ORIGINAL ARTICLE

Primary percutaneous coronary intervention for ST elevation myocardial infarction: performance with focus on timeliness of treatment

CME

Gary SH Cheung 張誠謙
KL Tsui 徐健霖
CC Lau 劉楚釗
HL Chan 陳曉藍
CH Chau 周志康
KL Wu 胡國樑
CY Cheung 張志揚
MC Choi 蔡文俊
TS Tse 謝德新
KK Chan 陳國強
SK Li 李樹堅

Objective To review primary percutaneous coronary interventions performed for patients with ST elevation myocardial infarction with a focus on door-to-treatment time, especially after introduction of a new management programme in November 2003.

Design Retrospective study.

Setting Regional hospital, Hong Kong.

Patients All patients with ST elevation myocardial infarction who underwent primary percutaneous coronary intervention in our hospital from January 2002 to December 2007.

Results In all, 209 patients with ST elevation myocardial infarction had primary percutaneous coronary interventions between January 2002 and December 2007; 140 of them were admitted within office hours, 125 of whom came directly from Accident and Emergency Department. The mean door-to-balloon time of these patients was 115 minutes, and in 41% the time was less than 90 minutes (as recommended by the American College of Cardiology/American Heart Association guidelines). Since introduction of the new programme, the mean door-to-balloon time has diminished significantly, from 146 to 116 minutes (P=0.047). Delay in diagnosis (28%) and Cardiac Catheterization Laboratory being occupied (20%) were the two most common reasons for prolonged door-to-balloon times.

Conclusion We achieved satisfactory performance in our primary percutaneous coronary intervention programme, providing timely reperfusion therapy for patients with ST elevation myocardial infarction. A well-organised and systematic clinical pathway is a prerequisite for a centre that provides a timely and effective primary percutaneous coronary intervention service for patients with ST elevation myocardial infarction. Better public education and greater awareness on the part of medical service providers are needed, so as to facilitate urgent revascularisation and improve outcomes in patients with ST elevation myocardial infarction.

Key words
Angioplasty, transluminal, percutaneous coronary; Myocardial infarction; Myocardial reperfusion; Thrombolytic therapy; Time factors

Hong Kong Med J 2010;16:347-53

Pamela Youde Nethersole Eastern Hospital, 3 Lok Man Road, Chai Wan, Hong Kong:
Department of Medicine
GSH Cheung, MB, BS, MRCP
KL Tsui, FRCP (Edin), FHKAM (Medicine)
HL Chan, MB, ChB, MRCP
CH Chau, MB, ChB, MRCP
KL Wu, MB, BS, MRCP
CY Cheung, MRCP, FHKAM (Medicine)
MC Choi, MRCP, FHKAM (Medicine)
TS Tse, MRCP, FHKAM (Medicine)
KK Chan, FRCP (Edin), FHKAM (Medicine)
SK Li, FRCP (Edin, Lond, Glasg), FHKAM (Medicine)
Department of Emergency Medicine
CC Lau, MRCP, FHKAM (Emergency Medicine)

Correspondence to: Dr GSH Cheung
Email: garycsh@hotmail.com

Introduction

In patients with acute ST elevation myocardial infarction (STEMI) or a myocardial infarction (MI) with a new or presumably new left bundle branch block (LBBB) or a true acute posterior MI, early reperfusion with primary percutaneous coronary intervention (PCI) or thrombolytic therapy improves outcomes.[1]

Although it usually takes a longer time to perform primary PCI than to give thrombolytic therapy, primary PCI is regarded as the therapy of choice, if performed in a timely manner. Normalisation of blood flow in coronary vessels, as assessed by the Thrombolysis In Myocardial Infarction flow grade, occurs in 93 to 96% of STEMI patients who undergo primary PCI, in contrast to 50 to 60% following thrombolytic therapy.[2,3] Moreover, primary PCI was shown to be superior to thrombolytic therapy in reducing the rates of death, reinfarction, recurrent ischaemia, reocclusion of the same artery, and stroke.[1]

On the other hand, reperfusion therapy was found to be underutilised and often

以直接經皮冠狀動脈介入治療ST段抬高型心肌梗塞：集中探討治療及時性的表現

目的 集中探討自2003年11月引入新處理程序後，以直接經皮冠狀動脈介入治療ST段抬高型心肌梗塞的入院至開始治療時間。

設計 回顧研究。

安排 香港一所分區醫院。

患者 2002年1月至2007年12月期間，所有於本院出現ST段抬高型心肌梗塞而接受直接經皮冠狀動脈介入治療的病人。

結果 研究期間共209名病人出現ST段抬高型心肌梗塞，須接受直接經皮冠狀動脈介入治療；當中140名於辦公時間內入院的病人，有125名經急症室轉介。病人從入院至血管被氣球打通的平均時間為115分鐘，其中41%患者可根據美國心臟專科學院和美國心臟協會指引的90分鐘內完成。自從引入新處理程序後，病人從入院至血管被氣球打通的平均時間顯著大減，由146分鐘縮短至116分鐘（P=0.047），而延遲診斷（28%）及心導管檢查室供不應求（20%）是導致延長入院至手術完成時間的兩大主因。

結論 本院對於出現ST段抬高型心肌梗塞的病人能及時提供再灌流治療，證明引入的直接經皮冠狀動脈介入治療的新處理程序有令人滿意的結果。要為病人提供及時和有效的介入治療，具良好組織及有系統的臨床路徑不可或缺。此外，必須加強市民教育以提高他們對醫療服務方面的意識，從而加快進行血管重建術的時間及改善ST段抬高型心肌梗塞病人的治療結果。

not administered soon after presentation.[4] Moreover, in patients treated with primary PCI, only about 40% achieved door-to-balloon times (DTBTs) within 90 minutes,[5] as recommended by the American College of Cardiology/American Heart Association guidelines.[6]

In Hong Kong, thrombolytic therapy has long been the territory-wide mainstay of treatment for STEMI. According to a multicentre registry of acute MI patients in Hong Kong from 1995 to 1996,[7] thrombolytic therapies were administered in 49% of affected patients, while only 4% were treated with PCI. Local data were lacking regarding the utilisation and performance of primary PCI in current clinical practice. In our hospital, a new primary PCI programme for STEMI patients presenting in office hours was implemented in 2003. In that context, the proportion of patients presenting in office hours who received primary PCI as their reperfusion therapy increased from 25% in 2002 to 95% in 2006. The corresponding figures for all patients (presenting in office and non-office hours) were 23% increasing to 69%. Comparing patient cohorts who received primary PCI as a routine reperfusion strategy with those receiving thrombolytic therapy over the period from January 2002 to July 2007, a statistically significant reduction in in-hospital mortality was demonstrated (11% vs 19%, P=0.04).[8] The aim of the current study was to report on the performance of primary PCI in our hospital, focusing on factors that affected achievement of timely reperfusion as reflected by DTBT, so as to provide targets for improvement.

Methods

Since November 2003, the Department of Medicine in our hospital collaborated with the Accident and Emergency Department (AED) to implement a primary PCI programme. Accordingly, patients attending the AED during office hours with symptoms suggestive of acute coronary syndrome had a 12-lead electrocardiogram (ECG) after initial assessment at the triage station. For patients with features of STEMI, the AED physician contacted the Cardiac Catheterization Laboratory (CCL) for the feasibility of primary PCI. A Cardiac Care Unit (CCU) medical officer would immediately assess the patient in the AED, and if appropriate obtain informed consent of PCI, and escort the patient to the CCL for the procedure. Attendance at the AED during office hours was defined as arrival at any time between 8:30 am to 5:00 pm except on Saturdays, Sundays, and public holidays. Patients presenting in non-office hours received thrombolysis as first-line therapy, but primary PCI was performed if thrombolysis was contra-indicated or for any other compelling reason.

From January 2002 to December 2007, all patients admitted to the CCU of our hospital with a diagnosis of STEMI or an MI with a new or presumed new LBBB or a true acute posterior MI, and who underwent urgent cardiac catheterization with a view to primary PCI were included in our study.

Patients were not included for analysis as part of this study if they had rescue PCI or early PCI during the index admission instead of primary PCI, their hospital records (eg AED admission sheet, or CCL record sheet) were missing, and if their symptom onset time, arrival time in the AED or CCL were missing or invalid.

The DTBT and door-to-door time (DTDT) were defined as the difference between the AED arrival time and the time of the first balloon inflation, and between the AED arrival time and the CCL on-table time, respectively. The DTDT was recorded, as in some patients no balloon inflation might be carried out. Moreover, any delays specifically between the AED and CCL (eg in obtaining an ECG, in contacting related to the medical team, or in transportation of the patients to CCL) were identified by comparing the difference between DTDT and DTBT. By this means it was feasible to address possible causes of

delay between the AED and CCL versus delays in the CCL.

In some situations, STEMI occurred among in-patients. As they had no relevant AED arrival time, the earliest time that medical staff were notified was considered equivalent to the AED arrival time. Accordingly, in these patients the notification-to-balloon time and notification-to-door time were counted as the DTBT and DTDT, respectively.

For patients receiving primary PCI with a DTBT exceeding the recommended 90 minutes, the causes of delay were assessed. The indications for those receiving primary PCI but in non-office hours were also reviewed.

Clinical outcomes (including in-hospital recurrent MI, unplanned repeated interventions, stroke, bleeding, and death) were recorded. The duration of hospitalisation in both acute and convalescent hospitals, recurrent MIs, repeated coronary interventions and death within 6 months post–primary PCI were also recorded.

Statistical analyses

All the data were entered into a specially designed data information sheet. Descriptive statistics were used for the demographic characteristics of the patients. Results were presented as means, medians, ranges and standard deviations, as appropriate. Differences in categorical and continuous data were assessed using the Chi squared test and Student's *t* test, respectively. A P value of less than 0.05 was considered significant.

Results

From 1 January 2002 to 31 December 2007, 213 patients with STEMI were treated with primary PCI. Four were excluded from the study owing to missing records. In the remaining 209 patients, 140 (67%) had primary PCIs within office hours. Among the latter, 125 (89%) were new patients presenting via the AED, and 15 were already in-patients (Fig 1).

Patient characteristics

The baseline demographic, haemodynamic, and clinical features of the patients are shown in Table 1. The majority were in Killip class 1, while 9% and 25% respectively also had heart failure and cardiogenic shock on presentation.

Regarding the 125 patients having primary PCI after presenting to the AED within office hours, the mean time between symptom onset and AED attendance was 7 hours 22 minutes (range, 24 minutes to 72 hours). In all, 32 (26%) of these patients attended more than 12 hours after onset of symptoms.

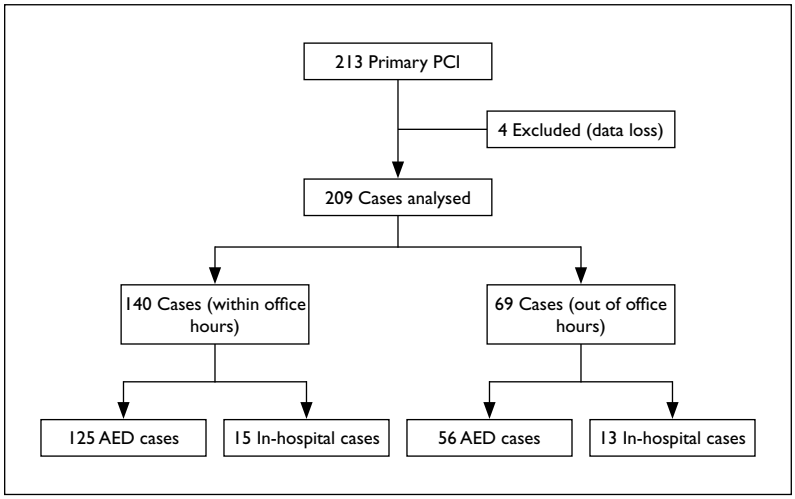

FIG 1. Flowchart
PCI denotes percutaneous coronary intervention, and AED accident and emergency department

TABLE 1. The baseline demographic, haemodynamic, and clinical characteristics of the study population

Characteristic*	Within office hours	Outside office hours	Total
No. of patients	140	69	209
Mean (range) age (years)	65 (29-89)	67 (40-87)	66 (29-89)
Sex (male)	68%	70%	68%
Smoking history	29%	28%	29%
Diabetes mellitus	26%	17%	23%
Hypertension	51%	55%	53%
Hyperlipidaemia	6%	17%	10%
Stroke	11%	11%	11%
Previous MI	6%	15%	9%
Systolic BP (mm Hg)			
<90	14 (10%)	7 (10%)	21 (11%)
>180	6 (4%)	8 (12%)	14 (7%)
Pulse (beats/min)			
<50	17 (12%)	10 (14%)	27 (13%)
>100	21 (15%)	8 (12%)	29 (14%)
Killip class			
I	98 (70%)	39 (57%)	137 (66%)
II and III	11 (8%)	8 (12%)	19 (9%)
IV	31 (22%)	22 (32%)	53 (25%)
Received CPR	15 (11%)	13 (19%)	28 (13%)
Required intubation	18 (13%)	18 (26%)	36 (17%)
Infarct-related artery			
LM	1 (1%)	0 (0%)	1 (1%)
LAD	65 (46%)	35 (51%)	100 (48%)
LCx	25 (18%)	15 (22%)	40 (19%)
RCA	49 (35%)	19 (28%)	68 (33%)

* MI denotes myocardial infarction, BP blood pressure, CPR cardiopulmonary resuscitation, LM left main coronary artery, LAD left anterior descending coronary artery, LCx left circumflex coronary artery, and RCA right coronary artery

TABLE 2. The indications for primary percutaneous coronary intervention (PCI) outside office hours (n=69)

Indication	No. (%)
Haemodynamic/electrical instability	30 (44)
Contra-indication to thrombolytics	11 (16)
History of intracranial bleeding	2
Deranged clotting profile with concurrent usage of warfarin	2
Major surgery within the preceding 3 weeks	6
Recent history of gastro-intestinal bleeding	1
Delayed presentation with ongoing ischaemia	11 (16)
Refusing any reperfusion therapy initially	7
Having delayed diagnosis on admission	4
Availability of manpower for primary PCI	17 (25)
Early morning in weekdays, ie 7:00 am to 8:30 am	12
Saturday morning	5

TABLE 3. The mean door-to-balloon time (DTBT) and door-to-door time (DTDT) in different patient groups

	DTBT (min)	DTDT (min)
Within office hours (n=140)	120	87
AED cases (n=125)	115	83
Non-office hours (n=69)	195	153
All patients (n=209)	144	109

The indications for primary PCI in the 69 patients having the procedure outside office hours are shown in Table 2, most (44%) of whom were suffering from haemodynamic or electrical instability attributed to STEMI.

Procedure characteristics

The overall mean DTBT and DTDT in all 209 patients were 144 and 109 minutes, respectively (Table 3). For the 125 patients with primary PCI directly admitted from the AED within office hours, the DTBT was 115 minutes, in 51 (41%) of whom it was less than 90 minutes.

Regarding the remaining 74 patients not achieving their primary PCI within the recommended 90-minute DTBT, the causes of delay are shown in Table 4. In more than one quarter of the patients, it was due to a delay in diagnosis, 16 of whom had equivocal ECGs at presentation and in another five patients there was a delay in obtaining an ECG owing to atypical presenting symptoms. In one fifth of the instances, the delay was due to the CCL being occupied, and in another one fifth the delay was deemed unavoidable—due to treatment for life-threatening conditions (11%) and anatomical challenges during PCI (11%). In four instances, there was a delay in obtaining consent for the procedure from the patients. In 18 patients, there was no specific identifiable cause for the delay, but their mean DTBT was relatively shorter than that of others with identifiable causes of delay. Moreover, after excluding patients with identifiable causes of delay (items 1 to 5 in Table 4), the average DTBT of the remaining patients (ie the 51 having the procedure within 90 minutes and the 18 with unknown causes of delay) was just 85 minutes.

Since implementation of the collaborative programme in 2003, the number of patients receiving primary PCI has increased, being four in 2002 to about 30 to 40 annually between 2004 and 2007. Moreover, there was significant improvement in DTBT from 146 to 116 minutes (P=0.047) [Fig 2].

Ten (5%) of the patients who underwent angiography were not deemed candidates for PCI. There were no significant residual stenoses in eight of them, presumably due to spontaneous clot lysis. The other two patients underwent surgical revascularisation.

Clinical outcome

The overall mean length of hospital stay was 7 (range, 4-63) days. Among the 125 patients having primary PCI after presenting to the AED within office hours,

TABLE 4. Causes of delay in patients with door-to-balloon time (DTBT) of more than 90 minutes

Causes of delay in DTBT >90 min*	No. (%)	DTBT (min)
(1) Delayed diagnosis	21 (28)	192
Equivocal ECG on presentation	16	
Delay in obtaining ECG at admission	5	
(2) Occupied CCL (ie patient transferral to CCU first instead of CCL directly)	15 (20)	131
(3) Evaluation and treatment for life-threatening conditions (eg cardiac arrest or respiratory failure)	8 (11)	135
(4) Anatomical challenges that prolonged the procedure (eg issues of arterial, coronary, or lesion access)	8 (11)	127
(5) Delay in giving consent by patients (eg patients need more time to discuss with relatives)	4 (5)	130
(6) No specific identifiable cause	18 (24)	109

* ECG denotes electrocardiogram, CCL Cardiac Catheterization Laboratory, and CCU Cardiac Care Unit

the mean length of hospital stay was just 6 (range, 4-22) days. In all, 24 of them underwent rehabilitation in a convalescent hospital, where the mean length of stay was 17 (range, 4-120) days.

Ten of the patients had unscheduled repeat coronary angiography during their initial admission; five had experienced haemodynamic deterioration, one had an acute MI complicated by a ventricular septal defect, and four had recurrent ischaemia. In three of these 10 patients, the restudy revealed acute or subacute stent thrombosis, while the remaining seven showed no abnormality. Five (2%) patients suffered an ischaemic stroke, and six (3%) endured significant (mostly gastro-intestinal) bleeding.

After being discharged following their index admission, five (2%) of the patients suffered a recurrent MI within 6 months. Ten (5%) of the patients had unscheduled repeat coronary angiography; one of whom had a subacute stent thrombosis, three had in-stent restenosis, and the remaining six had mild coronary artery disease.

With respect to the 209 primary PCI patients whose records were available, there were 32 in-hospital deaths; the time of death ranged from 1 to 30 (mean, 9) days post-MI. The 6-month and 1-year mortalities were 19% and 20%, respectively.

Regarding the 125 patients having primary PCI after presenting to the AED in office hours, their in-hospital, 6-month, and 1-year death rates were 12%, 14%, and 15%, respectively. In this subgroup, the 1-year mortality rate was significantly higher in patients presenting to the AED more than 12 hours after onset of symptoms (28% vs 11%, P=0.019). Moreover, the higher the Killip class at presentation, the greater was the death rate; in patients with classes I, II/III, and IV, respective 6-month mortality rates were 6%, 9%, and 32%.

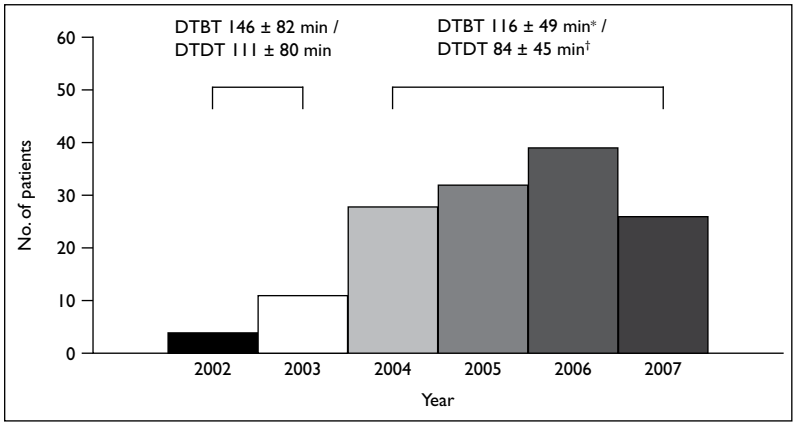

FIG 2. Primary percutaneous coronary intervention trends for patients presenting within office hours in 2002 to 2007 (n=140)

Data are shown as mean ± standard deviation. DTBT denotes door-to-balloon time, and DTDT door-to-door time

* P=0.047

† P=0.049

Discussion

This is the first report on the implementation and performance of primary PCI for STEMI in a regional hospital in Hong Kong. After its implementation in our hospital in November 2003, not only was the pattern of STEMI management transformed, the performance of primary PCI also improved.

The mean DTBT of patients having primary PCI via the AED presenting during office hours was 115 minutes, 41% being performed within 90 minutes. Although ideally every patient with a STEMI should undergo primary PCI as early as possible, this is very difficult to achieve in real-life environments worldwide. In a prospective multicentre registry study in Beijing involving 526 primary PCIs in 19 hospitals, the median DTBT for primary PCI was 132 minutes; only 22% were performed in less than 90 minutes.[9] In another prospective observational study in the United States with a cohort of 27 080 patients, 30 to 40% of all patients underwent primary PCI within 90 minutes, and 54% did so within 120 minutes.[10]

The component of delay in resuming coronary reperfusion that is directly under the control of the medical service providers (cardiologists, emergency physicians, nurses, and allied health staff) is the delay in initiation of reperfusion therapy after the patient arrived at the hospital. The time from hospital arrival to reperfusion (ie the DTBT) has been shown to be inversely associated with in-hospital mortality.[11] Therefore an aggressive attempt to minimise the time from entry into the medical system to implementation of a reperfusion is compelling, and should be pursued in a way analogous to the management of trauma patients.

Among patients having primary PCI directly after presentation to the AED within office hours, the DTBT exceeded 90 minutes in around 60%. Analysis of the causes of delay in these patients (Table 4) enables formulation of recommendations to reduce delays, improve performance, and facilitate better patient care. First, about one quarter of the delays were attributed to delay in making diagnosis (due to equivocal electrocardiographic features of STEMI or delay in obtaining ECG). These types of delays are possibly avoidable and may be reduced by repeating ECGs, improved interpretation with a high index of suspicion, expert input at an early stage, and closer monitoring. These goals may be facilitated by increasing the awareness among staff, re-training, and re-studying triage procedures. Second, due to limited availability of the CCL, about 20% of the patients were first transferred to the CCU instead of directly for PCI. This kind of delay is expected to decrease following opening of a second CCL at our

hospital in 2008. Delayed consent for the procedure occurred in four patients, which may be overcome by better health education including promotion of awareness and greater acceptance of primary PCI in the community.

Delays were unavoidable in STEMI patients with life-threatening complications (cardiac arrest and significant arrhythmias, cardiac failure, and cardiogenic shock) requiring immediate treatment. Similarly, difficulty in the arterial, coronary, or lesional access may also be regarded as unavoidable. Finally, delays in the remaining quarter of the patients were due to unidentified causes. In this subgroup, the mean DTBT (109 minutes) was close to the ideal limit of less than 90 minutes, and reflects the reality that it would be longer than 90 minutes in some patients, even every step of pathway from admission to balloon dilatation was apparently followed closely.

For primary PCI during non-office hours, in many studies the DTBT was found to be longer than that in office hours,[12] which was also noted in our series (195 vs 120 minutes; P<0.001). Moreover, a lower proportion of these patients attained DTBTs of less than 90 minutes (11% vs 41%; P<0.001). A possible reason could be the high proportion (44%) of patients who were haemodynamically unstable at presentation, which entailed more time before they were fit for PCI. Moreover, having no on-site cardiologists and CCL nursing staff during non-office hours impose an inevitable additional delay.

The introduction of the primary PCI programme in collaboration with the AED not only increased the number of procedures performed annually, but also facilitated the DTBTs; the mean time being 146 minutes before the programme and 116 minutes since its inception (P=0.047). It also facilitated a well-organised and systematic clinical pathway, which was a prerequisite to providing a timely and effective primary PCI service.

Our study showed that delayed presentation to the AED after symptom onset was associated with a higher 1-year mortality, being 28% in patients presenting more than 12 hours after symptom onset versus 11% in those presenting earlier. A significant correlation between time from symptom onset to balloon inflation and 1-year mortality was also reported in a study of 1791 from the Netherlands, this relationship being a continuum with a relative risk of death of 1.075 for every additional 30 minutes of delay till reperfusion.[13] Therefore, more public health education should be targeted at increasing public recognition of relevant acute MI symptoms and seek early assistance via hospital AEDs. By this means, delays between the onset of symptoms and treatment could be reduced.

Our study also demonstrated that a higher Killip class on presentation was associated with poorer outcomes; the 6-month mortality being 32% in class IV patients compared with 6% for those in class I. Such an association has also been shown in a previous study,[14] and in yet another study mortality was up to 53% in patients with cardiogenic shock.[15] In such patients at high risk of mortality, early revascularisation should be strongly considered, especially for those aged less than 75 years, as they may enjoy improved 6-month[16] and 1-year[15] survival rates in comparison to those treated medically at first to achieve stabilisation. Besides the above-mentioned suggestions for improving the DTBT within the current working environment, other recommendations have also emerged from elsewhere. A multivariate analysis of 365 hospitals identified strategies,[17] some of which may be applicable in our setting. Thus, a single call to a central page operator who activates the catheterization laboratory is one such potential application. Alternatively, the emergency medicine physician could activate the catheterization laboratory, so long as there was mutual understanding and confidence between the relevant parties.[18] Diagnosis via pre-hospital ECG and activation of the catheterization team, while the patient is en route is another strategy,[19] although it is not yet applicable in Hong Kong for logistic reasons. Ideally an attending cardiologist and CCL nursing team should always be on site, but due to limited resources and manpower this is difficult to achieve locally.

Primary PCI for hospitalised patients in contrast to direct transfer to the CCL via the AED during office hours was less than optimal, as the mean notification-to-balloon time (161 minutes) in the former was much longer than the average DTBT (115 minutes) of the latter. It is even postulated that patients with symptoms of MI developing in general medical or other wards may not be given due importance such that prompt diagnosis and activation for urgent revascularisation may be put off. More education on the concept of rapid revascularisation for STEMI patients is therefore needed for all health care providers, and not only for cardiac and AED team members.

This study had important limitations. First, it was retrospective, and hence important data may have been lost or only be inferred from available documentation. Second, the number of patients in the initial study period before implementation of PCI programme in collaboration with the AED was much smaller than the number in the subsequent period, resulting in limited validity for statistical comparisons of the two groups.

Conclusion

In our hospital the performance of primary PCI for STEMI appeared satisfactory and comparable to international experience. Room for improvement in

door-to-treatment time exists, and requires better collaboration between individuals from many different departments, and better education of the public and medical service providers, as well as more awareness of the need for urgent revascularisation. In future, regular review of the service should be undertaken to identify and improve weaknesses in the chain of events leading to primary PCI.

Acknowledgements

Special thanks are due to all nursing and supportive staff in the CCL and CCU of the Pamela Youde Nethersole Eastern Hospital for their dedicative work and support.

References

1. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. Lancet 2003;361:13-20.
2. Mehta RH, Harjai KJ, Cox D, et al. Clinical and angiographic correlates and outcomes of suboptimal coronary flow inpatients with acute myocardial infarction undergoing primary percutaneous coronary intervention. J Am Coll Cardiol 2003;42:1739-46.
3. Stone GW, Grines CL, Cox DA, et al. Comparison of angioplasty with stenting, with or without abciximab, in acute myocardial infarction. N Engl J Med 2002;346:957-66.
4. Eagle KA, Goodman SG, Avezum A, Budaj A, Sullivan CM, López-Sendón J; GRACE Investigators. Practice variation and missed opportunities for reperfusion in ST-segment-elevation myocardial infarction: findings from the Global Registry of Acute Coronary Events (GRACE). Lancet 2002;359:373-7.
5. McNamara RL, Herrin J, Bradley EH, et al. Hospital improvement in time to reperfusion in patients with acute myocardial infarction, 1999 to 2002. J Am Coll Cardiol 2006;47:45-51.
6. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction—executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Writing Committee to Revise the 1999 Guidelines for the Management of Patients With Acute Myocardial Infarction). Circulation 2004;110:588-636.
7. Woo KS, Wong SP, Chan WK, et al. Acute myocardial infarction in Hong Kong 1995-1996. Hong Kong: Hong Kong College of Cardiology; 2004.
8. Tsui KL, Cheung SH, Cheung CY, et al. Implementation of emergency service of primary percutaneous coronary intervention for ST-elevation myocardial infarction [Abstract]. Hong Kong: Hospital Authority Convention 2008. Hospital Authority website: http://www.ha.org.hk/haconvention/hac2008/proceedings/pdf/Free%20Paper/SPP3-6.pdf. Accessed 26 Apr 2010.
9. Zhang SY, Hu DY, Sun YH, Yang JG. Current management of patients with ST elevation myocardial infarction in Metropolitan Beijing, China. Clin Invest Med 2008;31:E189-97.
10. Cannon CP, Gibson CM, Lambrew CT, et al. Relationship of symptom-onset-to-balloon time and door-to-balloon time with mortality in patients undergoing angioplasty for acute myocardial infarction. JAMA 2000;283:2941-7.
11. Berger PB, Ellis SG, Holmes DR Jr, et al. Relationship between delay in performing direct coronary angioplasty and early clinical outcome in patients with acute myocardial infarction: results from the global use of strategies to open occluded arteries in Acute Coronary Syndromes (GUSTO-IIb) trial. Circulation 1999;100:14-20.
12. Magid DJ, Wang Y, Herrin J, et al. Relationship between time of day, day of week, timeliness of reperfusion, and in-hospital mortality for patients with acute ST-segment elevation myocardial infarction. JAMA 2005;294:803-12.
13. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction: every minute of delay counts. Circulation 2004;109:1223-5.
14. De Luca G, van't Hof AW, de Boer MJ, et al. Impaired myocardial perfusion is a major explanation of the poor outcome observed in patients undergoing primary angioplasty for ST-segment-elevation myocardial infarction and signs of heart failure. Circulation 2004;109:958-61.
15. Hochman JS, Sleeper LA, White HD, et al. One-year survival following early revascularization for cardiogenic shock. JAMA 2001;285:190-2.
16. Hochman JS, Sleeper LA, Webb JG, et al. Early revascularization in acute myocardial infarction complicated by cardiogenic shock. SHOCK Investigators. Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock. N Engl J Med 1999;341:625-34.
17. Bradley EH, Herrin J, Wang Y, et al. Strategies for reducing the door-to-balloon time in acute myocardial infarction. N Engl J Med 2006;355:2308-20.
18. Khot UN, Johnson ML, Ramsey C, et al. Emergency department physician activation of the catheterization laboratory and immediate transfer to an immediately available catheterization laboratory reduce door-to-balloon time in ST-elevation myocardial infarction. Circulation 2007;116:67-76.
19. Curtis JP, Portnay EL, Wang Y, et al. The pre-hospital electrocardiogram and time to reperfusion in patients with acute myocardial infarction, 2000-2002: findings from the National Registry of Myocardial Infarction-4. J Am Coll Cardiol 2006;47:1544-52.