16 (18.0)              | 14 (14.6)  | 10 (19.6)        | 4 (8.9)       | 0.551                                | 0.155                             |
| All-cause mortality (%)    | 17 (19.1)              | 16 (16.7)  | 12 (23.5)        | 4 (8.9)       | 0.701                                | 0.059                             |
| **1-year outcome**        |                         |            |                  |               |                                      |                                   |
| Cardiovascular mortality (%) | 20 (23.3)              | 22 (23.2)  | 16 (31.4)        | 6 (13.3)      | 0.914                                | 0.042                             |
| All-cause mortality (%)    | 24 (27.0)              | 31 (32.3)  | 23 (45.1)        | 8 (17.8)      | 0.498                                | 0.003                             |

**Table 2 Culprit and non-culprit vessel angiography and method of primary percutaneous coronary intervention**

| Culprit vessel | CR | \(P\)-value (culprit-only PCI vs. CR) | \(P\)-value (immediate vs. staged) |
|----------------|----|--------------------------------------|-----------------------------------|
| Pre-PCI angiography |    |                                      |                                   |
| Pre-PCI TIMI flow |    |                                      |                                   |
| \(\geq 2\) (%) | 20 (22.5) | 26 (27.1) | 15 (29.4) | 11 (24.4) | 0.500 | 0.650 |
| \(\leq 1\) (%) | 89 (77.5) | 70 (72.9) | 36 (70.6) | 34 (75.6) | 0.599 | 0.059 |
| Pre-PCI stenosis (%) | 95.14 ± 8.87 | 94.32 ± 8.73 | 93.53 ± 9.37 | 95.22 ± 7.95 | 0.527 | 0.348 |
| Pre-PCI MLD (mm) | 0.13 ± 0.05 | 0.15 ± 0.04 | 0.16 ± 0.04 | 0.13 ± 0.05 | 0.672 | 0.489 |
| Pre-PCI RLD (mm) | 3.07 ± 2.71 | 3.08 ± 0.68 | 2.98 ± 0.59 | 3.34 ± 0.67 | 0.864 | 0.001 |
| Post-PCI angiography |    |                                      |                                   |
| Post-PCI TIMI flow |    |                                      |                                   |
| \(\geq 2\) (%) | 87 (92.8) | 91 (94.8) | 49 (98.1) | 42 (93.4) | 0.446 | 0.663 |
| \(\leq 1\) (%) | 2 (2.2) | 5 (5.2) | 2 (3.9) | 3 (6.7) | 0.713 | 0.836 |
| Pre-PCI stenosis (%) | 17.16 ± 11.22 | 16.52 ± 12.25 | 16.27 ± 9.94 | 16.80 ± 5.49 | 0.713 | 0.836 |
| Post-PCI MLD (mm) | 2.66 ± 0.56 | 2.75 ± 0.66 | 2.66 ± 0.58 | 2.85 ± 0.73 | 0.346 | 0.151 |
| Post-PCI RLD (mm) | 3.24 ± 0.58 | 3.31 ± 0.80 | 3.17 ± 0.55 | 3.46 ± 0.63 | 0.448 | 0.019 |
| Method of PCI |    |                                      |                                   |
| Bare-metal stents (%) | 73 (82.0) | 79 (82.3) | 41 (80.4) | 38 (84.4) | 1.000 | 0.790 |
| Drug-eluting stents (%) | 16 (18.0) | 17 (17.7) | 10 (19.6) | 7 (15.6) | 1.000 | 0.790 |
| Non-culprit vessel |    |                                      |                                   |
| Stenosis (%) | 82.45 ± 12.26 | 84.27 ± 11.09 | 85.36 ± 11.58 | 83.24 ± 10.62 | 0.279 | 0.330 |

Data are expressed as mean ± SD or as number (percentage).

CR, complete revascularization; MLD, minimal luminal reference; PCI, percutaneous coronary intervention; RLD, reference luminal diameter; TIMI, thrombolysis in myocardial infarction.

**Thirty-day and 1-year clinical outcomes of patients with culprit-only percutaneous coronary intervention versus complete revascularization**

(Table 3) When the culprit-only PCI group was compared to complete revascularization group, there was a similar prevalence of 30-day cardiovascular mortality (18.0% vs. 14.6%; \(P = 0.551\)) and 30-day all-cause mortality (19.1% vs. 16.7%; \(P = 0.701\)) as well as 1-year cardiovascular mortality (23.3% vs. 23.2%; \(P = 0.914\)) and 1-year all-cause mortality (27.0% vs. 32.3%; \(P = 0.498\)).

In the complete revascularization group, a trend of lower 30-day cardiovascular mortality (19.6% vs. 8.9%; \(P = 0.155\)) and 30-day all-cause mortality (23.5% vs. 8.9%; \(P = 0.059\)) were noted in the staged complete revascularization group when compared to the immediate complete revascularization group. In addition, lower 1-year cardiovascular mortality (31.4% vs. 13.3%; \(P = 0.042\)) and 1-year all-cause mortality (45.1% vs. 17.8%; \(P = 0.003\)) were noted in the staged complete revascularization group when compared with the immediate complete revascularization group.

Univariate Cox regression analyses of complete revascularization and 30-day and 1-year cardiovascular mortality for whole study patients and different subgroups (Table 4).

Complete revascularization showed no significantly positive effect on the whole study population and different subgroups including the patients with Killip III status, Killip IV status, anterior wall involvement, non-culprit vessel as chronic total occlusion (CTO), intra-aortic balloon pumping support, and ECMO support.

**The Kaplan–Meier curves of 30-day cardiovascular mortality in all groups, and subgroups**

(Figs. 1 and 2) When comparing the culprit-only PCI group vs. the complete revascularization group or
comparing the culprit-only, immediate complete revascularization and staged complete revascularization groups, the Kaplan–Meier curve of 30-day cardiovascular mortality showed no significant differences (Fig. 1a and b).

There were similar outcomes in the Kaplan–Meier curve of 30-day cardiovascular mortality for the patients diagnosed with Killip III level MI, Killip IV level MI, anterior wall MI, non-culprit vessel as CTO, those who needed intra-aortic balloon pumping support, and those who received ECMO support (Fig. 2a through f).

### Discussion

In our study, thirty-day and 1-year clinical outcomes were similar between the culprit-only and complete revascularization groups. A trend toward a high incidence of post-PCI AKI was noted in the complete revascularization group. Better 1-year clinical outcomes were noted in the staged complete revascularization group. In high-risk patients (including those with Killip IV, Killip III, anterior wall MI, non-culprit vessel as CTO, and mechanical support), complete revascularization did not improve 30-day cardiovascular mortality.

The patients with STEMI and MVD have multifactorial problems including pan-coronary inflammation, diffuse atherosclerosis with multiple unstable coronary plaques, and impaired contractility of non-infarct zones resulting from multiple coronary stenosis [14,15]. Complete revascularization at the time of primary PCI increases myocardial salvage by increasing perfusion to the watershed areas by relieving flow limitations of the non-infarct artery and stabilizing other bystander vulnerable plaques [16]. One meta-analysis report stated that multi-vessel PCI either during primary PCI or staged PCI results in lower occurrences of major adverse cardiovascular events, revascularization, and cardiovascular mortality than infarct-only PCI [17]. However, these studies only focused on relatively stable patients and excluded patients with mechanical support. In addition, multi-vessel PCI increases the possibility of post-PCI AKI due to increasing contrast volume, especially in the patients who are in critical condition and require mechanical support [7,8]. Staged PCI during a short-term interval was also associated with a higher incidence of post-PCI AKI in patients with anterior MI [18]. Caspi et al. noted that AKI was strongly associated with baseline renal function, age, heart failure, hemodynamic

### Table 4 Univariate Cox regression analyses of complete revascularization and 30-day and 1-year cardiovascular mortality for whole study patients and different subgroups

| Variable                | Hazard ratio | 95% Confidence interval | P-value |
|-------------------------|--------------|-------------------------|---------|
| For whole study patients|              |                         |         |
| 30-day period           | 0.759        | 0.370–1.554             | 0.450   |
| 1-year period           | 0.990        | 0.540–1.814             | 0.973   |
| For only Killip III patients|          |                         |         |
| 30-day period           | 0.829        | 0.117–5.888             | 0.852   |
| 1-year period           | 1.698        | 0.424–6.795             | 0.465   |
| For only Killip IV patients|          |                         |         |
| 30-day period           | 0.768        | 0.355–1.662             | 0.503   |
| 1-year period           | 0.867        | 0.438–1.716             | 0.681   |
| For anterior wall STEMI |              |                         |         |
| 30-day period           | 0.938        | 0.395–2.217             | 0.885   |
| 1-year period           | 1.382        | 0.642–2.974             | 0.408   |
| For non-culprit vessel as CTO|       |                         |         |
| 30-day period           | 0.400        | 0.100–1.599             | 0.195   |
| 1-year period           | 0.793        | 0.050–12.680            | 0.870   |
| For the patients with IABP support|     |                         |         |
| 30-day period           | 0.889        | 0.406–1.948             | 0.769   |
| 1-year period           | 0.943        | 0.481–1.849             | 0.864   |
| For the patients with ECMO support|     |                         |         |
| 30-day period           | 0.769        | 0.223–2.657             | 0.678   |
| 1-year period           | 0.749        | 0.262–2.137             | 0.589   |

CTO, chronic total occlusion; ECMO, extra-corporeal membrane oxygenation; IABP, intra-aortic balloon pumping; STEMI, ST-segment elevation myocardial infarction.

Kaplan–Meier curves of 30-day cardiovascular mortality. (a) Kaplan–Meier curve of 30-day cardiovascular mortality of culprit-only PCI and CR group: There was no difference between two groups ($P = 0.745$). (b) A Kaplan–Meier curve of 30-day cardiovascular mortality of culprit-only PCI and immediate CR group and staged CR group: There was no difference between three groups ($P < 0.578$). CR, complete revascularization.
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In our study, all STEMI patients were Killip ≥ III status and were diagnosed with MVD. Baseline characteristics were similar between the study groups, except higher BMI was noted in the staged complete revascularization group (compared to the immediate complete revascularization group). In daily practice, interventionists may consider performing complete revascularization in those patients with anterior wall STEMI because anterior wall involvement may portend a poor prognosis [4]. We compared the clinical outcomes between culprit-only PCI group and multi-vessel PCI group. Better 30-day and 1-year cardiovascular mortality and all-cause mortality were found in the staged complete revascularization group (when compared to immediate complete revascularization group). In addition, it appeared that the staged complete revascularization group had the best performance though it was small and underpowered. Therefore, additional large randomized trials are required to elucidate the optimal strategies for the non-culprit vessel in STEMI patients with MVD and in critical clinical condition.

Limitations
This was a retrospective cohort study involving patients from a single-center and the findings were hypothesis-generating. However, we shared the results of the
clinical outcomes about the effect of complete revascularization in critical STEMI patients with MVD, and with Killip ≥ III. We also included patients who needed mechanical support unlike prior research in the area. Our research provides insight into possible improvements in healthcare protocols for critical STEMI patients with MVD in the future.

Conclusions
Complete revascularization was associated with a trend toward a higher incidence of post-PCI AKI and seemed not to improve 30-day and 1-year clinical outcomes. Staged complete revascularization during the same hospitalization may have better clinical outcomes than immediate complete revascularization.

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Conflicts of interest
There are no conflicts of interest.

References
1 Muller DW, Topol EJ, Ellis SG, Signon KN, Lee K, Califf RM. Multivessel coronary artery disease: a key predictor of short-term prognosis after reperfusion therapy for acute myocardial infarction. Thrombolysis and angioplasty in myocardial infarction (TAMI) study group. Am Heart J 1991; 121:1042–1049.
2 Jneid H, Addison D, Bhatt DL, Faxon DP, Gore JM, Grady KL, et al. 2017 AHA/ACC clinical performance and quality measures for adults with ST-elevation and non-ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on performance measures. J Am Coll Cardiol 2017; 70:2048–2090.
3 Ibanez B, James S, Agewall S, Antunes MJ, Bucciarelli-Ducci C, Bueno H, et al.; ESC Scientific Document Group. 2017 ESC guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: the task force for the management of acute myocardial infarction in patients presenting with ST-segment elevation of the European Society of Cardiology (ESC). Eur Heart J 2018; 39:119–177.
4 Hou LL, Gao C, Feng J, Chen ZF, Zhang J, Jiang YJ, et al. Prognostic factors for in-hospital and long-term survival in patients with acute ST-segment elevation myocardial infarction after percutaneous coronary intervention. Tohoku J Exp Med 2017; 242:27–35.
5 Di Mario C, Mara S, Flavio A, Imad S, Antonio M, Anna P, et al. Single vs multivessel treatment during primary angioplasty: results of the multicentre randomised heparcap for culprit or multivessel stenting for acute myocardial infarction (HELP AMI) study. Int J Cardiovasc Intervent 2004; 6:128–133.
6 Politi L, Sgura F, Rossi R, Monopoli D, Guerri E, Leuzzi C, et al. A randomised trial of target-vessel versus multi-vessel revascularisation in ST-elevation myocardial infarction: major adverse cardiac events during long-term follow-up. Heart 2010; 96:652–667.
7 Wald DS, Morris JK, Wald NJ, Chase AJ, Edwards RJ, Hughes LO, et al.; PRAMI Investigators. Randomized trial of preventive angioplasty in myocardial infarction. N Engl J Med 2013; 369:1116–1123.
8 Gershlick AH, Khan JN, Kelly DJ, Greenwood JP, Sasikaran T, Curzen N, et al. Randomized trial of complete versus lesion-only revascularization in patients undergoing primary percutaneous coronary intervention for STEMI and multivessel disease: the ckipvt trial. J Am Coll Cardiol 2015; 65:963–972.
9 de Waha S, Jobs A, Eitel I, Pöss J, Starmera T, Meyer-Sarasoi R, et al. Multivessel versus culprit lesion only percutaneous coronary intervention in cardiogenic shock complicating myocardial infarction: a systematic review and meta-analysis. Eur Heart J Acute Cardiovasc Care 2018; 7:28–37.
10 Thiele H, Akin I, Sandri M, Fuerma G, de Waha S, Meyer-Sarasoi R, et al.; CULPRIT-SHOCK Investigators. PCI strategies in patients with acute myocardial infarction and cardiogenic shock. N Engl J Med 2017; 377:2419–2432.
11 Thygensen K, Alpert JS, Jaffe AS, Simeson ML, Chaitman BR, White HD, et al.; Writing Group on the Joint ESC/ACCF/AHA/WHF Task Force for the Universal Definition of Myocardial Infarction; ESC Committee for Practice Guidelines (CPG). Third universal definition of myocardial infarction. Eur Heart J 2012; 33:2551–2567.
12 Killip T III, Kimball JT. Treatment of myocardial infarction in a coronary care unit. A two year experience with 250 patients. Am J Cardiol 1967; 20:457–464.
13 Narula A, Mehran R, Weisz G, Dangas GD, Yu J, Genéreux P, et al. Contrast-induced acute kidney injury after primary percutaneous coronary intervention: results from the HORIZONS-AMI substudy. Int J Cardiol 2014; 175:1535–1540.
14 Pollack A, Mohanty BD, Handa R, Looser PM, Fuster V, King SB III, Sharma SK. Preventive stenting in acute myocardial infarction. JACC Cardiovasc Interv 2015; 8:131–138.
15 Goldstein JA, Demetru DI, Grines CL, Pica M, Shoukfeh M, O’Neill WW. Multiple complex coronary plaques in patients with acute myocardial infarction. N Engl J Med 2000; 343:915–922.
16 McCann GP, Khan JN, Greenwood JP, Nazir S, Dalby M, Curzen N, et al. Complete versus lesion-only primary PCI: the randomized cardiovascular MR ckipvt substudy. J Am Coll Cardiol 2015; 66:2713–2724.
17 Shah R, Berzinski C, Muntaz M, Jasper JB, Goswami R, Morry MS, et al. Meta-analysis comparing complete revascularization versus infarct-related only strategies for patients with ST-segment elevation myocardial infarction and multivessel coronary artery disease. Am J Cardiol 2016; 118:1466–1472.
18 Lee WC, Wu BJ, Fang CY, Chen CJ, Yang CH, Yip HK, et al. Timing of staged percutaneous coronary intervention for a non-culprit lesion in patients with anterior wall ST segment elevation myocardial infarction with multiple vessel disease. Int Heart J 2016; 57:417–423.
19 Caspi O, Habib M, Cohen Y, Kerner A, Roguin A, Abergel E, et al. Acute kidney injury after primary angioplasty: is contrast-induced nephropathy the culprit? J Am Heart Assoc 2017; 6:e005715.
20 Dimitr Y-Leen AC, Hemnas MP, Vettman CE, van der Hoeven BL, van Rosendael AR, van Zandt E, et al. Prognosis of complete versus incomplete revascularisation of patients with STEMI with multivessel coronary artery disease: an observational study. Open Heart 2017; 4:e000541.
21 Lee WC, Fang CY, Chen HC, Chen CJ, Yang CH, Hang CL, et al. Associations with 30-day survival following extracorporeal membrane oxygenation in patients with acute ST segment elevation myocardial infarction and profound cardiogenic shock. Heart Lung 2016; 45: 532–537.
22 Li Z, Zhou Y, Xu Q, Chen X. Staged versus one-time complete revascularization with percutaneous coronary intervention in STEMI patients with multivessel disease: a systematic review and meta-analysis. Plos One 2017; 12:e0169406.