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PCI

Shorter Door-to-Balloon Time in ST-Elevation Myocardial Infarction Saves Insurance Payments: A Single Hospital Experience in Taiwan

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Background: The relationship between quality of care and cost of medical services is a popular topic. In this study, we examined whether a reduced door-to-balloon (D2B) time led to cost savings, benefitted insurance payers, and improved patient outcomes.

Methods: We retrospectively enrolled consecutive patients who presented with ST-segment elevation myocardial infarction (STEMI) and received primary percutaneous coronary intervention (PCI) between Feb. 1, 2007, and Jul. 31, 2009, at a tertiary hospital in Taiwan. The patient data were collected by chart review. We utilized claims data from the hospital financial system as the proxy for insurance payer costs. We only included the claims data, regardless of whether patients were inpatients or outpatients, associated with the first three cardiovascular related ICD-9 codes. Multivariable logistic regression was used to examine the relationships between the D2B time, in-hospital mortality and one-year cardiovascular readmission. We utilized a multivariable linear regression to test the relationships between the D2B time, hospitalization cost and one-year cardiovascular-related cost.

Results: The D2B time did not influence the in-hospital mortality rate, but a D2B time greater than 90 min increased the probability of one-year cardiovascular readmission ($p = 0.018$). The D2B time did not increase the index hospitalization cost, but patients with a D2B time above 90 min had 14.6% higher one-year cardiovascular-related costs.

Conclusions: Our study shows that the D2B time in patients with STEMI could impact the one-year cardiovascular readmission and one-year cardiovascular-related health cost. These results suggest that the pursuit of high-quality care not only leads to better outcomes, but also reduces costs.

Key Words: Acute myocardial infarction • Cost • Door-to-balloon time • Insurance payer • Quality

INTRODUCTION

The relationship between quality of care and medical costs has been widely discussed.[1-3] In some circumstances, it has been demonstrated that higher costs of care did not result in better outcomes.[4,5] As health care spending rises, health care providers, insurance payers, governments, and consumers pursue the highest quality of care with the lowest associated costs. Based on surgical experiences, improving the process of care improves the quality of care and reduces costs.[6-8]

In patients with acute ST-segment elevation myocardial infarction (STEMI), a door-to-balloon (D2B) time of less than 90 minutes is the established gold standard for primary percutaneous coronary intervention (PCI)[9,10] and is associated with lower in-hospital mortality rates.[11]

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However, only a limited number of studies have discussed the costs and the quality of care in acute STEMI. Whether or not the improvement of care processes reduces costs remains controversial.[12,13] The Premier Hospital Quality Incentive Demonstration (PHQID) in the United States improved the processes of care but did not significantly affect cost. Another single experience in the United States (in the State of Indiana) showed that reducing the D2B time in STEMI decreased insurance payments and total hospital costs. However, that study design utilized before-and-after intervention analysis and did not actually measure the impact of D2B time. Furthermore, that study was based on the prospective-payment system rather than the fee-for-service payment system for myocardial infarction in Taiwan.

In this study, we examined whether a reduced D2B time led to costs savings that benefited insurance payers and improved patient outcomes.

MATERIALS AND METHODS

Study design

Patient enrollment was conducted between Feb. 1, 2007, and Jul. 31, 2009, at Far Eastern Memorial Hospital, a 1053-bed tertiary hospital located in New Taipei City in northern Taiwan. We retrospectively enrolled consecutive patients who presented with STEMI and received primary PCI. We excluded the patients who were transferred from other hospitals or who only received diagnostic coronary angiography. Patient characteristics, disease severity on presentation (Killip score), infarct location as defined by electrocardiogram (ECG), time from symptom onset to arrival at the emergency department (ED), D2B time, past medical history, interventions, peak creatine phosphokinase (CPK) level, and length of stay were collected via chart review. We also recorded data on in-hospital mortality and readmission for these patients within the following year. Enrolled patients were divided into two groups according to whether the D2B time was less than or greater than 90 min. The institutional research ethics review committee of the Far Eastern Memorial Hospital approved this study and waived the requirement for informed consent (2011, 100046-E).

Outcome analysis

The first outcome assessed was in-hospital mortality. It is not rare for the family members of patients in critical condition to request a discharge contrary to the advice of medical providers. Taiwanese tradition dictates that people often prefer to die at home rather than in the hospital. We considered patients in critical condition who were discharged against medical advice in the index hospitalization as in-hospital mortality in addition to death declared at hospital. The second outcome was one-year cardiovascular readmission. Readmission was defined as any admission with a cardiovascular-related International Classification of Diseases, 9th Revision (ICD-9) code recorded in the first three discharge codings within one year after the index hospitalization. The cardiovascular-related ICD-9 codes included 410 acute myocardial infarction, 411 other acute or subacute forms of ischemic heart disease, 412 old myocardial infarction, 413 angina pectoris, 414 other forms of chronic ischemic heart disease, 423 other disease of pericardium, 424 other disease of endocardium, 427 cardiac dysrhythmias, and 428 heart failure.

Cost analysis

The only health insurance payer in Taiwan is the Bureau of National Health Insurance (NHI), and the payments for hospital admission with STEMI and outpatient services are fee-for-service payments. The hospitals received the reimbursement after they claimed the service fee. Because we could not obtain the data from the Bureau of National Health Insurance, the claims data from a hospital financial system served as the proxy for payer cost. Inpatient and outpatient claims data associated with the first three cardiovascular related ICD-9 codes were included in the cost analysis. The admission cost indicated the cost of the first hospitalization, and the one-year cardiovascular-related cost indicated all costs that were incurred during the first hospitalization and the one-year follow-up period.

Statistical analysis

Continuous variables are presented as the means $\pm$ standard deviations and were analyzed using the Student's t-test to compare the two D2B groups. The peak CPK level, length of stay, and cost data were not normally distributed, so we conducted a natural log transformation prior to analysis.

We transformed coefficients back into natural units with geometric means for ease of interpretation. Categorical data are presented as proportions and were analyzed by the $\chi 2$ test or the Fisher's exact test.

Variables that potentially influence clinical outcomes and cost spending were treated as confounding factors, included age, gender, diabetes, hypertension, prior coronary artery disease (CAD), prior myocardial infarction (MI), prior coronary artery bypass graft (CABG), prior cerebral vascular disease (CVA), end-stage renal disease (ESRD), smoking history, hyperlipidemia, time from symptom onset to arrival at the ED, Killip classification, location of infarction as defined by ECG, result of coronary arteriogram (CAG) (1-, 2-, or 3-vessel disease), interventions (balloon only, bare-mental stent, or drug-eluting stent), mechanical intervention (temporary pacemaker, intra-aortic balloon pump, or extracorporeal membrane oxygenation) after emergent PCI, CABG during first hospitalization, and peak CPK level. Owing to the fact that left ventricular ejection fraction was not obtained on every patient during our chart review process, we abandoned this important factor in our analysis.

Outcome analyses of the in-hospital mortality was conducted by multivariable logistic regression using the backward method with the significance level for removal from the model set at 0.05. Outcome analysis of cardiovascular-related readmission was conducted by Cox regression on those who survived from the first admission. The backward likelihood ratio method was used for final model selection. Because one patient might be readmitted more than once during one year follow-up period, the first-time readmission was identified as the end point in Cox regression analysis. Only significant factors in the final model were displaced in the tables. Because patients potentially received follow-up care at other hospitals, the analyses of the one-year cardiovascular-related cost excluded patients who did not complete the one-year follow-up and who died during the first admission. The D2B group was treated as a fixed independent variable in the following regression models. To determine whether clinical status mediated the D2B time and the cost spending, we assessed the D2B groups and all of the potential confounding factors using the multivariate linear regression model by taking the natural logarithm of the first hospitalization cost and the one-year cardiovascular-related cost. A final cost prediction model was defined by a backward elimination procedure starting from the full model, with the significance level for removal from the model set at 0.05. Also, only significant factors in the final model were displaced in the table. The generalized linear model was used for cost estimation.

We conducted the statistical analysis with SPSS software (version 15.0, SPSS Inc., Chicago, IL, USA); a p-value of 0.05 or less was considered to be statistically significant.

RESULTS

Table 1 shows that the median D2B time was 90 min (interquartile range, 69-130) for the 210 patients enrolled in this study. The group with a D2B time over 90 min (n = 104, 49.52%) consisted of more elderly patients and females and fewer patients with a history of smoking. Seven patients died during the first admission, 4 patients were documented as deceased, and 24 patients were categorized as lost to follow-up during the following year. A total of 175 patients were included in the one-year cardiovascular-related cost analyses; their characteristics were similar to those of the original patient group.

The group with a D2B time over 90 min had a higher in-hospital mortality rate (4.8 vs. 1.9%). Two of the 7 patients who died were recorded with septic shock as the main cause of death (Table 2). However, they all have ventilator-associated pneumonia after intubation managed for cardiogenic shock and lung edema. Table 3 shows that only mechanical intervention with intra-aortic balloon pump (IABP) after PCI and prior history of MI and CVA had significant impacts on in-hospital mortality.

The overall cardiovascular readmission rate for those patients who survived the first admission (n = 203) was 29.1%, and the group with a D2B time over 90 min had a higher cardiovascular readmission rate (35.4 vs. 23.1%, p = 0.06). There were 74 readmission events for 59 patients in one-year after index hospitalization. The details of patient readmission were stable/unstable angina (42, 56.8%), heart failure (14, 18.9%), scheduled PCI for none-infarct related vessels (5, 67.6%), ventricular tachycardia/fibrillation (4, 5.4%), for CABG (4, 5.4%),

Table 1. Patient characteristics

	Original			Complete one-year follow-up		
	D2B time ≦ 90 min (n = 106)	D2B time > 90 min (n = 104)	p	D2B time ≦ 90 min (n = 89)	D2B time > 90 min (n = 86)	p
Males, n (%)	97 (91.5)	83 (79.8)	0.02	82 (92.1)	69 (80.2)	0.02
Age, years (±SD)	56.47 ± 10.64	59.57 ± 13.61	0.07	56.00 ± 9.58	59.33 ± 12.93	0.05
Medical history, n(%)						
Diabetes	18 (17.0)	25 (24.0)	0.21	16 (18.0)	21 (24.4)	0.30
Hypertension	68 (64.2)	59 (56.7)	0.27	57 (64.0)	49 (57.0)	0.34
Coronary artery disease	11 (10.4)	10 (9.6)	0.85	9 (10.1)	6 (7.0)	0.46
Myocardial infarction	6 (5.7)	5 (4.8)	0.78	6 (6.7)	2 (2.3)	0.28
CABG	0 (0.0)	2 (1.9)	0.24	0 (0.0)	1 (1.2)	0.49
ESRD	1 (0.9)	2 (1.9)	0.62	1 (1.1)	2 (2.3)	0.62
CVA	8 (7.5)	8 (7.7)	0.97	2 (2.2)	3 (3.5)	0.68
Smoking history	73 (68.9)	48 (46.2)	0.001	63 (70.8)	41 (47.7)	0.002
Hyperlipidemia	18 (17.0)	23 (22.1)	0.35	17 (19.1)	21 (24.4)	0.39
Onset to presentation, n (%)			0.77			0.81
< 1 hour	34 (32.1)	31 (29.8)		28 (31.5)	25 (29.1)	
1-3 hours	46 (43.4)	42 (40.4)		40 (44.9)	36 (41.9)	
3-6 hours	18 (17.0)	19 (18.3)		15 (16.9)	16 (18.6)	
6-12 hours	8 (7.5)	12 (11.5)		6 (6.7)	9 (10.5)	
Killip score on presentation, n (%)			0.19			0.27
I	66 (62.3)	60 (57.7)		56 (62.9)	46 (57.0)	
II	27 (25.5)	23 (22.1)		25 (28.1)	21 (24.4)	
III	4 (3.8)	2 (1.9)		2 (2.2)	2 (2.3)	
IV	9 (8.5)	19 (18.3)		6 (6.7)	14 (16.3)	
Location of infarct, n (%)			0.69			0.99
Anterior wall	54 (50.9)	57 (54.8)		49 (55.1)	46 (53.5)	
Inferior wall	44 (41.5)	36 (34.6)		33 (37.1)	32 (37.2)	
Lateral wall	2 (1.9)	2 (1.9)		1 (1.1)	1 (1.2)	
Inferior wall + RV	6 (5.7)	9 (8.7)		6 (6.7)	7 (8.1)	
Result of CAG, %			0.85			0.49
1-vessel disease	25 (23.6)	28 (26.9)		22 (24.7)	24 (27.9)	
2-vessel disease	36 (34.0)	33 (31.7)		26 (29.2)	30 (34.96)	
3-vessel disease	45 (42.5)	43 (41.3)		41 (46.1)	32 (37.2)	
Intervention, n (%)			0.34			0.26
Balloon only	6 (5.7)	6 (5.8)		3 (3.4)	2 (2.3)	
Bare-metal stent	96 (90.6)	89 (85.6)		83 (93.3)	76 (88.4)	
Drug-eluting stent	4 (3.8)	9 (8.7)		3 (3.4)	8 (9.3)	
Mechanical intervention, n (%)						
IABP	14 (13.2)	22 (21.2)	0.13	11 (12.4)	16 (18.6)	0.25
Pacemaker	15 (14.2)	16 (15.4)	0.80	13 (14.6)	15 (17.4)	0.61
ECMO	0 (0.0)	2 (1.9)	0.24	0 (0)	0 (0)	
CABG during first admission, n (%)	2 (1.9)	1 (1.0)	1.00	2 (2.2)	1 (1.2)	1.00
Peak CPK level, mg/L (±SD)	2992.28 (±2351.09)	3413.40 (±2899.85)	0.25	2873.33 (±2375.03)	3430.07 (±2731.26)	0.15
Length of first admission, days (±SD)	9.76 (±13.21)	8.53 (±5.64)	0.38	7.9 (±6.00)	8.59 (±5.42)	0.42

CI, confidence interval; D2B, door-to-balloon; CABG, coronary artery bypass graft; ESRD, end-stage renal disease; CVA, cerebrovascular accident; RV, right ventricle; CAG, coronary angiography; IABP, intra-aortic balloon pump; ECMO, extracorporeal membrane oxygenation.

Table 2. Cause of in-hospital mortality of index hospitalization

	D2B time ≦ 90 min (n = 106)	D2B time > 90 min (n = 104)
Cardiovascular origin	1 (0.94%)	4 (3.85%)
Non-Cardiovascular origin	1 (0.94%)	1 (0.96%)

*Fisher's exact test p-value = 1.00. D2B, door-to-balloon.

myocardial infarction (3, 4.1%), post-MI pericarditis (1, 1.4%), and chronic ischemic heart disease (1, 1.4%). Table 4 shows that D2B time over 90 min, 3-vessel disease, IABP after PCI, and a history of ESRD significantly increased the one-year cardiovascular readmission rate using Cox regression. For those patients who were readmitted one year after index admission (n = 59), forty-five patients (76.3%) received coronary angiogram and 16 patients had intra-stent restenosis. In all of the 16 patients, bare-metal stent was deployed during index admission but only 5 of them received revascularization on the infarct-related vessel again. Another 24 patients with multivessel disease received stent implementation on the none-infarct related vessel in the following year.

The unadjusted geometric mean index hospitalization cost and geometric mean annual cardiovascular-related cost of D2B time less than 90 minutes group and D2B time more than 90 minutes group were NT$ 196516 [95% confidence interval (CI): 182153, 211928] vs. NT$ 201915 (95% CI: 188649, 216079) and NT$ 247409 (95% CI: 230522, 265508) vs. NT$ 275488 (95% CI: 251224, 302126), respectively. Table 5 shows that the D2B time was not significantly related to the cost associated with the first admission. However, elderly status, cardiogenic shock on presentation, inferior wall infarction, a higher peak CPK level, stenting of the infarction-related vessel, and further interventions after PCI

Table 3. Results of multivariable logistic regression for in-hospital mortality

	β	OR	95% CI for OR	p
D2B time > 90 min*	0.91	2.48	0.30, 20.62	0.40
IABP after PCI#	3.33	27.79	2.41, 321.06	0.008
Prior MI†	5.00	8.98	5.64, 3928.89	0.003
Prior CVA‡	4.31	74.06	5.63, 974.38	0.001

Reference group: * D2B time ≦ 90 min, # Without IABP after PCI, † No prior MI, ‡ No prior CVA.
CI, confidence interval; CVA, cerebrovascular accident; D2B, door-to-balloon; IABP, intra-aortic balloon pump; MI, myocardial infarction; OR, odds ratio; PCI, percutaneous coronary intervention.

significantly increased the cost of index admission. Results of the one-year cardiovascular-related cost analysis were very similar to those of the one-year readmission analysis.

DISCUSSION

This study demonstrated that the D2B time over 90 min does not influence the short-term outcome or first admission cost but increases the one-year cardiovascular readmission rate and one-year cardiovascular-related cost.

The overall in-hospital mortality rate in our study was 3.3%, which is lower than that in previous studies.[14-18] In our study, we found a higher in-hospital mortality rate among patients who received mechanical intervention with an IABP after a primary PCI. Previous studies demonstrated that the use of an IABP was associated with a 6% increase in 30-day mortality in patients treated with primary PCI.[19] We found no statistically sig-

Table 4. Results of Cox regression for one-year cardiovascular readmission rate

	β	HR	95% CI for HR	p
D2B > 90 min*	0.72	2.06	1.13-3.76	0.02
Result of coronary angiography#				
Two-vessel disease	0.83	2.30	0.93-5.71	0.07
Three-vessel disease	1.18	3.26	1.37-7.72	0.007
IABP after PCI†	1.25	3.49	1.63-7.48	0.001
Prior ESRD‡	1.87	6.49	1.38-30.55	0.02

Reference group: * D2B time ≦ 90 min, # One-vessel disease, † Without IABP after PCI, ‡ No prior ESRD.
CI, confidence interval; D2B, door-to-balloon; ESRD, end-stage renal disease; HR, hazard ratio; IABP, intra-aortic balloon pump; PCI, percutaneous coronary intervention.

Table 5. Results of the multivariable linear regression for medical cost data

	First admission cost (ln-NT$) n = 210		One-year cardiovascular cost (ln-NT$) n = 175	
	β	p	β	p
Constant	11.31	< 0.001	12.18	< 0.001
D2B > 90 min	-0.54	0.17	0.11	0.03
Age	0.005	0.004		
Killip score*				
II	-0.76	0.12		
III	0.13	0.29		
IV	0.19	0.004		
Location of infarction#				
Inferior wall	0.11	0.01		
Lateral wall	0.15	0.32		
Inferior wall + right ventricle	-0.12	0.88		
Result of coronary angiography†				
Two-vessel disease			0.06	0.35
Three-vessel disease			0.14	0.02
Intervention‡				
Bare-mental stent	0.21	0.02		
Drug-eluting stent	0.15	0.20		
Peak CPK level (ln)	0.05	0.01		
Mechanical intervention				
IABP	0.37	< 0.001	0.58	< 0.001
ECMO	0.82	< 0.001		
CABG during first admission	0.59	0.003		
Medical history				
Hypertension	-.11	0.01		
ESRD	0.53	0.005	0.51	0.006
Smoking history			0.12	0.02
	$R^2 = 0.50$		$R^2 = 0.39$	

Reference group: * Killip I, # Anterior wall, † One-vessel disease as the reference variable, ‡ Balloon only.
CABG, coronary artery bypass graft; CI, confidence interval; D2B, door-to-balloon; ECMO, extracorporeal membrane oxygenation; ESRD, end-stage renal disease; IABP, intra-aortic balloon pump.

nificant differences for in-hospital mortality rate between the two D2B groups, despite the fact that the group with a D2B time over 90 min had higher mortality. We also had tried 30-day mortality and Kaplan-Meier estimate for 1 year survival (not shown in the result), but the results unfortunately did not reveal any benefit obtained from a reduced D2B time. However, the reason for that result could be the insufficient case numbers.

Scheduled or unscheduled readmission means more resource consumption. Previous studies in the literature indicate that approximately 36.7% of STEMI patients were readmitted for coronary diseases within one year,[20] and timely reperfusion therapy decreased the risk of mortality or readmission for acute myocardial infarction or heart failure within 1 year.[21] Because of the insufficient case number for statistical analysis, we could not stratify the real causes of the cardiovascular readmission in statistics.

Multivessel coronary disease is also an independent predictor of an increased risk of impaired myocardial salvage after primary PCI.[22] Patients with multi-vessel disease were potentially readmitted for any cardiac event. Guidelines from the American College of Cardiology, the American Heart Association, and the European Society of Cardiology support the utilization of primary PCI directed at the infarction-related artery.[9,10] As a result, patients with multi-vessel coronary disease might be readmitted for repeat invasive assessments and subsequent revascularization. In the one-year cardiovascular-related cost analysis, patients with multivessel disease spent more money in one-year follow-up. The general linear model estimated the one-year cardiovascular-related cost of a patient with single vessel disease, 2 vessel disease, and 3 vessel diseased were NT$ 247,707, NT$ 290,977, and NT$ 381,551, respectively.

In the first hospitalization cost analysis, the D2B time did not affect cost. Cost was highly correlated with the length of stay (Pearson correlation = 0.72, $p < 0.001$, not shown), but there was no difference in the length of stay between the two groups. We found that patients with inferior MI had a higher cost of index hospitalization compared with those who with anterior MI. If we only measured patients with inferior MI and patients with anterior MI, the numbers would be 80 vs. 111 patients, respectively. The possible reason might be that patients with inferior MI had a higher proportion of Killip IV classification upon presentation and a greater frequency of temporary pacemaker implantation than those who had anterior MI, 11 (13.8%) vs. 11 (9.9%) p-value 0.04 and 23 (28.8%) vs. 0 (0%) p-value < 0.001, respectively, by Chi-Square analysis. There were no significant differences on IABP or ECMO support, CABG during admission, and use of PCI intervention between these two groups. This might explain why inferior MI cost more money than anterior MI.

According to the one-year cardiovascular-related cost analysis, the cost of patients who had a D2B time of less than 90 min was nearly 14.6% (49,000 NT$) (estimated by general linear model) less than that for patients who had a D2B time greater than 90 min during the one-year follow-up period. This result revealed that a better quality of care could reduce the cost of medical services. In 2003, Fish et al. disclosed that Medicare enrollees in higher-spending regions receive more care than those in lower-spending regions, but they do not benefit from improved health outcomes or quality of care.[4,5] The regions that provide better quality of care to patients with acute MI had less Medicare spending. The mechanism associated with the correlation between the quality of care and cost is still not well-known. Based on previous experiences with trauma patients,[23] it has been shown that better trauma mortality rates found in higher-quality hospitals are associated with lower care costs. One possible reason for this could be the fact that there are fewer complications in higher-quality hospitals. In a single hospital study analyzing the financial impact of a reduction in D2B time in STEMI,[12] private and Medicare/Medicaid insurance payers saw a reduction in average payment during initial hospitalization and during the one-year follow-up period after the implementation of a quality initiative aimed at reducing the D2B time. That study demonstrated that an improvement in D2B time decreases the relative weight of the Diagnosis-Related Group (DRG). This study finding suggests that cost savings follow a reduction in disease severity and resource utility after improvements in the D2B performance time. However, that study was a before-and-after intervention analysis. The reduced cost might be caused by the intervention, not the real impact of D2B time. Our study directly explored the relationship between D2B time and the cost, and was different from that study. Our study also found that, in addition to the factor of ESRD, the results of the one-year cardiovascular-related cost analysis were consistent with the one-year cardiovascular readmission rate. Due to the nature of our study's design, we did not know the main reason each patient was readmitted. We believe that a reduction in resource consumption, an improvement in cardiac function, and a reduction in readmission rates are possible if the D2B time is 90 min or less.

The National Health Insurance (NHI) system in Taiwan is a single-payer system, and the insured rate has exceeded 97% since 1995. Almost all hospitals have contracts with the NHI, and health providers are reimbursed for services provided according to a standard fee schedule set by the NHI. Cost savings associated with a reduction in the D2B time in patients with STEMI benefited the NHI. An annual cardiovascular-related cost savings for every patient of nearly 14.6% (49,000 NT$) (estimated by general linear model) can be achieved with a D2B time of less than 90 min.

Our study has several limitations. First, we did not count any out-of-pocket spending and any expense from local clinics for chronic diseases including hypertension, diabetes, and hyperlipidemia. Patients may pay an out-of-pocket fee or copayment if their treatment is not included in the NHI fee schedule. For example, the NHI provides full coverage for bare-metal stents. However, patients must pay several tens of thousands of New Taiwan dollars out of pocket if they elect to have a drug-eluting stent implanted during PCI. Second, owing to the smaller number of cases in our study, which could affect statistical analysis, we could not identify the main reason for one-year cardiovascular readmission as intended or unintended for stratified analysis. Furthermore, one patient might be readmitted more than once, and we could not identify the relationship between each readmission. Third, there were 24 patients (11%) excluded from the one-year CV cost analysis. Patients in Taiwan can go anywhere they like to receive treatment, and this circumstance might decrease the accuracy of the annual cost. In the meantime, patients in Taiwan have some kind of "loyalty" to hospital. They tend to follow-up or are admitted for one specific disease at the same hospital. To eliminate the confounding of patients who may have been treated at other hospitals after index hospitalization, we excluded those patients who had no medical record one year after index hospitalization. Therefore, this process led to a smaller sample size in our study, and could confound its associated statistical accuracy. To obtain a 15% reduction in the annual cost, we calculated that for a power of 80%, we needed to recruit 76 or 95 patients in each group if we calculated the significance level of 0.05 by one-sided or two-sided, respectively. Nearly 90 patients in each group were recruited in the analysis of annual cost, although the results might be barely enough to be acceptable. Fourth, our results reflect the experience of one tertiary hospital under a fee-for-service and single-payer reimbursement system. Our research may not be applicable to other hospitals or to the broader Taiwanese health care system. In addition, only about 50% of our patients had a D2B time less than 90 minutes. These results were far behind the current standard which requires that at least 75% of the treated STEMI patients should have D2B time of less than 90 minutes. However, this standard for hospital accreditation was set in July 2009 by the Department of Health. The need for external validation necessitates further nationwide acute MI registration and a large-scale study of NHI databases in the current era.

CONCLUSIONS

Our study demonstrated that the D2B time in patients with STEMI could reduce the one-year cardiovascular readmission rate and one-year cardiovascular-related health cost. The pursuit of high-quality care not only improves outcomes but also reduces costs.

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