Early discharge after primary percutaneous coronary intervention for ST-elevation myocardial infarction

European Heart Journal: Acute Cardiovascular Care
2(3) 262–269

© The European Society of Cardiology 2013

Reprints and permissions:

sagepub.co.uk/journalsPermissions.nav

DOI: 10.1177/2048872612475231

acc.sagepub.com

**Awsan Noman¹, Azfar G Zaman^{1,2}, Clyde Schechter³,
Karthik Balasubramaniam² and Rajiv Das¹**

Abstract

Background: To assess safety of early discharge following primary percutaneous coronary intervention (PPCI) for ST-elevation myocardial infarction (STEMI).

Methods and results: Retrospective analysis of prospectively collected data of 2448 STEMI patients treated with PPCI surviving to hospital discharge. Post-discharge all-cause mortality was reported at 1, 7, and 30 days and long-term follow up. A total of 1542 patients (63.0%) were discharged within 2 days of admission (early discharge group) and 906 patients (37.0%) after 2 days (late discharge group). In both groups, no deaths were recorded 1 day post discharge. The early and late discharge group mortality figures for 7 days were 0 and 4 patients (0.04%) and between 7 and 30 days were 11 (0.7%) and 11 patients (1.2%), respectively. During a mean follow up of 584 days, 178 patients (7.3%) died: 67 in the early discharge group (4.3%) and 111 in the late discharge group (12.3%).

Conclusions: This exploratory, observational study demonstrates that discharging low-risk STEMI patients within 2 days following PPCI is safe. For providers of health care, early discharge can help to allay the cost of providing a 24-hour PPCI service and adds to the recognized benefits arising from PPCI.

Keywords

Mortality, myocardial infarction, primary angioplasty

Received: 8 October 2012; accepted: 31 December 2012.

Introduction

Primary percutaneous coronary intervention (PPCI) significantly reduces mortality and morbidity of ST-segment elevation myocardial infarction (STEMI) patients compared to thrombolysis and is the preferred reperfusion strategy.^{1–4}

Whilst clinical outcomes undoubtedly favour mechanical reperfusion over thrombolysis, there is paucity of data on the optimal length of hospital stay in patients undergoing PPCI for STEMI, with existing guidelines reflecting this lack of evidence.^{3,4} Although guidelines recognize that hospital stay in PPCI-treated STEMI patients has reduced due to a reduction in early post-infarct complications (such as arrhythmias, heart failure, recurrent ischaemia, and death)^{1,5} and improved risk stratification of STEMI patients resulting from quantification of the coronary artery disease burden,^{6–8} there are no recommendations as to the appropriate duration of hospitalization after PPCI.

Some studies have established safety of discharging STEMI patients within 3 or 4 days following PPCI.^{9–14} However, studies assessing safety and feasibility of shorter hospital stay after PPCI are scarce and lack sufficient power.

The primary objective of this study was to assess safety of early discharge in patients treated with PPCI for acute STEMI by examining early and late discharge mortality.

¹Freeman Hospital, Newcastle-upon-Tyne, UK

²Newcastle University, Institute of Cellular Medicine, Newcastle-upon-Tyne, UK

³Albert Einstein College of Medicine, New York, USA

Corresponding author:

Azfar G Zaman, Institute of Cellular Medicine, Newcastle University, Freeman Hospital, Newcastle-upon-Tyne, NE7 7DN, UK.
Email: Azfar.zaman@nuth.nhs.uk

Methods

Study population

All STEMI patients, who underwent PPCI between March 2008 and June 2011 at Freeman Hospital (Newcastle-upon-Tyne, UK) and survived to hospital discharge, were included. Freeman Hospital is a tertiary centre performing over 800 primary PCI procedures per year.

The diagnosis of STEMI was based on the presence of chest pain suggestive of myocardial ischaemia >30 mins, time of onset of symptoms within 12 hours, and new ST-segment elevation or left bundle branch block (LBBB) on the ECG. Patients were transferred from the ambulance directly to a pre-informed waiting team in the cardiac catheterization room and culprit vessel revascularization was undertaken using the radial artery for access, whenever possible. Multivessel PCI was considered in patients with cardiogenic shock, on-going ischaemic chest pain despite successful PCI to culprit lesion or as part of Preventive Angioplasty in Myocardial Infarction (PRAMI) trial (comparing culprit only with full revascularization during PPCI).¹⁵

All patients had cardiac rhythm monitoring for 24 hours post procedure via telemetry (those with sustained arrhythmias were monitored until stable) and haemodynamic parameters were recorded every 4 hours, in the absence of complications. Patients with Thrombolysis in Myocardial Infarction (TIMI) 3 flow in the infarct-related artery and without haemodynamic or arrhythmic complications were considered for early discharge, at the discretion of the attending physician, whose clinical judgment alone determined the actual timing of discharge.

During the index STEMI admission, all patients received the cardiac rehabilitation manual as well as counselling regarding risk factors and lifestyle modification. Appointments were made for early post-discharge consultation with cardiac rehabilitation teams in their local hospitals.

Study design

This is a retrospective observational cohort study. The primary data source was our local coronary artery disease database (Dendrite) which holds information on every PCI procedure performed at our hospital. Baseline demographics, clinical presentation, procedure details, and complications are prospectively entered into Dendrite at the end of each PCI procedure. Clinical data and discharge medications are updated on discharge.

This study was a clinical audit and an evaluation of our services and practices. Therefore, it did not require approval by the ethics committee as per local guidelines. The National Health Service (NHS) Caldicott Guardian gave permission for data extraction and acquisition. All data were collected as part of the Central Cardiac Audit Database (CCAD) and Myocardial Ischaemia National Audit Project (MINAP).

Outcome measures

The main outcome measure was all-cause mortality, on days 1, 7, and 30 post discharge and at long-term follow up. Patient status in relation to mortality was provided by the Office of National Statistics. This information was linked to our database using the patient's NHS patient-unique identification number and confirmed by the patient's date of birth and home address. Mortality was assessed up to 31 July 2011, and patient follow up was censored at the time of death.

Length of hospital stay

Patients were classified depending on length of hospital stay: (1) the early discharge group: discharged from hospital within 2 days following PPCI; and (2) the late discharge group: all others.

Statistical analysis

We calculated the means and standard deviations for continuous variables, contrasting the discharge groups using the Student t-test. Categorical variables were tabulated and contrasted using the Pearson chi-squared test.

Survival functions for the early and late discharge groups were calculated using the Kaplan–Meier estimator and were contrasted using the log-rank statistic. Because, in this observational study, the two groups differed in many ways that may affect their survival, we also carried out an analysis in which this potential bias is reduced through the use of propensity score matching.

A probit regression-based propensity model of discharge in 2 days or less was constructed, using age (linear spline with knot at 50), gender, peripheral vascular disease, insulin-treated diabetes, previous myocardial infarction (MI), heart failure, cerebrovascular accident or transient ischaemic attack (CVA/TIA), cardiogenic shock pre-procedure, anterior infarct location, TIMI 3 flow post procedure, radial vs. femoral procedure entry, non-sinus rhythm, multivessel or left main stem disease, cardiac arrest, any cardiovascular complication, troponin exceeding sample median, and creatinine >120 mmol/l.

Each short-stay patient was matched with the conventional-stay patient having the closest propensity score. Cox proportional hazards regression was applied to the matched-pair sample.

To generate hypotheses concerning which attributes might predict longer survival in our patients, we performed an exploratory Cox regression including as covariates 19 additional variables which, in bivariate analysis, were associated with the survival outcome (hazard ratio <0.85 or >1/0.85), and not already accounted for in the propensity model. These variables were use of angiotensin-converting-enzyme inhibitors or angiotensin-receptor blockers,

age, aspirin, use of atherothrombectomy, beta-blocker use, serum cholesterol, clopidogrel use, diabetes (oral hypoglycaemics), ex-smoker, family history of coronary artery disease, use of glycoprotein inhibitors, heparin dose, heart rate, presence of significant (>50%) left main stem disease, vessel diameter, onset of symptom to first balloon inflation, previous angina, previous coronary angioplasty, and use of statin therapy.

A p -value <0.05 (2-sided) was considered statistically significant. All analysis was performed using Stata 10 (StataCorp, Texas, USA).

Results

Patient characteristics

During the study period, PPCI was performed in 2571 STEMI patients and of these 116 patients (4.5%) died during the index hospital admission (age 73.3 ± 13.2 , 56.9% male). Discharge data were missing in seven patients. Mortality in hospital was associated with diabetes (10.8 vs. 23.3%, $p < 0.001$), previous MI (14.7 vs. 26.3%, $p = 0.003$), cardiogenic shock (3.1 vs. 35.7%, $p < 0.001$), ventilated patients (1.2 vs. 16.3%, $p < 0.001$), multivessel coronary artery disease (32.4 vs. 62.6%, $p < 0.001$), and lower procedural success rate as reflected by lower post-PPCI TIMI 3 flow rate (92.5 vs. 61.9%, $p < 0.001$).

The remaining 2448 patients, who underwent PPCI and survived to hospital discharge, (age 62.7 ± 13.2 years, 71.1% male) were included in the analysis of this study. There were 1542 patients (63.0%) in the early-discharge group and 906 patients (37.0%) in the late-discharge group. The median and interquartile range (IQR) of length of hospital stay was 2 (1–2) days (mean 1.4) in the early discharge group compared to 3 (3–5) days (mean 5.1) in the late discharge group.

Baseline demographics and procedure-related characteristics are shown in Tables 1 and 2, respectively. Patients in the early discharge group were younger with less comorbidities and were more likely to have undergone successful PPCI (defined as achieving TIMI 3 flow post PCI) with an uncomplicated recovery.

The PPCI-related procedure timings for the two groups are also shown in Table 2. The door-to-balloon time was longer in the late discharge group compared to the early discharge group. There was no significant difference in the onset-to-balloon time between the two groups.

Medication on discharge

A higher proportion of patients were discharged on angiotensin-converting-enzyme inhibitors or angiotensin-receptor blockers in the early discharge group compared to the late discharge group (87.8 vs. 83.6%, $p = 0.004$). Similar trends were seen with beta-blockers (85.2 vs. 82.4%,

$p = 0.08$) and aspirin (91.7 vs. 89.2%, $p = 0.05$). There were no significant differences in the proportion of patients who were discharged on dual antiplatelet therapy (91.3 vs. 89.4%, $p = 0.13$) and statin (90.3 vs. 88.7%, $p = 0.22$) between the early and late discharge groups, respectively. The duration of dual antiplatelet therapy did not differ between the early and late discharge groups (1.4 vs. 1.8% for 4 weeks, 1.3 vs. 1.6% for 12 weeks, and 96.2 vs. 94.9% for 12 months, respectively, $p = 0.17$).

Predictors of early discharge

In a multiple logistic regression model, the following variables were tested for their effect on time to discharge: age, sex, previous history of CVA/TIA, peripheral vascular disease, heart failure, insulin-dependent diabetes mellitus, or MI, cardiogenic shock on presentation, anterior MI site, PPCI access site (radial or femoral), TIMI 3 flow post PCI, non-sinus rhythm on admission, multivessel or left main stem disease, cardiac arrest, any in-hospital complication (except death), admission creatinine >120 mmol/l, troponin exceeding sample median (troponin T was measured in 72% of patients and the median was 33.12 µg/l whereas high-sensitivity troponin I was measured in the remaining 28% and the median was 1639 ng/l). These variables were selected as they are recognized to be clinically important in defining low-risk patients and were found to have a significant impact on early discharge on univariate analysis. Predictors of early discharge and their odds ratios in multiple logistic regression analysis are shown in Table 3.

Mortality outcomes

No patient died within the first 24 hours post discharge. A total of four patients (all in the late discharge group) died within 7 days post discharge. The overall 30-day post-discharge mortality rate was 1.06% ($n = 26$): 0.71% ($n = 11$) in the early discharge group and 1.66% ($n = 15$) in the late discharge group.

During a mean follow-up period of 584 days (585 days in the early discharge group and 582 days in the late discharge group), all-cause mortality occurred in 178 patients (7.3%): 67 patients (4.3%) in the early discharge group and 111 patients (12.3%) in the late discharge group. Figure 1 shows the Kaplan–Meier survival curves for the early and late discharge groups.

Without propensity weighting or adjustment for covariates, a Cox regression estimated the early discharge group experienced a mortality hazard ratio of 0.35 (95% CI 0.26–0.48).

The propensity score matching produced a well-balanced matched pair sample, with average bias reduced from 17.8% before matching to 2.5% after.

With propensity matching but no additional adjustments, the crude hazard ratio was 0.48 (95% CI 0.32–0.71). With

Table 1. Baseline demographics and clinical characteristics.

	Early discharge (n=1542)	Late discharge (n=906)	p-value
Age (years)	61.4±12.8	64.8±13.6	<0.0001
Male	72.7	68.3	0.021
Bloods			
Haemoglobin (g/dl)	13.9±1.7	13.6±1.8	<0.0001
Creatinine (µmol/l)	94.4±39.6	102.1±53.1	<0.0001
Glucose (mmol/l)	8.3±3.4	8.8±3.4	0.003
Cholesterol (mmol/l)	5.04±1.29	4.85±1.42	0.001
Risk factors			
Hypertension	40.7	42.5	0.40
Diabetes mellitus	10.4	11.7	0.31
IDDM	2.3	3.7	0.04
Hypercholesterolaemia	34.3	31.9	0.23
Family history	47.2	44.0	0.14
Current smoking	49.4	39.3	<0.0001
BMI (kg/m ²)	27.7±5.0	27.1±5.2	0.006
Previous history			
Angina	19.9	22.7	0.10
MI	12.9	17.9	0.001
PCI	7.6	7.6	0.9
CVA/TIA	4.7	6.7	0.04
PVD	3.2	5.3	0.01
Renal disease	0.5	1.4	0.02
Airways disease	12.1	13.3	0.37
Admission status			
Heart rate (bpm)	74±18	77±21	<0.0001
Systolic BP (mmHg)	133±28	128±30	<0.0001
Cardiogenic shock	0.9	7.1	<0.0001
Ventilated	0.1	2.9	<0.0001
Cardiac arrest	6.0	12.3	<0.0001
Non-sinus rhythm	6.2	8.2	0.07
Anterior MI	33.2	47.2	<0.0001
Impaired LVSF ^a	58	71.2	<0.0001

Values are mean±SD or %.

^aData were available in only 1043 patients (42.6%).

BMI, body mass index; BP, blood pressure; CVA/TIA, cerebrovascular accident/transient ischaemic attack; IDDM, insulin-dependent diabetes mellitus; LVSF, left ventricular systolic function; MI, myocardial infarction; PCI, percutaneous coronary intervention; PVD, peripheral vascular disease.

adjustment for the other covariates, the hazard ratio estimate was 0.36 (95% CI 0.21–0.62). In this analysis, haemoglobin, infarct artery flow before PCI, and TIMI class 2 or 3 after PCI emerged as suggested predictors of survival. Due, however, to the large number of variables adjusted for in this analysis, these findings may have arisen due to overfitting of the model and should be confirmed independently in other research.

Discussion

The main finding from this study in an unselected cohort of consecutive ‘real-world’ STEMI patients is that low-risk patients can be safely discharged within 2 days following PPCI. Importantly, this early discharge strategy may be

feasible in almost two-thirds of PPCI-treated STEMI patients. The findings are novel and have the potential to change existing practice in the studied patient population.

In our cohort, the overall mortality of all PPCI-treated STEMI patients within 30 days of hospital admission was 4.5% and was consistent with previously reported data.^{5,16,17} The mortality within 7 days of discharge was low and there were no deaths at all within 7 days in the early discharge group and only four patients died in the late discharge group. At 30 days and long-term follow up, mortality in the early discharge group also remained low and this underscores the safety of discharging uncomplicated STEMI patients within 2 days after PPCI.

The aim of this study was not to compare the mortality outcomes of the early versus the late discharge groups but

Table 2. Procedure-related characteristics.

	Early discharge	Late discharge	p-value
Radial access	72.6	64.1	<0.0001
TIMI 3/2 flow pre-PPCI	23.7	25.1	0.46
TIMI 3 flow post PPCI	94.1	89.6	<0.0001
Thrombectomy	45.7	39.3	0.002
Glycoprotein inhibitors	83.3	79.4	0.017
Drug-eluting stent	59.5	53.6	0.004
Total contrast (ml)	140±62	153±68	<0.0001
Significant LMS stenosis	3.3	9.8	<0.0001
Multivessel disease	29.0	38.3	<0.0001
Multivessel PCl ^a	8.2	14.2	<0.0001
Any complication ^b	11.1	25.4	<0.0001
Procedure timings (min)			
Onset to balloon	168 (116–270)	166 (118–270)	0.81
Door to balloon	24 (18–34)	26 (19–36)	0.0003

Values are %, mean±SD, or median (interquartile range).

^aAt time of index procedure.

^bInclude all procedural, arterial access, and post-procedure cardiac and non-cardiac complications.

LMS, left main stem; PPCI, primary percutaneous coronary intervention; TIMI, Thrombolysis in Myocardial Infarction.

rather to assess the safety of the early discharge strategy in low-risk patients. As would be expected, the early and late discharge groups in our cohort differed in many ways that were predictive of subsequent survival. For example, the early discharge group were younger and had fewer comorbidities and less complex disease and PPCI was performed more often via the radial approach. It must be acknowledged, however, that clinical judgement by the attending physician which was based on procedural success and haemodynamic stability during hospital stay was central to the decision making for early discharge.

An important question is whether the mortality rate in the early discharge group could have been reduced by keeping these patients in hospital for longer than 2 days. In order to answer this question we tried to reduce the confounding

bias between the early and late discharge groups by using propensity score matching. The survival advantage for the early discharge group remained evident even after this adjustment. This finding is to be expected given the non-randomized design and further confirms the safety of an early discharge strategy and argues against any mortality benefit, which may be derived from keeping low-risk patients in hospital for longer than 2 days. Of course, only large randomized control trials can conclusively answer this question. However, our low mortality figures in the early discharge group and the propensity analysis findings strongly support our conclusion of the safety of an early discharge strategy.

Although the decision to discharge patients within 48 hours was a clinical one based on close haemodynamic and rhythm monitoring, it is likely that several factors other than the recognized cardiovascular risk factors that were recorded influenced length of hospital stay, such as non-cardiac comorbidities and social and home circumstances.

Overall ischaemic time (onset to balloon) did not differ between groups and the median time of less than 3 hours is testament to the pivotal role of the emergency services in the provision of a successful PPCI service. Whilst the overall median door-to-balloon time was under 30 minutes, there was a significantly higher median time for the late discharge group, reflecting complications early in the course of STEMI presentation. This is likely to be due to the complexity of patients and lesions treated in the late discharge group. Patients in this group were more likely to have multivessel coronary artery disease and undergo multivessel PCI but had a lower rate of post-PPCI TIMI 3 flow. In addition, they had higher proportions of patients presenting with cardiac arrest, cardiogenic shock, or ventilation

Table 3. Multivariate logistic regression for predictors of early discharge.

	OR (95% CI)	p-value
PVD	0.61 (0.38–0.98)	0.041
Cardiogenic shock	0.19 (0.09–0.38)	<0.0001
Anterior MI	0.48 (0.39–0.59)	<0.0001
Radial access	1.30 (1.06–1.59)	0.013
MVD or LMS	0.64 (0.52–0.78)	<0.0001
Cardiac arrest	0.63 (0.44–0.91)	0.013
Any complications	0.46 (0.36–0.60)	<0.0001
Age (per 10 years)	0.87 (0.80–0.94)	<0.0001
Creatinine >120 µmol/l	0.61 (0.46–0.83)	0.001
Tn (above median)	0.75 (0.62–0.91)	0.003

LMS, left main stem; MVD, multivessel disease; PVD, peripheral vascular disease; Tn, serum troponin.

Figure 1. Kaplan–Meier survival curves for adjusted cumulative post-discharge survival in the early and late discharge groups.

pre PPCI and requiring support prior to revascularization. The mortality from cardiogenic shock resulting from STEMI remains high even in the era of PPCI¹⁸ and those that survive to arrival to hospital require intensive monitoring and care. In our study, 118 STEMI patients were in cardiogenic shock on admission and, of these, 77 patients (65.2%) survived to hospital discharge. The median length of hospital stay was considerably longer in patients with cardiogenic shock and confirms the challenge that this patient group presents to providers of STEMI care.

The length of hospital stay of STEMI patients has gradually decreased over time.^{3,4,18,19} In the thrombolysis era, a randomized controlled trial of 80 patients demonstrated the feasibility of discharging low-risk STEMI patients 3 days after admission.²⁰ These patients, however, were highly selected from 507 consecutive STEMI patients, of whom 65% showed early post-infarct complications such as angina, heart failure, or arrhythmia by day 3 and a further 7% demonstrated ischaemia on exercise testing. Of note, this study confirmed that, even in the low-risk group defined by the authors, the conventional length of hospital stay in the thrombolysis era was 7–10 days.

A recent paper by Jones and colleagues²¹ in over 2700 patients also demonstrated the safety and feasibility of early (within 48 hours) discharge after PPCI. The authors reported no difference in readmission rates in the first 30

days and no all-cause mortality difference in the early discharge group. One notable difference with our data was that only 42% were discharged within 48 hours against 63% in our study. One reason may be due to our shorter period (24 hours) of monitoring for sustained arrhythmias. The optimal duration for monitoring arrhythmias after PPCI has not been determined. A recent study²² showed that arrhythmias can be present up to 48 hours after PPCI but Mehta and colleagues²³ reported results from the HORIZONS-AMI trial confirming that these late arrhythmias were not associated with morbidity or mortality. Our data supports monitoring for 24 hours in low-risk patients after PPCI.

In the era of PPCI, there are two main reasons why a further reduction of hospital stay in STEMI patients can be considered. First, PPCI has been shown to reduce the mortality and morbidity of post-infarct complications compared to thrombolysis.^{1,2,5} Second, angiographic data obtained during PPCI allows assessment of reperfusion (TIMI flow and myocardial blush grade) and quantifies the extent of coronary artery disease, thereby providing rapid risk stratification of STEMI patients which is invaluable for selecting patients for early discharge.^{7,8,13,24}

Current guidelines of STEMI management acknowledge that shorter hospital stay (after approximately 72 hours) is reasonable in selected low-risk patients⁴ despite limited evidence in this field. To date, there are few trials,

which have assessed the appropriateness of early discharge following uncomplicated PPCI. In the Primary Angioplasty in Myocardial Infarction (PAMI-II) study,⁹ 471 low-risk PPCI-treated STEMI patients were randomized to either accelerated hospital care with early discharge (mean hospital stay of 4.2 days) or traditional care (mean hospital stay of 7.1 days). The groups showed similar mortality, recurrent ischaemia, stroke, and heart failure at 6 months. In an observational study of low-risk 463 PPCI patients (selected out of 898 patients),¹⁰ the 30-day mortality was similar in those who were discharged within 4 days following PPCI ($n=266$) and those who were hospitalized for more than 4 days ($n=197$). In another small cohort of 267 patients successfully treated with PPCI,¹¹ 69% were discharged within 48 hours with low major adverse cardiovascular event (MACE) rates reported at 30 days and 1 year follow up. The findings of three other smaller pilot studies have also supported the feasibility of early discharge following uncomplicated PPCI.^{12–14} However, these trials were too small to be sufficiently powered to evaluate mortality. The on-going Effects on Health Status in Patients Early Discharged After PPCI (INUT) is aimed address outcomes with regards to patients' satisfaction of care and health quality of life.²⁵ However, large randomized trials with sufficient power to assess mortality outcomes of early discharge strategy are clearly required.

Length of hospital stay is recognized as a major contributor to the cost of in-hospital treatment of myocardial infarction.²³ In addition, various studies have demonstrated the potential cost saving with reduced length of hospital stay in STEMI patients.^{7,9,26,27} Although cost effectiveness was not assessed in our study, the finding that early discharge is safe has the potential to reduce the health cost of providing a primary PCI service.

Limitations and strengths

The strength of our study is that it is reflective of contemporary practice and the primary outcome measure was the hard endpoint of mortality. As with all retrospective, observational studies, it is not possible to account for all confounders. We did not have data on Killip class and LVSF was recorded in only 40% of patients on discharge. Such data would likely have improved our prediction of late discharge patients and given insight into the increased mortality in this group. However, this is a study of real world, unselected, consecutive patients with long-term follow up and the primary objective of assessing safety of early discharge only required recording the 'hard' endpoint of mortality. Another limitation is this being a single-centre experience. However, our hospital provides PPCI to a population of approximately 2 million and serves seven satellite hospitals. Finally, translation of our data on the safety of early discharge may need to be treated with caution in centres with longer balloon times or in centres without

established early cardiac rehabilitation and physician-led consultation following discharge.

Conclusions

This study of 2448 patients undergoing PPCI for acute STEMI shows that early discharge (within 2 days) is safe and feasible in two-thirds of such patients. Whilst the benefits of primary PCI over thrombolysis are proven, establishing an effective primary PCI service is demanding of health resources. Early discharge may help to reduce healthcare costs for providers of a PPCI service.

Acknowledgements

We are grateful to Sheila Jamieson for her assistance with the coronary artery disease database and to our colleagues at Freeman Hospital, Doctors Ahmed, Bagnall, Edwards, Egred, Purcell, and Kunadian and Professors Keavney and Spyridopoulos, for their help in collecting data.

Conflict of interest

The authors declare that there are no conflicts of interest.

Funding

AGZ was supported by a British Heart Foundation Clinical Research Fellowship (FS/07/33).

References

1. Keeley EC, Boura JA and 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. Andersen HR, Nielsen TT, Rasmussen K, et al. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. *N Engl J Med* 2003; 349: 733–742.
3. Kushner FG, Hand M, Smith SC Jr, et al. 2009 Focused Updates: ACC/AHA Guidelines for the Management of Patients With ST-Elevation Myocardial Infarction (updating the 2004 Guideline and 2007 Focused Update) and ACC/AHA/SCAI Guidelines on Percutaneous Coronary Intervention (updating the 2005 Guideline and 2007 Focused Update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation* 2009; 120: 2271–2306.
4. Steg PG, James SK, Atar D, et al. ESC Guidelines for the management of acute myocardial infarction in patients presenting with ST-segment elevation: The Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology (ESC). *Eur Heart J* 2012; 33: 2569–2619.
5. Stenestrand U, Lindback J and Wallentin L. Long-term outcome of primary percutaneous coronary intervention vs prehospital and in-hospital thrombolysis for patients with ST-elevation myocardial infarction. *JAMA* 2006; 296: 1749–1756.
6. Heggumje PS, Harjai KJ, Stone GW, et al. Procedural success versus clinical risk status in determining discharge of patients

- after primary angioplasty for acute myocardial infarction. *J Am Coll Cardiol* 2004; 44: 1400–1407.
7. De Luca G, Suryapranata H, van 't Hof AW, et al. Prognostic assessment of patients with acute myocardial infarction treated with primary angioplasty: implications for early discharge. *Circulation* 2004; 109: 2737–2743.
 8. Halkin A, Singh M, Nikolsky E, et al. Prediction of mortality after primary percutaneous coronary intervention for acute myocardial infarction: the CADILLAC risk score. *J Am Coll Cardiol* 2005; 45: 1397–1405.
 9. Grines CL, Marsalese DL, Brodie B, et al. Safety and cost-effectiveness of early discharge after primary angioplasty in low risk patients with acute myocardial infarction. PAMI-II Investigators. Primary Angioplasty in Myocardial Infarction. *J Am Coll Cardiol* 1998; 31: 967–972.
 10. Yip HK, Wu CJ, Chang HW, et al. The feasibility and safety of early discharge for low risk patients with acute myocardial infarction after successful direct percutaneous coronary intervention. *Jpn Heart J* 2003; 44: 41–49.
 11. Karabulut A, Cakmak M, Uzunlar B, et al. What is the optimal length of stay in hospital for ST elevation myocardial infarction treated with primary percutaneous coronary intervention? *Cardiol J* 2011; 18: 378–384.
 12. Jirmar R, Widimsky P, Capek J, et al. Next day discharge after successful primary angioplasty for acute ST elevation myocardial infarction. An open randomized study 'Prague-5'. *Int Heart J* 2008; 49: 653–659.
 13. Kotowycz MA, Cosman TL, Tartaglia C, et al. Safety and feasibility of early hospital discharge in ST-segment elevation myocardial infarction—a prospective and randomized trial in low-risk primary percutaneous coronary intervention patients (the Safe-Depart Trial). *Am Heart J* 2010; 159: 117 e1–e6.
 14. Dirksen MT, Ronner E, Laarman GJ, et al. Early discharge is feasible following primary percutaneous coronary intervention with transradial stent implantation under platelet glycoprotein IIb/IIIa receptor blockade. Results of the AGGRASTENT Trial. *J Invasive Cardiol* 2005; 17: 512–517.
 15. Current Controlled Trials. Preventive Angioplasty in Myocardial Infarction (PRAMI). Available at: www.controlled-trials.com/ISRCTN73028481 (consulted November 2012).
 16. Morrow DA, Antman EM, Parsons L, et al. Application of the TIMI risk score for ST-elevation MI in the National Registry of Myocardial Infarction 3. *JAMA* 2001; 286: 1356–1359.
 17. Lambert L, Brown K, Segal E, et al. Association between timeliness of reperfusion therapy and clinical outcomes in ST-elevation myocardial infarction. *JAMA* 2010; 303: 2148–2155.
 18. Babaev A, Frederick PD, Pasta DJ, et al. Trends in management and outcomes of patients with acute myocardial infarction complicated by cardiogenic shock. *JAMA* 2005; 294: 448–454.
 19. Pryor DB, Hindman MC, Wagner GS, et al. Early discharge after acute myocardial infarction. *Ann Intern Med* 1983; 99(4): 528–538.
 20. Ross RS. Early discharge after heart attacks and the efficient use of hospitals. *N Engl J Med* 1978; 298: 275–277.
 21. Jones DA, Rathod KS, Howard JP, et al. Safety and feasibility of hospital discharge 2 days following primary percutaneous intervention for ST-segment elevation myocardial infarction. *Heart* 2012; 98: 1722–1727.
 22. Ohlow MA, Geller JC, Richter S, et al. Incidence and predictors of ventricular arrhythmias after ST-segment elevation myocardial infarction. *Am J Emerg Med* 2012; 30: 580–586.
 23. Mehta RH, Yu J, Piccini JP, et al. Prognostic significance of postprocedural sustained ventricular tachycardia or fibrillation in patients undergoing primary percutaneous coronary intervention (from the HORIZONS-AMI Trial). *Am J Cardiol* 2012; 109: 805–812.
 24. Kotowycz MA, Syal RP, Afzal R, et al. Can we improve length of hospitalization in ST elevation myocardial infarction patients treated with primary percutaneous coronary intervention? *Can J Cardiol* 2009; 25: 585–588.
 25. ClinicalTrials.gov. Effects on Health Status in Patients Early Discharged After Primary Percutaneous Coronary Intervention (PCI) (INUT). Available at: <http://clinicaltrials.gov/ct2/show/NCT01244841?term=inut&rank=1> (consulted November 2012).
 26. Topol EJ, Burek K, O'Neill WW, et al. A randomized controlled trial of hospital discharge three days after myocardial infarction in the era of reperfusion. *N Engl J Med* 1988; 318: 1083–1088.
 27. Newby LK, Eisenstein EL, Califf RM, et al. Cost effectiveness of early discharge after uncomplicated acute myocardial infarction. *N Engl J Med* 2000; 342: 749–755.