Original Article

Door-to-device time and mortality in patients with ST-elevation myocardial infarction treated with primary percutaneous coronary intervention: insight from real world data of Thai PCI Registry

Kitcha Champasri[1]^, Suphot Srimahachota[2]^, Mann Chandavimol[3]^, Wasan Udayachalerm[4]^, Ammarin Thakkinstian[5]^, Bancha Sookananchai[6]^, Wannakorn Phatharajaree[7]^, Songsak Kiatchoosakun[8]^, Nakarin Sansanayudh[9]^

[1]Department of Medicine, Phramongkutklao Hospital, Bangkok, Thailand; [2]Cardiac Center, King Chulalongkorn Memorial Hospital, Bangkok, Thailand; [3]Division of Cardiology, Department of Medicine, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand; [4]Cardiac Center, King Chulalongkorn Memorial Hospital, Bangkok, Thailand; [5]Department of Clinical Epidemiology and Biostatistics, Faculty of Medicine Ramathibodi Hospital, Bangkok, Thailand; [6]Maharat Nakornratchasima Hospital, Nakornratchasima, Thailand; [7]Chiangmai Ram Hospital, Chiang Mai, Thailand; [8]Cardiology Unit, Department of Medicine, Khon Kaen University, Khon Kaen, Thailand; [9]Cardiology Unit, Department of Medicine, Phramongkutklao Hospital, Bangkok, Thailand

Contributions: (I) Conception and design: K Champasri, N Sansanayudh; (II) Administrative support: N Sansanayudh, A Thakkinstian; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: K Champasri, A Thakkinstian, N Sansanayudh; (V) Data analysis and interpretation: A Thakkinstian; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Nakarin Sansanayudh, MD, PhD. Cardiology Unit, Department of Medicine, Phramongkutklao Hospital, 315 Rajavithee Road, Ratchathewi District, Bangkok 10400, Thailand. Email: dr_nakarin@hotmail.com.

Background: Timely reperfusion therapy is recommended for patients with ST-segment elevation myocardial infarction (STEMI), and system delay <90 minutes and door-to-device (D2D) time <60 minutes are recommended by the 2017 ESC Guidelines for the management of STEMI patients and have been proposed as a performance measure for triaging patients for primary percutaneous coronary intervention (PCI). However, previous research produced contradictory results regarding the association between D2D time and mortality. Therefore, this study aimed to examine the associations between D2D time and mortality in Thailand.

Methods: This cohort study included STEMI patients treated with primary PCI in 39 PCI centres in Thailand from February 27, 2018, to August 1, 2019. Patients were eligible if they met the following criteria: primary STEMI diagnosis, symptom onset within 12 hours, and ST-segment elevation of at least 0.1 mV in 2 or more contiguous leads (at least 0.2 mV in V1–V3) or a new left bundle branch block.

Results: Within 12 hours of symptom onset, 3,874 patients underwent primary PCI. The median D2D time was 54 minutes [interquartile range (IQR) 29–90], and there was a significant difference between patients transferred from other hospitals (44 minutes, IQR 25–77, n=2,871) and patients presented directly to PCI centres (81 minutes, IQR 56–129, n=1,003) (P<0.001). Overall, in-hospital mortality was 7.8%. In a multivariable analysis, adjusting for other predictors of mortality and stratifying according to intervals of D2D time, cumulative in-hospital mortality was significantly higher in patients with a D2D time greater than 90 minutes [hazard ratio (HR) 1.5, 95% confidence interval (CI): 1.0–2.1, P=0.046] but not associated with D2D time shorter than 60 minutes (HR 1.2, 95% CI: 0.8–1.8, P=0.319).

Conclusions: A D2D time greater than 90 minutes was related to in-hospital mortality in patients with

^ ORCID: Kitcha Champasri, 0000-0002-3382-5012; Suphot Srimahachota, 0000-0002-5181-961X; Mann Chandavimol, 0000-0001-8795-4103; Wasan Udayachalerm, 0000-0003-3249-9996; Ammarin Thakkinstian, 0000-0001-9991-386X; Bancha Sookananchai, 0000-0001-8266-9012; Wannakorn Phatharajaree, 0000-0002-5834-6712; Songsak Kiatchoosakun, 0000-0001-8943-382X; Nakarin Sansanayudh, 0000-0001-5668-7559.

STEMI treated with primary PCI, but a D2D time less than 60 minutes was not consistently associated with D2D time-improved survival in real-world, contemporary practice in Thailand.

Keywords: Percutaneous coronary intervention (PCI); ST-segment elevation myocardial infarction (STEMI); door-to-device time (D2D time); mortality; multi-centre registry

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Introduction

Background

Since the initial success of Andreas Gruentzig in 1977 (1), percutaneous coronary intervention (PCI) has been used for more than four decades, with better outcomes and fewer periprocedural adverse events (2). Delay in reperfusion therapy is the central issue in the management of ST-segment elevation myocardial infarction (STEMI), as the most significant benefit occurs within the first few hours of symptom onset. Therefore, the formulation of the optimal revascularization strategy, taking into account the social and cultural context, is of utmost importance (3,4).

Highlight box

Key findings

- Door-to-device (D2D) time greater than 90 minutes is associated with in-hospital mortality in ST-segment elevation myocardial infarction (STEMI) patients treated with primary percutaneous coronary intervention (PCI) in Thailand.

What is known and what is new?

- D2D time was improved over time, but previous data showed contradictory results regarding the association between D2D time and mortality, particularly in real-world settings in developing nations.
- A D2D time of less than 90 minutes was significantly associated with survival benefit; however, the survival benefit of shortening the D2D time was not consistently observed with a D2D time of less than 60 minutes in STEMI patients undergoing primary PCI in developing nations.

What is the implication, and what should change now?

- Every PCI center should have a system to monitor and reduce D2D time to less than 90 minutes in order to improve the outcomes of STEMI patients.

Rationale and knowledge gap

Door-to-Device (D2D) time, the time between the arrival of a STEMI patient at a hospital and the initiation of PCI (*Figure 1*) is a crucial indicator in the STEMI treatment system (5). Some reports indicated that a delay in the D2D time was the most significant predictor of clinical outcome (6-11), while in other studies D2D time did not affect the mortality rate (12-17). Meta-analysis revealed that longer D2D time was associated with higher mortality (18). However, approximately half of the studies included in this meta-analysis did not find D2D time to be associated with increased mortality, and there was heterogeneity among the included studies (I^2=45%). Therefore, additional information, particularly data from extensive cohort studies, is essential to represent real-world outcomes of contemporary practice in low- to middle-income countries such as Thailand.

Objective

Using the Thai PCI Registry, our objective was to determine the relationship between D2D time, system delay, treatment delay, patient delay, and in-hospital mortality in a real-world setting (19). We present this article in accordance with the STROBE reporting checklist (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-611/rc).

Methods

The Cardiac Intervention Association of Thailand (CIAT) developed the Thai PCI Registry (19), a prospective cohort, multicenter research. All Thai catheterization laboratories were asked to join in this national register. A well-designed case record form (CRF) was used to capture PCI-related

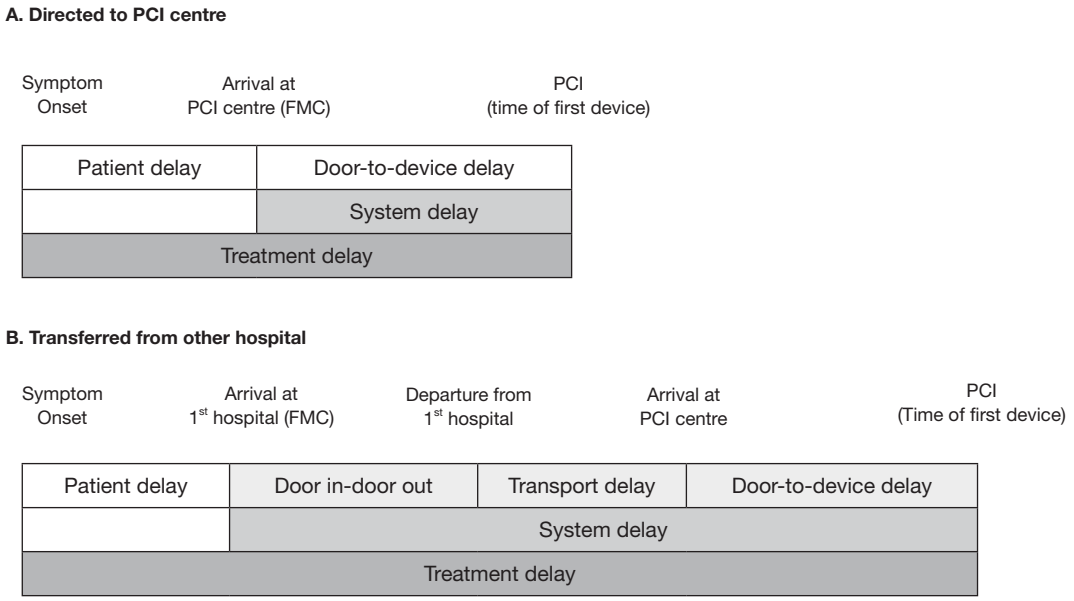

Figure 1 Delay from symptom onset to PCI in patients with ST-segment elevation myocardial infarction. PCI, percutaneous coronary intervention; FMC, first medical contact.

patient information, procedure data, equipment, and results. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The informed consent was taken from all the patients. The Central Research Ethics Committee (CREC) of Thailand approved the study (CREC No. CREC017/60BRm, certificate No. COA-CREC 002/2018). The project began on February 27, 2018 and ended on August 1, 2019. This study's data was gathered in January 2021, and there were no missing data.

Patient population

Patients were eligible if they met the following criteria: primary STEMI diagnosis, symptom onset within 12 hours, and ST-segment elevation of at least 0.1 mV in 2 or more contiguous leads (at least 0.2 mV in V1–V3) or a new left bundle branch block. In addition, patients were excluded if they had non-STEMI, stable coronary artery disease, and primary PCI was not performed within 48 hours.

Study factors

Four variables were of interest: D2D time, system delay, treatment delay, and patient delay. System delay was calculated by the time between first medical contact (FMC) and primary PCI (time of first device); treatment delay was defined as the time between symptom onset to reperfusion time; and 'patient delay' was calculated as the time between symptom onset and FMC (*Figure 1*).

Outcome measures

The primary outcome of the trial was in-hospital mortality. The patients were classified into two categories, patients who presented directly to PCI centres and those who were transferred from other hospitals. The classification is according to the patient's own choice, according to the patient's place of residence. At the start of the trial, characteristics and death rates were recorded throughout various periods.

Data management and quality control

The definitions of all variables used in this study were standardized and published in a handbook of definitions. The electronic databases were created with CRFs in mind. Catheterization lab personnel were instructed to enter data previously captured in CRFs onto computerized databases. To ensure data quality, data quality control programs were

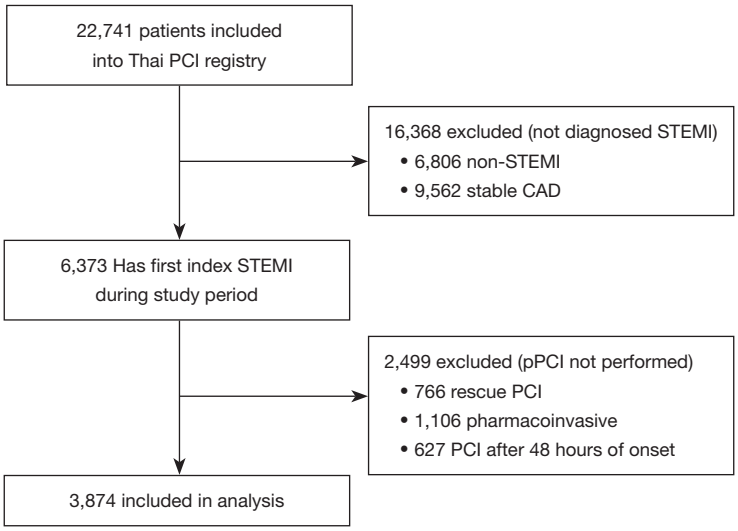

Figure 2 Flow of patients inclusion into the study. PCI, percutaneous coronary intervention; pPCI, primary PCI; STEMI, ST-segment elevation myocardial infarction; CAD, coronary artery disease.

created that included range values, must enter variables, skip, and cross-link between variables (19).

Statistical analysis

Numbers and means (standard deviation) or medians [interquartile range (IQR)] were used to depict dichotomous and continuous data, respectively. By subtracting the death date from the date of the PCI procedure, the time to death was estimated. Patients who were alive at the time of hospital release were censored from the research. The log-rank statistics were used to compare the odds of mortality by D2D time groups using a Kaplan-Meier curve.

We evaluated whether catheterization delays (i.e., D2D time, system delay, treatment delay, and patient delay) and other factors were linked with mortality using a simple Cox regression model. Variables having a P value of 0.1 were included simultaneously in a multivariate Cox regression model in this phase. Only variables with a likelihood ratio (LR) test P value of 0.05 were kept in the final model. The level of testing for the P is 0.05 and it was a two-sided test. The hazard ratio (HR) and 95% confidence interval (CI) were calculated. The proportional hazard assumption was tested using the Chi-square test and -log[-log(survival)] curves per group based on the Schoenfeld residuals. Stata Statistical Software Release 17 [2021] was used for all statistical analyses (StataCorp LLC, College Station, TX, USA).

Results

Of the 22,741 patients in the Thai PCI Registry (*Figure 2*), 6,373 patients presented with STEMI and 3,874 received primary PCI. Depending on the location of presentation, the baseline patient characteristics were stratified into two groups: transferred from other hospitals (n=2,871) and directed to PCI centres (n=1,003) (*Table 1*). Significantly more patients in the PCI centre group had a family history of premature coronary artery disease, hypertension, dyslipidemia, cerebrovascular disease, prior PCI, prior coronary artery bypass grafting (CABG), and cardiogenic shock prior to PCI than in the transferred group (*Table 1*).

System delay was significantly shorter in the group that presented directly to PCI centres than in the group that was transferred from other hospitals, with median times [interquartile ranges (IQRs)] of 94 (67 to 168) and 192 (132 to 301), respectively. In contrast, D2D time was significantly longer in the former than in the latter, with medians (IQRs) of 81 (56 to 129) and 44 (25 to 77), respectively (*Table 1*).

The most prevalent hospital-specified causes for delay from FMC to device (system delay) in the directed to PCI center group (n=1,003) were delayed diagnosis (42.8%), delay of in-hospital transfer (20.6%), and cardiac arrest and/or necessity for intubation (10.8%) (*Table 2*).

A simple Cox regression was used to examine the delay time, demographics, and clinical characteristics linked with in-hospital death (*Table 3*). D2D time and system delay were shown to be strongly linked with in-hospital mortality.

Table 1 Characteristics of patients with ST-segment elevation myocardial infarction and treated with primary percutaneous coronary intervention by mode of presentation

Variables	All patients (N=3,874)	Group A (N=2,871)	Group B (N=1,003)	P
Demographic and clinical characteristics				
Age, year	62.7±13.0	63.0±13.0	61.9±13.0	0.03
Female	1,013 (26.1)	745 (25.9)	268 (26.7)	0.63
Body mass index, kg/m^2	24.1±4.2	23.9±4.2	24.5±4.2	<0.001
Family history of premature CAD	212 (5.5)	140 (4.9)	72 (7.2)	0.01
Smoking status				
Current smoker	1,738 (44.9)	1,345 (46.8)	393 (39.2)	<0.001
Ex-smoker	723 (18.7)	526 (18.3)	197 (19.6)	
Never	1,413 (36.5)	1,000 (34.8)	413 (41.2)	
Cardiogenic shock prior to PCI	956 (24.7)	758 (26.4)	198 (19.7)	<0.001
Comorbid conditions				
Hypertension	1,988 (51.3)	1,431 (49.8)	557 (55.5)	0.002
Diabetes mellitus	1,765 (45.6)	1,288 (44.9)	477 (47.6)	0.14
Dyslipidemia	1,841 (47.5)	1,317 (45.9)	524 (52.2)	<0.001
Prior myocardial infarction	306 (7.9)	218 (7.6)	88 (8.8)	0.23
Prior PCI	196 (5.1)	133 (4.6)	63 (6.3)	0.04
Prior CABG	11 (0.3)	5 (0.2)	6 (0.6)	0.03
Prior heart failure	239 (6.2)	175 (6.1)	64 (6.4)	0.75
Chronic kidney disease	1,184 (30.6)	880 (30.7)	304 (30.3)	0.84
Cerebrovascular disease	197 (5.1)	134 (4.7)	63 (6.3)	0.05
Peripheral arterial disease	33 (0.9)	23 (0.8)	10 (1.0)	0.56
Time of delays, min[a]				
Door-to-device time	54.0 [29.0, 90.0]	44.0 [25.0, 77.0]	81.0 [56.0, 129.0]	<0.001
System delay	170.0 [105.0, 275.0]	192.0 [132.0, 301.0]	94.0 [67.0, 168.0]	<0.001
Patient delay	115 [45, 250]	110 [44, 240]	120 [54, 287]	0.014
Treatment delay	326 [209, 560]	345 [232, 591]	259 [155, 474]	<0.001

Data were presented as mean ± standard deviation, n (%), and median [interquartile range]. [a], system delay indicates time between FMC to primary PCI (time of first device); time from arrival at PCI centre to primary PCI; patient delay, time between symptom onset to FMC; treatment delay, time between symptom onset to primary PCI. Group A: transferred from another hospital; Group B: directed to a PCI centre. CAD, coronary artery disease; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; IQR, interquartile range; FMC, first medical contact.

Furthermore, age, sex, body mass index, smoking status, cardiogenic shock prior to PCI, heart failure, chronic kidney disease (CKD), and peripheral artery disease (PAD) were all substantially linked with in-hospital mortality. In a multivariate Cox regression model with time delay factors, these variables were considered concurrently.

A multivariate Cox regression demonstrated that only D2D time and system delay were substantially linked with in-hospital mortality after controlling for covariates (*Table 4*). The mortality probability curve showed a tendency of difference between D2D time >90 minutes versus 60 minutes and 30 minutes (*Figure 3*). D2D times

Table 2 Hospital-specified reasons for delay from first medical contact to device in directed to PCI centre group

Reasons[a]	Patients, No. (%)
Delay diagnosis	230 (42.8)
Delay of in-hospital transfer	111 (20.6)
Cardiac arrest and/or need for intubation before PCI	58 (10.8)
Patient delays in providing consent for the procedure	26 (4.8)
Difficulty crossing the culprit lesion during PCI	25 (4.6)
Difficult vascular access	23 (4.3)
Cath.Lab not available	21 (3.9)
Others	44 (8.2)

[a], the reason(s) of delay (can choose more than 1). PCI, percutaneous coronary intervention.

of 31–60 minutes, 61–90 minutes, and >90 minutes were related with a 1.1 (95% CI: 0.7–1.5), 1.2 (95% CI: 0.8–1.8), and 1.5 (95% CI: 1.0–2.1) times greater risk of mortality than D2D times of 30 minutes, respectively. Patients with 91–180 minutes system delays, 181–270 minutes system delays, and >270 minutes system delays were 1.5 (95% CI: 1.0–2.3), 1.7 (95% CI: 1.1–2.6), and 1.4 (95% CI: 0.9–2.2) times more likely to die than patients with fewer than 90 minutes system delays, respectively.

Discussion

Key findings

This study provides a current assessment of the relationships between time delay (i.e., D2D time and system delay) and

Table 3 Crude hazard ratios of covariates associated with in-hospital mortality in univariable Cox regression analysis

Characteristics	All (N=3,874)	Death (N=302)	Time at risk (days)	Incidence rate	HR (95% CI)	P
Demographic & clinical characteristics						
Age, year	62.7±13.0	70.1±13.1	–	–	1.04 (1.03, 1.05)	<0.001
Female	1,013 (26.1)	116 (38.4)	4,790	0.024	1.7 (1.3, 2.1)	<0.001
Body mass index, kg/m^2	24.1±4.17	23.3±4.1	–	–	0.96 (0.93, 0.99)	0.004
Family history of premature CAD	212 (5.5)	12 (4.0)	872	0.014	0.7 (0.4, 1.3)	0.28
Smoking status						
Current smoker	1,738 (44.9)	106 (35.1)	7,130	0.015	0.6 (0.5, 0.8)	<0.001
Ex-smoker	723 (18.7)	46 (15.2)	3,613	0.013	0.6 (0.4, 0.8)	0.001
Never	1,413 (36.5)	150 (49.7)	6,576	0.023	1	
Cardiogenic shock prior to PCI	956 (24.7)	220 (72.8)	5,263	0.042	7.0 (5.4, 9.0)	<0.001
Referred case	2,871 (74.1)	211 (69.9)	12,093	0.017	1.0 (0.8, 1.3)	0.85
Comorbid conditions						
Hypertension	1,988 (51.3)	172 (57.0)	9,616	0.018	1.1 (0.9, 1.4)	0.38
Diabetes mellitus	1,765 (45.6)	154 (51.0)	8,988	0.018	1.0 (0.8, 1.3)	0.75
Prior myocardial infarction	306 (7.9)	26 (8.6)	1,520	0.017	1.0 (0.7, 1.5)	0.89
Prior PCI	196 (5.1)	16 (5.3)	1,029	0.015	1.0 (0.6, 1.6)	0.86
Prior CABG	11 (0.3)	2 (0.7)	78	0.026	1.8 (0.5, 7.4)	0.39
Prior heart failure	239 (6.2)	47 (15.6)	1,465	0.032	2.2 (1.6, 3.0)	<0.001
Chronic kidney disease	1,184 (30.6)	202 (66.9)	6,492	0.031	3.8 (3.0, 4.8)	<0.001
Cerebrovascular disease	197 (5.1)	25 (8.3)	1,070	0.023	1.4 (1.0, 2.2)	0.08
Peripheral arterial disease	33 (0.9)	9 (3.0)	239	0.038	2.4 (1.2, 4.7)	0.01

Table 3 (*continued*)

Table 3 (*continued*)

Characteristics	All (N=3,874)	Death (N=302)	Time at risk (days)	Incidence rate	HR (95% CI)	P
Type of delay						
Door-to-device time, min						
>90	945 (24.4)	111 (36.8)	4,987	0.022	1.9 (1.3, 2.6)	<0.001
61–90	754 (19.5)	69 (22.8)	3,639	0.019	1.6 (1.1, 2.2)	0.02
31–60	1,113 (28.7)	72 (23.8)	5,063	0.014	1.2 (0.8, 1.7)	0.43
≤30	1,062 (27.4)	50 (16.6)	3,630	0.014	1	
Time of system delay, min						
>270	998 (25.8)	96 (31.8)	4,933	0.019	1.9 (1.3, 2.8)	0.001
181–270	804 (20.8)	72 (23.8)	3,699	0.019	1.9 (1.2, 2.8)	0.003
91–180	1,346 (34.7)	99 (32.8)	5,563	0.018	1.6 (1.1, 2.3)	0.02
≤90	726 (18.7)	35 (11.6)	3,124	0.011	1	

Data were presented as mean ± standard deviation and n (%), except otherwise specified. HR, hazard ratio; CI, confidence interval; CAD, coronary artery disease; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting.

Table 4 Multivariable Cox regression analysis of covariates associated with in-hospital mortality in patients with ST-elevation myocardial infarction treated with primary percutaneous intervention (N=3,874)

Covariates remaining significant	Considered door-to-devices time[a]		Considered system delay[b]	
	HR (95% CI)	P	HR (95% CI)	P
Door-to-device time, min				
>90	1.5 (1.0, 2.1)	0.05		
61–90	1.2 (0.8, 1.8)	0.32		
31–60	1.1 (0.7, 1.5)	0.78		
≤30	1			
Time of system delay, min				
>270			1.4 (0.9, 2.2)	0.09
181–270			1.7 (1.1, 2.6)	0.02
91–180			1.5 (1.0, 2.3)	0.04
≤90			1	
Demographics & clinical characteristics				
Age, year	1.02 (1.01, 1.03)	<0.001	1.02 (1.01, 1.03)	<0.001
Smoking status				
Current smoker	0.8 (0.6, 1.1)	0.20	0.8 (0.6, 1.1)	0.21
Ex-smoker	0.6 (0.4, 0.9)	0.01	0.6 (0.5, 0.9)	0.01
Never	1		1	
Referred case	1.0 (0.8, 1.4)	0.86	0.8 (0.6, 1.1)	0.15
Comorbid conditions				
Dyslipidemia	0.6 (0.5, 0.8)	<0.001	0.6 (0.5, 0.8)	<0.001
Chronic kidney disease	2.7 (2.1, 3.5)	<0.001	2.7 (2.1, 3.5)	<0.001
Prior heart failure	1.5 (1.1, 2.0)	0.02	1.5 (1.1, 2.1)	0.01

[a], time from arrival at PCI centre to primary PCI; [b], time between first medical contact to primary PCI (time of the first device). HR, hazard ratio; CI, confidence interval; PCI, percutaneous coronary intervention.

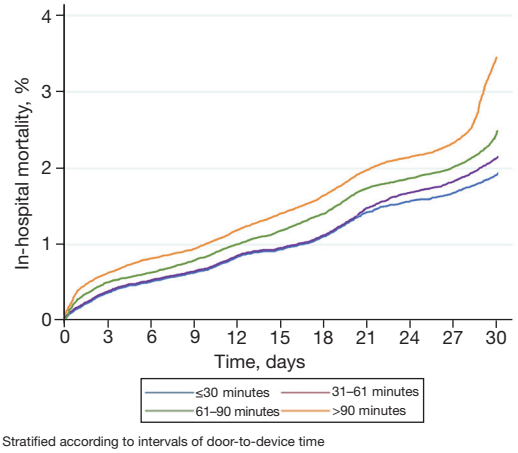

Figure 3 Probability of death by door-to-device time in STEMI patients treated with primary percutaneous coronary intervention (n=3,874). STEMI, ST-segment elevation myocardial infarction.

mortality in STEMI patients treated with primary PCI. Our findings indicate that a D2D time of more than 90 minutes is independently associated with in-hospital mortality, increasing the risk by roughly 50% when compared to a D2D time of less than or equal to 30 minutes. Furthermore, a system delay of more than 90 minutes was related with a 40% to 70% increase in risk.

Strengths and limitations

There were a few strengths in our study. First, this was data from a prospective, nationwide registry that could represent real-world practice in Thailand. Second, unlike nearly all previous publications conducted over a decade ago (7,8,10,12-14), this latest study confirmed and emphasized the importance of shorter D2D time in contemporary practice. Third, the sample size of our study was large and adequate for subgroup and multivariate analysis.

Certain limitations to our study should be noted. First, unmeasured factors might have influenced our findings because our research was based on observational data. We sought to reduce this impact using rigorous risk adjustment, but we cannot rule out the possibility of residual confounding by additional non-measured hospital characteristics related to D2D time or death in other non-measured individuals.

Comparison with similar researches

Previous studies on the relationship between D2D time and mortality revealed inconsistent results. Cannon *et al.* (7) and Rathore *et al.* (8), for example, found that any delay in primary PCI after a patient arrives at the hospital was related with an increase in in-hospital mortality among STEMI patients. Park *et al.* (9) also demonstrated that lowering D2D time was substantially linked with survival and that the survival effect of reducing D2D time was continuously detected, even when the duration was less than 60 to 90 minutes. Similarly, McNamara *et al.* (10) and Foo *et al.* (11) discovered that patients with a D2D time greater than 90 minutes died at a higher rate than those with a period less than 90 minutes.

On the other hand, De Luca *et al.* (12) discovered no link between D2D time and mortality in either low-risk or high-risk patients. Soon *et al.* (13) showed that after logistic regression, D2D time had no statistically significant influence on outcomes. Song *et al.* (14) looked at patients who reported within 12 hours of symptom onset and were treated with primary PCI from the Korea Acute Myocardial Infarction Registry (KAMIR). Mortality at one month did not rise substantially with increasing D2D time (4.3% for 90 minutes, 4.4% for >90 minutes; P=0.94).

The impact of D2D time, particularly those smaller than 60 minutes, on patient mortality after initial PCI for STEMI remains debatable. Tsukui *et al.* (15) observed that a lengthy D2D time (>2 h) was substantially linked with mortality from all causes despite correcting for variables such as Killip class 4, decreased renal function, and the number of diseased arteries. However, short D2D time (one hour) was not related with mortality from any cause in the multivariate Cox regression analysis. Consistent with our study, STEMI patients treated with primary PCI, D2D time longer than 90 minutes was related with in-hospital mortality, but D2D time less than 60 minutes was not consistently associated with survival benefit (HR 1.2, 95% CI: 0.8–1.8, P=0.319).

We discovered no link between death and patient delay or treatment delays (Tables S1 and S2, Figures S1 and S2). This finding might be explained by selection bias, which could be explained in part by the over-representation of cardiogenic shock in patients who present early (20,21). Moreover, recall bias is a substantial confounding factor, which is particularly important given that AMI may have

been preceded by hours of unstable angina, and patients must be able to recollect when the angina began. Finally, the difference between patient population, angioplasty techniques, ancillary medication and health care system, especially in STEMI network, may be other factors contributed to the inconsistency between the results of these studies. Baseline characteristics of participants with time of D2D time delay, system delay, patient delay and treatment delay are available in Tables S3-S6.

Explanations of findings

The main factors that can be improved by modifying the in-hospital process are D2D time and system delay. They are reliable parameters because they are not influenced by selection bias from early mortality in STEMI patients and recall bias (22,23).

Some studies discovered a link between system delay and death in STEMI patients receiving primary PCI (24-28). In the univariate study, we also discovered a link between system delay and mortality (Table S1), but after controlling for risk variables in the multivariate Cox regression analysis, the link was no longer statistically significant (*Table 4*, Figure S3).

Implications and actions needed

Improving the STEMI network in a developing country has resulted in better and faster care for STEMI patients, which has been linked to a reduction in in-hospital mortality (29-31). In the 2006 Thai national PCI registry, the median D2D time for STEMI patients was 122 minutes, and the overall mortality rate was 17.0% (29). Compared to our study, the median D2D time in STEMI patients was only 54 minutes, and the in-hospital mortality rate was 6.8% (30). In contrast, numerous studies in the United States showed that the median D2D time decreased annually (32,33), while in-hospital mortality remained unchanged (17,34-36).

Several studies have also found that the D2D time in transfer from other hospital groups is shorter than the directed to PCI centre group (37,38). Communication between the referring hospital and the PCI centre can activate the catheterization team and reduce the DTD time, allowing patients transferred from other hospital groups to receive early revascularization therapy. This finding may show the value of Thailand's well-established Hub and Spoke Referral System.

Our findings indicate that a D2D time of less than 90 minutes will reduce the mortality rate among STEMI patients undergoing primary PCI. Therefore, to improve the outcomes of STEMI patients, all PCI centres should have a system to monitor and improve D2D time to less than 90 minutes.

The Hub and Spoke Referral System in Thailand effectively reduces D2D time, so there is no need to rapidly expand the number of PCI centres in the near future.

Conclusions

A D2D time greater than 90 minutes was related to in-hospital mortality in patients with STEMI treated with primary PCI, but a D2D time less than 60 minutes was not consistently associated with D2D time-improved survival in real-world, contemporary practice in Thailand.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-611/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://cdt.amegroups.com/article/view/10.21037/cdt-22-611/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related

to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The informed consent was taken from all the patients. The Central Research Ethics Committee (CREC) of Thailand reviewed and approved the study (CREC No. CREC017/60BRm. Certificate No. COA-CREC 006/2018).

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