Journal of the Hong Kong College of Cardiology

Volume 29 | Issue 5 Article 2

Retrospective observational study comparing two reperfusion strategies in patients with acute STEMI presenting outside office hours

Derek Pok-Him Lee
Divison of Cardiology, Department of Medicine, Queen Elizabeth Hospital, Hong Kong, lph748@ha.org.hk

Kam-Tim Chan
Division of Cardiology, Department of Medicine, Queen Elizabeth Hospital, Hong Kong

Michael Kang-Yin Lee
Division of Cardiology, Department of Medicine, Queen Elizabeth Hospital, Hong Kong

Eric Chi-Yuen Wong
Division of Cardiology, Department of Medicine, Queen Elizabeth Hospital, Hong Kong

Recommended Citation

Derek Pok-Him Lee, Kam-Tim Chan, Michael Kang-Yin Lee, Eric Chi-Yuen Wong, Retrospective observational study comparing two reperfusion strategies in patients with acute STEMI presenting outside office hours *Journal of the Hong Kong College of Cardiology* 2023;29(5) https://doi.org/10.55503/2790-6744.1494

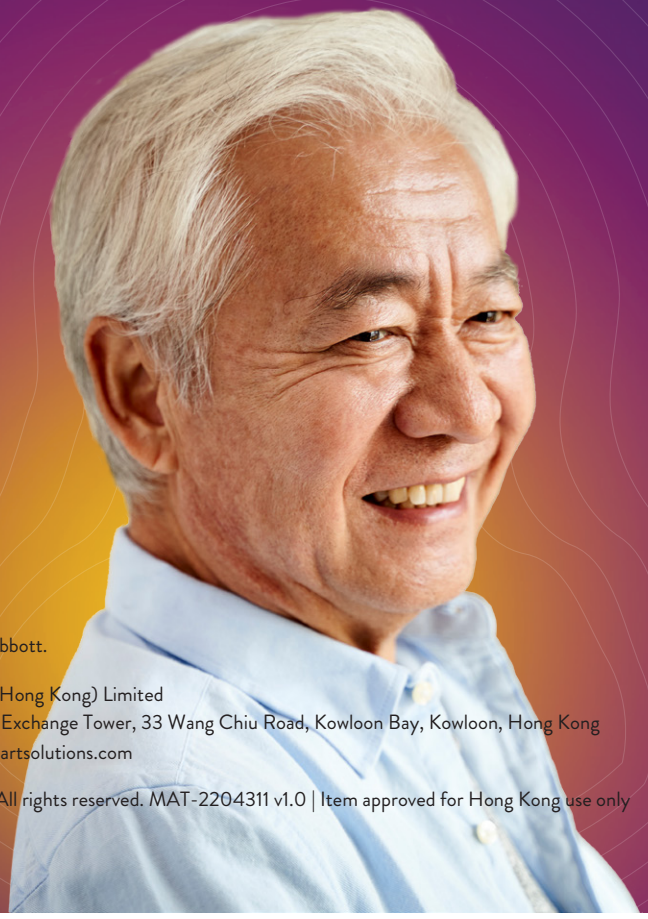
MitraClip™
Transcatheter Edge-to-Edge Repair

150K CHANGED LIVES

AND COUNTING with MitraClip™ Therapy

More than 150,000 patients with mitral regurgitation have had their lives transformed with MitraClip.

For all who were a part of achieving this milestone – and all who will be a part of the next one – Abbott thanks you.



Data on File at Abbott.

Abbott Medical (Hong Kong) Limited
Suite 1608, 16/F Exchange Tower, 33 Wang Chiu Road, Kowloon Bay, Kowloon, Hong Kong
www.structrualheartsolutions.com

Abbott

ORIGINAL ARTICLE

Retrospective Observational Study Comparing Two Reperfusion Strategies in Patients with Acute STEMI Presenting Outside Office Hours

Derek Pok-Him Lee*, Kam-Tim Chan, Michael Kang-Yin Lee, Eric Chi-Yuen Wong

Department of Medicine, Queen Elizabeth Hospital, Hong Kong

Abstract

Introduction: **A pilot cluster-based 24-hour primary percutaneous coronary intervention (PPCI) service in a phased expansion program was launched in October 2018. This study aimed to compare the 30-day mortality and major bleeding event in acute ST-elevation myocardial infarction (STEMI) patients presenting outside office hours who received historical thrombolytic therapy and PPCI under the newly implemented 24-hour service model.**

Methods and results: **A single center retrospective study was conducted on consecutive STEMI patients presenting outside office hours, who received urgent thrombolytic therapy or PPCI between 2016-2019. The primary endpoints were 30-day mortality and major bleeding event. The secondary endpoints were thrombolytic failure rate and hospital length of stay. A total of 331 patients were analyzed. 30-day mortality occurred in 11.7% in thrombolytic group and 4.2% in PPCI group ($P = .02$). Major bleeding events occurred in 8% in thrombolytic group and 2.1% in PPCI group ($P = .02$). Multivariate analysis identified age ≥ 75 as an independent factor associated with major outcomes. Thrombolytic failure occurred in 31.4% of patients. The median lengths of stay were not different between the two groups (5 vs 4 days, $P = .29$).**

Conclusions: **Compared with thrombolytic therapy, PPCI in patients with acute STEMI presenting outside office hours is associated with lower risks of 30-day mortality and major bleeding event. Age ≥ 75 was an independent risk factor associated with mortality and bleeding outcome.**

Classifications: STEMI, Clinical research, Original article

Keywords: Myocardial infarction, Thrombolysis, Angioplasty

Introduction

Acute ST-elevation myocardial infarction (STEMI) carries high morbidity and mortality. Timely coronary reperfusion, either by pharmacological or mechanical means, has significantly altered the outcome of these patients. In the first studies on primary percutaneous coronary intervention (PPCI) in 1990s [1,2], immediate angioplasty was shown to be superior to thrombolytic therapy. This was supported by subsequent numerous randomized controlled trials (RCT) conducted worldwide showing a reduction in mortality and major adverse cardiovascular events [3–6]. However, due to geographical reasons and lack of resources including catheterization laboratory facilities and experienced PCI operators, limited access to PPCI service is still evident in resource-limited centers worldwide. In Hong Kong, PPCI service is available in the majority of public hospitals on a limited basis (i.e. 8am to 8pm on weekdays). Nonetheless, thrombolytic therapy remains the mainstay of treatment for STEMI

Received 25 July 2022; revised 11 September 2022; accepted 1 October 2022.
Available online 31 January 2023

* Corresponding author at:
E-mail address: dereklph@gmail.com (D.P.-H. Lee).

https://doi.org/10.55503/2790-6744.1494

New knowledge added by the study:

1. Asian data on comparison between PPCI versus thrombolytic therapy in management of STEMI was scarce. In Hong Kong there is no previous regional data reported. The current observation study extended the evidence on superiority of mechanical reperfusion in management of STEMI to our local population.
2. The PPCI program was a new program recently launched and the current study confirmed the efficacy and feasibility of implementing such program in our locality with resource-limited settings.
3. The current study discovered areas of improvement to further enhance the program and to refine our clinical service.

Implications for clinical practice or policy

1. Our study confirmed the superiority of PPCI for STEMI in Asian population and demonstrated the efficacy and feasibility of our pilot service model in a resource-limited setting. Our study also identified important areas of improvement to enhance our service model in this phased expansion program.
2. The stakeholders of the health system should consider support of the PPCI program in terms of supplementing manpower and resources to regional hospitals to implement such program.

presenting outside office hours with the exception of contraindications to thrombolytic therapy or other compelling reasons such as cardiogenic shock or severe acute heart failure. A pilot cluster-based 24-h PPCI service in a phased expansion program was launched in October 2018. This study aimed to compare the clinical outcomes of acute STEMI patients presenting outside office hours who received historical thrombolytic therapy and PPCI under the newly implemented 24-h service model.

Methods

Study design & patient selection

The current study was a single center retrospective observational study on consecutive patients diagnosed with acute STEMI outside office hours, who received urgent thrombolytic therapy between January 2016 and September 2018 and PPCI between October 2018 and December 2019. For optimal comparison between the two groups, only patients who presented to our emergency department outside office hours and eventually received PPCI were included. Office hours are defined as 8am to 8pm on weekdays excluding Saturdays, Sundays and public holidays. The diagnosis of STEMI was in accordance with the current international guidelines. Patients who presented with cardiogenic shock or severe acute heart failure requiring high flow oxygen supplement or mechanical ventilation complicating acute STEMI were excluded. Other exclusion criteria were patients who had diagnosis of STEMI excluded after subsequent coronary workup and patients who were contraindicated for thrombolytic therapy (see Table 1). In the event of thrombolytic failure, rescue PCI would be performed with consent.

Historical thrombolytic protocol

Before October 2018, all patients presenting to the Accident and Emergency Department (AED) outside the office hours who received a diagnosis of acute STEMI with an onset within 12 hours or between 12 and 24 hours with persistent chest pain, thrombolytic therapy was the default reperfusion strategy. The exceptions were patients who had contraindications to thrombolytic therapy or those with other compelling reasons including cardiogenic shock or severe acute heart failure to whom urgent PCI service would be provided.

A pre-procedural checklist and working protocol would be undertaken in the AED. These included key information on current presentation, clinical suspicion for aortic dissection, eligibility and consent for thrombolytic therapy, pre-procedural blood

Table 1. Contraindications to thrombolytic therapy.

Absolute Contraindications
Any prior intracranial hemorrhage
Known Intracranial malformation or neoplasm
Ischemic stroke within the past 3 months
Suspected aortic dissection
Recent surgery
Recent head trauma
Bleeding diathesis
Relative contraindications
Age ≥75 years
Current use of anticoagulants
Pregnancy
Cardiopulmonary resuscitation >10 minutes
Recent internal bleed within 1 month
Uncontrolled hypertension ≥180/110 mmHg
Remote ischemic stroke
Major surgery within 3 weeks

taking, pre-treatment with dual antiplatelet therapy and intravenous anticoagulant. Regarding the pre-treatment, our choice of antiplatelet therapy was a combination of Aspirin 320 mg orally (for treatment naïve patients) and Clopidogrel 300 mg orally with a concomitant Enoxaparin 30 mg injection intravenously followed by weight-based dosing (1 mg per kg) of Enoxaparin injection subcutaneously 15 minutes later. As for choice of thrombolytic agent, Tenecteplase was administered on a weight-based dosing (30 mg if the weight was less than 60 kg, 35 mg if the weight was 60−69 kg, 40 mg if the weight was 70−79 kg, 45 mg if the weight was 80−89 kg, and 50 mg if the weight was 90 kg or more). For patients who had the diagnosis of acute STEMI made after admission to medical wards, the above-mentioned pre-procedural checklist and working protocol would then be undertaken in respective wards by the on-duty physicians or on-site cardiac fellow if available. All patients after receiving urgent thrombolytic therapy would be admitted to our cardiac care unit for intensive care.

For patients with successful thrombolysis, routine PCI would be performed on the next normal working day (i.e. normal working hours on weekdays excluding Saturdays, Sundays and public holidays). For patients with failed thrombolysis, timely rescue PCI would be performed at the earliest time.

24-Hour PPCI service model

Since the launch of the PPCI program in October 2018, we have collaborated with the AED in the provision of 24-h PPCI service. All patients who presented to the AED with a diagnosis of acute STEMI received PPCI as the default reperfusion strategy. A designated in-house AMI nurse would be alerted and PPCI service would be activated after discussion with on-duty senior cardiologists. To cater for PPCI service outside office hours, a roster system was established for junior fellows and senior cardiologists. In the event of service activation, on-duty junior fellow and senior cardiologist, both of whom may not be on-site, would be alerted for the service.

A pre-procedural checklist and working protocol would be undertaken in a similar manner as aforementioned. For preloading of medications in AED before PCI, Ticagrelor 180 mg orally would be administered instead of Clopidogrel (except in patients with history of intracranial hemorrhage or moderate to severe hepatic impairment) and 4000 units of unfractionated heparin would be administered intravenously instead of Enoxaparin. Verbal consent for the procedure would be taken by AED colleagues and formal written consent would be taken in the catheterization laboratory upon patient arrival by cardiologist. Similarly, for patients who had the diagnosis of acute STEMI made after admission to medical wards, our AMI nurse would be alerted in a similar way as in the AED for the activation of inpatient PPCI service. The pre-procedural checklist and working protocol would then be undertaken in respective wards by the on-duty physicians or on-site cardiac fellows if available.

Data collection & outcome measurement

Patients' clinical records were extracted from hospital electronic system and the following data were analyzed: patient demographics, history of present illness, time from symptom onset, hemodynamic and cardiac status at the time of presentation, coronary angiography findings, utilization of mechanical circulatory support devices, major adverse cardiac and cerebrovascular events. Data on performance measures including door-to-needle (DTN) time, door-to-balloon (DTB) time were also collected. For patients who were given an initial diagnosis other than STEMI but were subsequently diagnosed as acute STEMI in Emergency Observation Unit or after admission to medical ward (including evolution of electrocardiographic (ECG) evidence of STEMI, initial missed diagnosis, initial refusal of reperfusion treatment and new development of acute STEMI in-patient) with urgent reperfusion given, they would be excluded from analysis of door-to-needle or door-to-balloon time.

The primary outcomes were 30-day mortality and major bleeding event. Major bleeding event was defined using standardized bleeding definitions for cardiovascular clinical trials from Bleeding Academic Research Consortium (BARC) of type 3 or above. The secondary outcomes were thrombolytic failure rate and hospital length of stay. With reference to findings from previous trials investigating independent predictors of short-term mortality [7,8] in acute STEMI patients, subgroup analysis of primary outcomes was also performed in two subsets of population— patients with early presentation (time from symptom onset $\leq$3 hours) and elderly population (age $\geq$75).

Statistical design and analysis

Statistical analysis was performed using IBM SPSS Statistics for Mac Version 21 (IBM Corp, Armonk [NY], United States). Figures are presented in absolute numbers with percentage, mean value with standard deviation or median with interquartile range as appropriate. Categorical variables were

analyzed using the Chi-squared test and continuous variables were compared using Student's *t* test. A *P* value of < 0.05 was considered statistically significant. Chi-squared test and Student's *t*-test were used to compare the two groups and to perform univariate analysis to identify potential risk factors for 30-day mortality and major bleeding event. Variables with $P < .1$ in the univariate analysis were included in a multivariate analysis using a binary logistic regression model with stepwise backward entry. $P < .05$ indicated significant risk factor associated with outcome measurement. Kaplan–Meier survival curve was used to illustrate the 30-day mortality in the two investigational groups and log-rank test was performed for statistical comparison.

Results

From January 2016 to September 2018, 197 patients received thrombolytic therapy in the treatment of acute STEMI. 4 patients were excluded after the diagnosis of acute STEMI was ruled out by coronary angiogram and/or intravascular imaging. 5 patients were excluded due to refusal of coronary angiogram after thrombolytic therapy or discharge against medical advice. 188 patients were eventually included for analysis in the thrombolytic therapy group. From October 2018 to December 2019, 343 patients received PPCI in the treatment of acute STEMI. 139 patients were excluded for presentation during office hours. 21 patients were excluded due to cardiac arrest, cardiogenic shock or severe acute heart failure on presentation. 40 patients were excluded after the diagnosis of acute STEMI was ruled out by coronary angiogram and/or intravascular imaging due to absence of significant epicardial stenoses. 143 patients were eventually included for analysis in PPCI group.

Patient characteristics

The baseline characteristics, angiographic features and clinical presentation of patients are shown in Table 2. The baseline characteristics between the two groups were similar. 15 patients in PPCI group had unknown chest pain onset time and were excluded from analysis of mean onset time.

Door-to-needle and door-to-balloon time

The mean DTN time was 36 minutes (36 ± 14.7 minutes) in thrombolytic therapy group and the mean DTB time was 73.8 minutes (73.8 ± 23.6 minutes) in PPCI group. 171 patients were included in DTN time analysis whereas 122 patients were included in DTB time analysis. 17 patients in thrombolytic therapy group were excluded from DTN time analysis due to various reasons including initial missed diagnosis, evolving ECG evidence of STEMI in patients who were initially diagnosed as unstable angina or non-ST-segment elevation myocardial infarction, initial refusal of reperfusion

Table 2. Baseline characteristics of the patients.

Characteristic	Thrombolytic therapy group (N = 188)	Primary PCI group (N = 143)	*P* value
Age (years)	61.4 ± 12.7	63.0 ± 14.3	0.29
• Age ≥75	31 (16.5)	34 (23.8)	0.10
Female sex	32 (17)	25 (17.5)	0.91
Hypertension	72 (38.3)	59 (41.3)	0.56
Diabetes Mellitus	43 (22.9)	44 (30.8)	0.11
Hypercholesterolemia	77 (41.0)	47 (32.9)	0.13
Atrial Fibrillation	7 (3.7)	8 (5.6)	0.42
History of PCI or CABG	14 (7.4)	10 (7)	0.88
Severe chronic kidney disease[a]	4 (2.1)	4 (2.8)	0.69
Active or Ex-smoker	97 (51.6)	81 (56.6)	0.36
Previous Stroke	14 (7.4)	12 (8.4)	0.75
Poor left ventricular systolic function[b]	15 (8.0)	14 (9.8)	0.56
Culprit vessel			
• Left anterior descending artery	99 (55.9)	89 (62.2)	0.08
• Left circumflex artery	14 (7.9)	16 (11.2)	0.24
• Right coronary artery	69 (39.0)	49 (34.3)	0.65
Angiographic features			
• Single-vessel disease	83 (44.1)	72 (50.3)	0.26
• Two-vessel disease	63 (33.5)	46 (32.2)	0.80
• Triple-vessel disease	31 (16.5)	25 (17.5)	0.81
Chest pain onset (mean hours)	3.9 ± 3.3	4.7 ± 5.1	0.11
• Chest pain onset ≤3 hours	117 (62.2)	81 (56.6)	0.30

[a] Severe chronic kidney disease refers to absolute value of serum creatinine ≥200 μmol/L.
[b] History of or current presentation with poor left ventricular systolic function refers to left ventricular ejection fraction ≤35%.

therapy and in-patient new development of acute STEMI. In PPCI group, 21 patients were excluded from DTB time analysis due to similar mentioned reasons. Detail information regarding data exclusion is shown in Table 3.

Clinical outcomes

The clinical outcomes in thrombolytic therapy group and PPCI group were shown in Table 4, Figures. 1 and 2. 22 of 188 patients (11.7%) who received thrombolytic therapy died within 30 days after treatment, compared with 6 of 143 patients (4.2%, $P = .02$) receiving PPCI. Among the mortality cases in thrombolytic therapy group, 10 of 22 died of sudden cardiac arrest, of which 5 of them were diagnosed cardiac rupture before death. 3 of 22 died of progressive heart failure and/or cardiogenic shock with major organ dysfunction. 7 of 22 died of other major bleeding complications, of which 3 died of major intracranial hemorrhage. The remaining 2 of 22 died of non-cardiac causes. Among the 6 mortality cases in PPCI group, 1 patient presented with delayed STEMI with presence of left ventricular thrombus who developed major cardio-embolic stroke after PPCI. The patient received urgent thrombolytic therapy within therapeutic window of index major stroke but it was complicated by massive intracranial hemorrhage resulting in death. This patient was excluded from analysis of major bleeding due to mixed contributions of thrombolysis and procedure. 2 patients died of progressive heart failure and/or cardiogenic shock with major organ dysfunction despite successful initial revascularization. 2 patients died of sudden cardiac arrest from cardiac rupture which was diagnosed during resuscitation. The remaining 1 patient died of frontal intracranial hemorrhage after PCI. Major bleeding complications occurred in 15 of 188 patients receiving thrombolytic therapy (8%), compared with 3 of 143 patients receiving PPCI (2.1%, $P = .02$). 59 patients had failed thrombolytic therapy. 11 patients died shortly after thrombolytic therapy before urgent rescue PCI could be performed. With regard to hospital length of stay, the median duration was 4 days (IQR 3−7 days) in PPCI group compared with 5 days (IQR 4−7 days) in thrombolytic therapy. Such difference was otherwise statistically insignificant ($P = .29$).

Table 3. Reason for data exclusion in DTN and DTB time analysis.

Reason	DTN time in thrombolytic therapy group (no. of patient)	DTB time in PPCI group (no. of patient)
Initial missed diagnosis	6	8
Hyperacute T wave	0	1
Anterior ST- elevation	2	2
Lateral ST-elevation	1	0
Inferior ST-elevation	1	2
Posterior ST-elevation	0	1
New LBBB	1	0
New RBBB	1	1
AVR ST-elevation	0	1
Evolving electrocardiographic evidence of STEMI	5	11
Initial refusal of reperfusion therapy	5	0
In-patient new development of STEMI	1	2

Subgroup analysis

The primary outcomes were further analyzed in two subgroups: patients who presented early (≤3 hours from symptoms onset) and elderly population (age ≥75) as shown in Table 5. In the subgroup of early symptom presentation, 117 patients in thrombolytic therapy group and 81 patients in PPCI group were included in analysis. There was a trend towards lower risk of primary composite outcome (4.9% vs 9.4%, $P = .24$), 30-day mortality (4.9% vs 6.8%, $P = .58$) and major bleeding event (3.7% vs 6%, $P = .47$) in PPCI group as compared with thrombolytic therapy group, but the differences were not statistically significant. In the subgroup of elderly population, 31 patients in thrombolytic therapy group and 34 patients in PPCI group were included for analysis. Compared with thrombolytic therapy group, PPCI group had a significantly lower risk of primary composite outcome (17.6% vs 41.9%, $P = .03$) and major bleeding event (8.8% vs 29%, $P = .04$) with a trend towards a lower 30-day mortality (17.6% vs 38.7%, $P = .06$).

Factors associated with 30-day mortality and major bleeding event

Results of univariate and multivariate analysis of potential risk factors associated with primary outcomes were shown in Table 6. With regard to 30-day mortality, age ≥75 (OR: 1.10, 95% CI: 1.06−1.14) and left ventricular ejection fraction ≤35% (OR: 6.01, 95% CI: 2.04−18.07) were shown to be independent risk factors associated with outcome upon multivariate regression analysis. PPCI was also shown to reduce 30-day mortality by 4.3 fold (OR: 0.23, 95% CI 0.09−0.65) compared with thrombolytic therapy. With regard to major bleeding event, age ≥75 (OR: 1.10, 95% CI 1.04−1.14) was shown to be independent risk factor associated with outcome. PPCI was

Table 4. Clinical outcomes.

Outcome	Thrombolytic therapy group (N = 188)	PPCI group (N = 143)	P value
Primary outcome			
Composite outcome of 30-day mortality and major bleeding event	25 (13)	6 (4.2)	0.005
30-day mortality	22 (11.7)	6 (4.2)	0.02
Sudden cardiac death	10	2	
Progressive heart failure and/or cardiogenic shock	3	2	
Major intracranial hemorrhage	3	1	
Non-ICH bleeding complication	4		
Non-cardiac related cause	2		
Major bleeding event	15 (8.0)	3 (2.1)	0.02
Secondary outcome			
Thrombolytic failure	59 (31.4)		
Length of stay (median days)	5 (4–7)	4 (3–7)	0.29

also shown to reduce major bleeding event by 5.3 fold (OR 0.19, 95% CI 0.05–0.69) compared with thrombolytic therapy.

Discussion

In Hong Kong, majority of public hospitals are PCI-capable centers and PPCI services are available during office hours, this is in contrast to some of the medical systems in other countries where PCI service is not available in smaller centers but only in tertiary centers. The major limitation to PPCI service is the shortage of manpower where most centers in Hong Kong do not always have on-site cardiac fellow outside office hours and the on-call cardiac fellow and senior operator will have to be called back for PCI service once activated. In this retrospective observational study in the management of patients presenting with acute STEMI outside office hours, PPCI was associated with an overall reduction in primary composite outcome, 30-day mortality and major bleeding event. This finding is consistent with previous major trials comparing PPCI versus thrombolytic therapy in acute STEMI patients [1–6,9,10]. In our study, mortality rate in STEMI patients without cardiogenic shock or severe acute heart failure receiving PPCI was 4.9% and thrombolytic therapy was 11.7%, both of which were comparable to international data in major trials (1–8). When considering ethnic differences in bleeding risks, several studies suggested that Asians, as compared with African Americans and Whites, are more susceptible to bleeding events when treated with antiplatelets, anticoagulants and thrombolytic agents [11–15]. A higher rate of major bleeding complications was noted in our study in the thrombolytic group as compared with previous studies in other ethnicities. Such bleeding

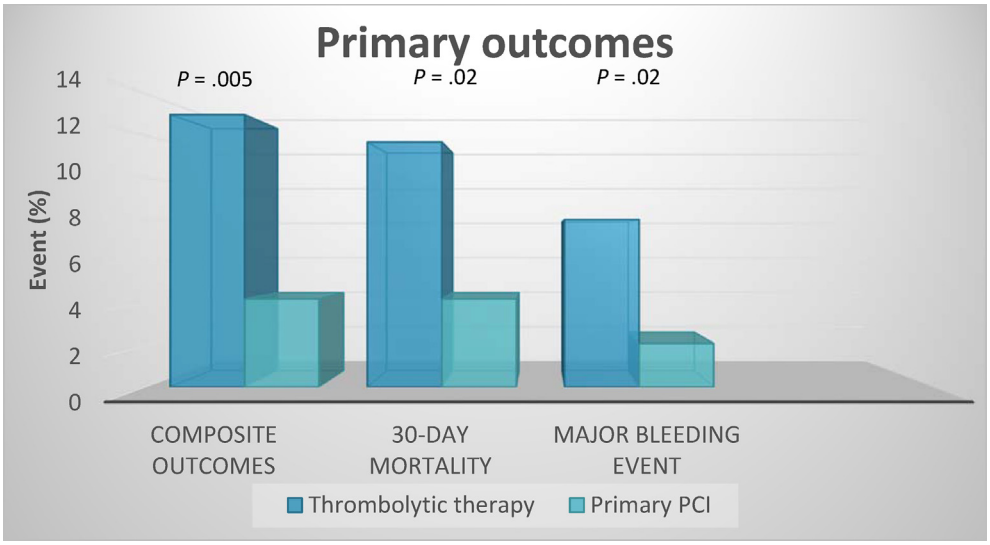


Figure. 1. Primary outcomes.

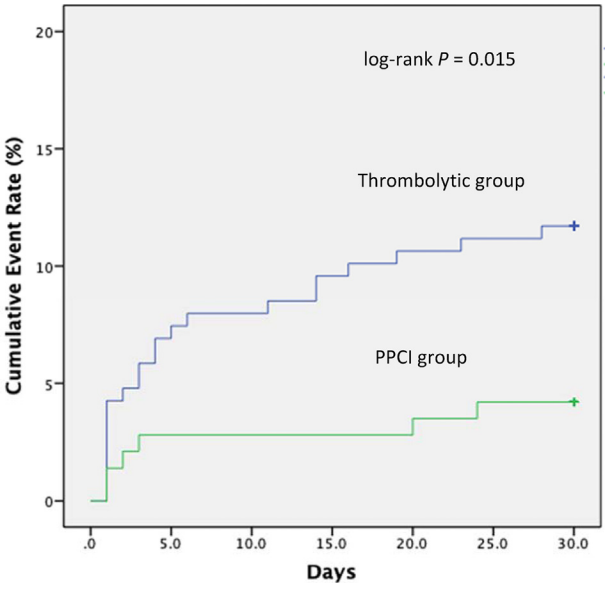


Figure. 2. 30-Day mortality.

complications are considered especially important in cases of STEMI-mimic such as acute pericarditis and myocardial infarction with non-obstructive coronary arteries (MINOCA). In these cases, a diagnostic coronary angiogram could have ruled out the diagnosis of STEMI and hence not exposed patients to potential major bleeding complications from thrombolytic use. In our PPCI registry during the same study period, 74 patients (out of a total of 420 PPCI service activations) had the diagnosis of STEMI excluded after coronary angiogram. In this regard, PPCI may be a more relevant option especially in our population given the significant mortality risk reduction and lower occurrence of major bleeding events.

One of the major challenges with thrombolytic therapy in acute STEMI setting is its limited efficacy of successful reperfusion, ranging from 57% to 66% in literature [16]. In our study, the success rate of thrombolytic therapy was 68.6%, which was comparable to international data. 11 patients died after thrombolytic therapy before rescue PCI could be performed, highlighting the risk of delaying reopening of occluded arteries in patients with failed thrombolytic therapy. Another 4 patients developed ventricular tachycardia or ventricular fibrillation despite thrombolytic therapy requiring immediate resuscitation. Among the 59 patients who had thrombolytic failure, 15 patients (25.4%) eventually succumbed within two weeks. Some literatures have shown a better reperfusion rate with thrombolytic therapy in patients who were treated early within 3 hours from symptom onset [17−19] and hence suggested that pharmacological reperfusion strategy may be an alternative or even superior option to PPCI in this group. However, our data in this subgroup showed a trend towards a lower mortality rate (4.9% vs 6.8%, $P = .58$) as well as major bleeding events (3.7% vs 6%, $P = .47$) in PPCI group, though the differences were statistically insignificant.

STEMI complicated with cardiogenic shock and severe acute heart failure represents a unique entity with extremely high mortality and morbidity. In the IABP-SHOCK II trial, patients with acute STEMI complicated by cardiogenic shock, despite the use of intra-aortic balloon pump, had a mortality rate as high as 66% [20]. A more contemporary registry, the RUTI-STEMI-SHOCK registry, still reported a mortality rate up to 50−60% [21]. Similarly, acute STEMI complicated by acute heart failure also represents another high risk subset. In a US national registry, NRMI-2, the overall in-hospital mortality in patients with acute heart failure complicating acute STEMI was up to 21.4% [22] and a differential outcome was seen in different Killip classes [23]. In Hong Kong, these two high risk subsets of acute STEMI patients would preferentially receive PPCI whenever possible, even before 24-h PPCI program.

Table 5. Subgroup analysis.

Subgroup/Outcome	Thrombolytic therapy group (n = 117)	PPCI group (n = 81)	P value
Early presentation (≤3hr from symptom onset)			
• Composite outcome of 30-day all-cause mortality and major bleeding	11 (9.4)	4 (4.9)	0.24
• 30-day all-cause mortality	8 (6.8)	4 (4.9)	0.58
• Major bleeding	7 (6)	3 (3.7)	0.47
Subgroup/Outcome	Thrombolytic therapy group (n = 31)	PPCI group (n = 34)	P value
Elderly population (Age ≥75)			
• Composite outcome of 30-day all-cause mortality and major bleeding	13 (41.9)	6 (17.6)	0.03
• 30-day all-cause mortality	12 (38.7)	6 (17.6)	0.06
• Major bleeding	9 (29)	3 (8.8)	0.04

Table 6. Multiple logistic regression analysis of variables associated with primary outcome.

	30-day mortality				Major bleeding event			
	Univariate analysis		Multivariate analysis		Univariate analysis		Multivariate analysis	
	OR (CI)	p value	OR (CI)	p value	OR (CI)	p value	OR (CI)	p value
Age ≥ 75 (years)	N/A	<0.001	1.10 (1.06–1.14)	<0.001	N/A	<0.001	1.10 (1.05–0.1.14)	<0.001
Female sex	0.23 (0.10–0.52)	<0.001	1.65 (0.62–4.45)	0.32	0.30 (0.11–0.81)	0.01	1.38 (0.45–4.31)	0.57
Poor LV systolic function	5.37 (2.12–13.6)	<0.001	6.01 (2.04–18.07)	0.001	2.21 (0.60–8.13)	0.22		
Time from symptom onset (hours)	N/A	0.84			N/A	0.36		
Multi-vessel disease	2.87 (1.18–6.94)	0.02	1.70 (0.64–4.49)	0.29	1.41 (0.53–3.73)	0.49		
Culprit vessel (LAD)	0.74 (0.34–1.61)	0.45			0.46 (0.18–1.23)	0.12		
PPCI	0.33 (0.13–0.84)	0.02	0.23 (0.09–0.65)	0.005	0.25 (0.07–0.87)	0.02	0.19 (0.05–0.69)	0.01

These patients were thus excluded from our study to enhance the comparativeness of both groups and minimize heterogeneity.

Elderly population represents another challenging subset in the context of acute STEMI and we also showed that age ≥75 was an independent risk factor associated with 30-day mortality and major bleeding event which was consistent with previous trials [8,24]. Given the higher prevalence of coronary artery disease, atypical presentations, complexity of coronary lesions such as calcified disease and greater ischemic burden, elderly population often has higher mortality rate in acute STEMI compared with younger population despite treatment [25]. Bleeding complications after antiplatelet, anticoagulant or thrombolytic therapies occur more often in elderly population [26] and greatly challenge clinical management, especially when hypovolemia, medication discontinuation and multiple blood transfusion ensue. All these in turn increase the risk of death, myocardial infarction and prolonged hospitalization. In our subgroup analysis of elderly population, PPCI group was shown to have statistically significant reduction in primary composite outcome and major bleeding events as compared with thrombolytic therapy group. This added further to the existing evidence [27–33] that PPCI is the preferred reperfusion strategy in elderly population.

With regard to DTN time, the mean time in our study was 36.0 (±14.7) minutes (42.7% within 30 minutes, 71.9% within 40 minutes and 93% within 60 minutes). Prolonged DTN time was associated with a number of factors including initial triage to lower urgency category due to atypical presentations such as dizziness or syncope, suspicion of dissection requiring further imaging with computer tomography, waiting time for cardiac consultation for management of STEMI and blood pressure control before thrombolytic therapy. With regard to DTB time, we were able to achieve a mean time of 73.8 (±23.6) minutes, which was consistent with international standard. Factors associated with prolonged DTB time largely resembled that of prolonged DTN time and it highlighted the areas for improvement such as modification of triage system, improvement in diagnostic confidence in cases with low clinical likelihood of aortic dissection and not to mention the current trend of pre-hospital diagnosis of STEMI with ambulance ECG to reduce system delay. As aforementioned in Table 4, 17 and 21 patients were excluded from DTN and DTB time analysis respectively for a number of reasons including initial missed diagnosis, evolving ECG evidence of STEMI, initial refusal to treatment and in-patient new development of STEMI. This underlay the essential skills in interpretation of ECG especially some "atypical yet important" findings such as new onset right bundle branch block, ST-elevation in aVR lead with specific repolarization pattern and isolated posterior ST-elevation. On the other hand, serial ECG monitoring in cases of unstable angina or non-ST elevation myocardial infarction was also crucial in picking up early evolution to STEMI for timely reperfusion, and hence achieving better outcome in these patients.

Limitations

Our study has a limited sample size from single center using our first year data but the results were meaningful in the context of pilot phase of this territory-wide phased expansion 24-h PPCI program. Secondly, the inherent risks of selection bias, information bias and recall bias were present as with any retrospective non-randomized studies. Thirdly, patients with cardiogenic shock and severe acute heart failure complicating STEMI were excluded in our study and hence conclusion from this study may not be extrapolated to these subsets of patients.

Conclusion

Compared with historical thrombolytic therapy, PPCI in patients presenting with acute STEMI outside office hours was associated with a significant reduction in 30-day mortality and major bleeding event. Age ≥75 was an independent risk factor associated with mortality and bleeding outcome.

Ethics approval

The study obtained ethics approval (REC KC/KE; Document No: KCKE SOP001F9 b) and that the requirement for informed consent was waived by the ethics committee.

Acknowledgement

None.

Funding information

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

All authors have disclosed no conflicts of interest.

References

[1] Global Use of Strategies to Open Occluded Coronary Arteries in Acute Coronary Syndromes Angioplasty Substudy, I. A clinical trial comparing primary coronary angioplasty with tissue plasminogen activator for acute myocardial infarction. N Engl J Med 1997;336(23):1621−8.

[2] Grines CL, Browne KF, Marco J, Rothbaum D, Stone GW, O'Keefe J, et al. A comparison of immediate angioplasty with thrombolytic therapy for acute myocardial infarction. The Primary Angioplasty in Myocardial Infarction Study Group. N Engl J Med 1993;328(10):673−9.

[3] Andersen HR, Nielsen TT, Vesterlund T, Grande P, Abildgaard U, Thayssen P, et al. DANAMI-2 Investigators. Danish multicenter randomized study on fibrinolytic therapy versus acute coronary angioplasty in acute myocardial infarction: rationale and design of the DANish trial in Acute Myocardial Infarction-2 (DANAMI-2). Am Heart J 2003 Aug; 146(2):234−41.

[4] Aversano T, Aversano LT, Passamani E, Knatterud GL, Terrin ML, Williams DO, et al. Atlantic Cardiovascular Patient Outcomes Research Team (C-PORT). Thrombolytic therapy vs primary percutaneous coronary intervention for myocardial infarction in patients presenting to hospitals without on-site cardiac surgery: a randomized controlled trial. JAMA 2002 Apr 17;287(15):1943−51.

[5] Di Mario C, Dudek D, Piscione F, Mielecki W, Savonitto S, Murena E, et al. CARESS-in-AMI (Combined Abciximab REteplase Stent Study in Acute Myocardial Infarction) Investigators. Immediate angioplasty versus standard therapy with rescue angioplasty after thrombolysis in the Combined Abciximab REteplase Stent Study in Acute Myocardial Infarction (CARESS-in-AMI): an open, prospective, randomised, multicentre trial. Lancet 2008 Feb 16;371(9612): 559−68.

[6] Huynh T, Perron S, O'Loughlin J, Joseph L, Labrecque M, Tu JV, et al. Comparison of primary percutaneous coronary intervention and fibrinolytic therapy in ST-segment-elevation myocardial infarction: bayesian hierarchical meta-analyses of randomized controlled trials and observational studies. Circulation 2009;119(24):3101−9.

[7] Rollando D, Puggioni E, Robotti S, De Lisi A, Ferrari Bravo M, Vardanega A, et al. Symptom onset-to-balloon time and mortality in the first seven years after STEMI treated with primary percutaneous coronary intervention. Heart 2012;98(23):1738−42.

[8] Gharacholou SM, Lopes RD, Alexander KP, Mehta RH, Stebbins AL, Pieper KS, et al. Age and outcomes in ST-segment elevation myocardial infarction treated with primary percutaneous coronary intervention: findings from the APEX-AMI trial. Arch Intern Med 2011;171(6):559−67.

[9] Doost Hosseiny A, Moloi S, Chandrasekhar J, Farshid A. Mortality pattern and cause of death in a long-term follow-up of patients with STEMI treated with primary PCI. Open Heart 2016;3(1):e000405.

[10] Grines CL, Westerhausen Jr DR, Grines LL, Hanlon JT, Logemann TL, Niemela M, et al. Air PAMI Study Group. A randomized trial of transfer for primary angioplasty versus on-site thrombolysis in patients with high-risk myocardial infarction: the Air Primary Angioplasty in Myocardial Infarction study. J Am Coll Cardiol 2002 Jun 5;39(11):1713−9.

[11] Mehta RH, Cox M, Smith EE, Xian Y, Bhatt DL, Fonarow GC, et al. Get With The Guidelines-Stroke Program. Race/Ethnic differences in the risk of hemorrhagic complications among patients with ischemic stroke receiving thrombolytic therapy. Stroke 2014 Aug;45(8):2263−9.

[12] Saunders E, Ofili E. Epidemiology of atherothrombotic disease and the effectiveness and risks of antiplatelet therapy: race and ethnicity considerations. Cardiol Rev 2008;16(2):82−8.

[13] Wang TY, Chen AY, Roe MT, Alexander KP, Newby LK, Smith Jr SC, et al. Comparison of baseline characteristics, treatment patterns, and in-hospital outcomes of Asian versus non-Asian white Americans with non-ST-segment elevation acute coronary syndromes from the CRUSADE quality improvement initiative. Am J Cardiol 2007;100(3):391−6.

[14] Misumida N, Ogunbayo GO, Kim SM, Olorunfemi O, Elbadawi A, Charnigo RJ, et al. Higher risk of bleeding in Asians presenting with ST-segment elevation myocardial infarction: analysis of the national inpatient sample database. Angiology 2018;69(6):548−54.

[15] Mehta RH, Stebbins A, Lopes RD, Rao SV, Bates ER, Pieper KS, et al. Race, bleeding, and outcomes in STEMI patients treated with fibrinolytic therapy. Am J Med 2011; 124(1):48−57.

[16] Boersma E, Steyerberg EW, Van der Vlugt MJ, Simoons ML. Reperfusion therapy for acute myocardial infarction. Which strategy for which patient? Drugs 1998;56(1):31−48.

[17] Boersma E, Maas AC, Deckers JW, Simoons ML. Early thrombolytic treatment in acute myocardial infarction: reappraisal of the golden hour. Lancet 1996;348(9030):771−5.

[18] Gersh BJ, Stone GW, White HD, Holmes Jr DR. Pharmacological facilitation of primary percutaneous coronary intervention for acute myocardial infarction: is the slope of the curve the shape of the future? JAMA 2005;293(8):979−86.

[19] Steg PG, Bonnefoy E, Chabaud S, Lapostolle F, Dubien PY, Cristofini P, et al. Comparison of Angioplasty and Prehospital Thrombolysis In acute Myocardial infarction (CAPTIM) Investigators. Impact of time to treatment on mortality after prehospital fibrinolysis or primary angioplasty: data from the CAPTIM randomized clinical trial. Circulation 2003 Dec 9;108(23):2851−6.

[20] Thiele H, Zeymer U, Thelemann N, Neumann FJ, Hausleiter J, Abdel-Wahab M, et al. Intraaortic balloon pump in cardiogenic shock complicating acute myocardial infarction: long-term 6-year outcome of the randomized IABP-SHOCK II trial. Circulation 2019 Jan 15;139(3):395−403.

[21] García-García C, Oliveras T, El Ouaddi N, Rueda F, Serra J, Labata C, et al. Short- and long-term mortality trends in STEMI-cardiogenic shock over three decades (1989-2018): the ruti-STEMI-shock registry. J Clin Med 2020;9(8).
[22] Wu AH, Parsons L, Every NR, Bates ER. Second National Registry of Myocardial Infarction. Hospital outcomes in patients presenting with congestive heart failure complicating acute myocardial infarction: a report from the Second National Registry of Myocardial Infarction (NRMI-2). J Am Coll Cardiol 2002 Oct 16;40(8):1389−94.
[23] Miller WL, Wright RS, Grill JP, Kopecky SL. Improved survival after acute myocardial infarction in patients with advanced Killip class. Clin Cardiol 2000;23(10):751−8.
[24] Fach A, Bünger S, Zabrocki R, Schmucker J, Conradi P, Garstka D, et al. Comparison of outcomes of patients with ST-segment elevation myocardial infarction treated by primary percutaneous coronary intervention analyzed by age groups (<75, 75 to 85, and >85 Years); (results from the Bremen STEMI registry). Am J Cardiol 2015;116(12): 1802−9.
[25] Shanmugam VB, Harper R, Meredith I, Malaiapan Y, Psaltis PJ. An overview of PCI in the very elderly. J Geriatr Cardiol 2015;12(2):174−84.
[26] Moscucci M, Fox KA, Cannon CP, Klein W, López-Sendón J, Montalescot G, et al. Predictors of major bleeding in acute coronary syndromes: the global registry of acute coronary events (GRACE). Eur Heart J 2003;24(20):1815−23.
[27] Mehta RH, Granger CB, Alexander KP, Bossone E, White HD, Sketch Jr MH. Reperfusion strategies for acute myocardial infarction in the elderly: benefits and risks. J Am Coll Cardiol 2005;45(4):471−8.
[28] Toleva O, Ibrahim Q, Brass N, Sookram S, Welsh R. Treatment choices in elderly patients with ST: elevation myocardial infarction-insights from the Vital Heart Response registry. Open Heart 2015;2(1):e000235.
[29] Peiyuan H, Jingang Y, Haiyan X, Xiaojin G, Ying X, Yuan W, et al. CAMI Registry study group. The Comparison of the Outcomes between Primary PCI, Fibrinolysis, and No Reperfusion in Patients $\geq$ 75 Years Old with ST-Segment Elevation Myocardial Infarction: Results from the Chinese Acute Myocardial Infarction (CAMI) Registry. PLoS One 2016 Nov 3;11(11):e0165672.
[30] Lattuca B, Kerneis M, Zeitouni M, Cayla G, Guedeney P, Collet JP, et al. Elderly patients with ST-segment elevation myocardial infarction: a patient-centered approach. Drugs Aging 2019;36(6):531−9.
[31] Fernández-Bergés D, Degano IR, Gonzalez Fernandez R, Subirana I, Vila J, Jiménez-Navarro M, et al. ATHOS investigators. Benefit of primary percutaneous coronary interventions in the elderly with ST segment elevation myocardial infarction. Open Heart 2020 Aug;7(2):e001169.
[32] Bueno H, Betriu A, Heras M, Alonso JJ, Cequier A, García EJ, et al. TRIANA Investigators. Primary angioplasty vs. fibrinolysis in very old patients with acute myocardial infarction: TRIANA (TRatamiento del Infarto Agudo de miocardio eN Ancianos) randomized trial and pooled analysis with previous studies. Eur Heart J 2011;32(1):51e60.
[32] Bueno H, Betriu A, Heras M, Alonso JJ, Cequier A, García EJ, et al. TRIANA Investigators. Primary angioplasty vs. fibrinolysis in very old patients with acute myocardial infarction: TRIANA (TRatamiento del Infarto Agudo de miocardio eN Ancianos) randomized trial and pooled analysis with previous studies. Eur Heart J 2011;32(1):51−60.
[33] de Boer SP, Barnes EH, Westerhout CM, Simes RJ, Granger CB, Kastrati A, et al. High-risk patients with ST-elevation myocardial infarction derive greatest absolute benefit from primary percutaneous coronary intervention: results from the Primary Coronary Angioplasty Trialist versus thrombolysis (PCAT)-2 collaboration. Am Heart J 2011;161(3):500−507 e1.