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Safety and Feasibility of 48 h Discharge After Successful Primary Percutaneous Coronary Intervention

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Abstract

Background: The aim of the current study is to determine the safety of early discharge (ED) within 48 hours (h) for ST-elevation myocardial infarction (STEMI) patients who underwent primary percutaneous coronary intervention (PPCI) and to define the criteria of low-risk patients that can be considered for ED.

Methods: This is a single-center retrospective study that took place at Mohammed bin Khalifa Cardiac Centre in the Kingdom of Bahrain. 301 patients who underwent PPCI between January 2018 and March 2019 were included. Endpoints at 30 days follow-up comprised cardiac re-admission, cardiovascular death, non-fatal myocardial infarction, stroke, and major adverse cardiovascular and cerebrovascular events.

Results: Of the 301 patients included in our study, 74 (24.5%) were discharged within 48 h (group 1) compared with 227 (75.5%) hospitalized for more than 48 h after PPCI (group 2) ($P < 0.0001$). In terms of baseline characteristics, group 2 had higher proportions of chronic kidney disease ($P = 0.051$), mean HbA1c ($P = 0.016$) and mean CPK ($P < 0.0001$) compared to their group 1 counterparts. The prevalence of anterior STEMI was twice as high among group 2 ($P < 0.0001$), with a significantly higher prevalence of left main stenting ($P = 0.025$). Additionally, larger proportion of group 2 required inotropic therapy ($P = 0.031$), oral anticoagulation ($P = 0.005$) and had a significantly lower ejection fraction (LVEF) ($P < 0.0001$) with more procedural complications ($P = 0.005$).

LVEF exerts a large effect on ED, as reflected by a high deviance $R^2 = 20.4\%$, and was able to correctly classify the subjects into their pertaining discharge group with an accuracy of 80.4%, a specificity of 82.7%, and a sensitivity of 71.2%. According to the fitted LVEF values using the logistic equation, each 1% increase in LVEF is associated with a 3.5% increase in the chance of ED. The two groups recorded fairly similar clinical outcomes at 30-day.

Conclusion: Preserved LV systolic function is a good predictor of early and safe discharge after successful PPCI. The presented data support the practice of ED, with length of stay even shorter than current guidelines recommendation in selected low-risk patients.

Keywords: STEMI, Percutaneous coronary intervention, Hospital stay, Early discharge, MACCE, Ejection fraction

1. Introduction

Acute coronary syndrome, especially STEMI, is considered the leading cause of mortality and morbidity worldwide, and primary percutaneous coronary intervention (PPCI) has emerged

as the gold standard reperfusion strategy scoring significantly over thrombolysis [1].

The hospitalization cost of STEMI is high, particularly in the PPCI era, and hence substantial efforts are exerted by healthcare systems to determine low-risk patients in whom early discharge (ED) after PPCI would be appropriate and deemed safe [2].

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Previous studies have provided sufficient evidence of safe discharge 72 hours (h) after uncomplicated PPCI of low-risk patients. However, the definition of low-risk patients remains ambiguous, and studies assessing the safety and feasibility of shorter hospital stays after PPCI are scanty [3, 4].

The 2017 European Society of Cardiology (ESC) guidelines of acute myocardial infarction (AMI) in patients presenting with STEMI recommend ED (within 48–72 h) if early rehabilitation and adequate follow-up are arranged (class of recommendation (COR) IIa; level of evidence (LOE) A). Although ED is not associated with late mortality, there is no clear definition of low-risk patients in this document [5].

The aim of the current study is to determine the safety of discharge within 48 h for STEMI patients who underwent PPCI and to define the criteria of low-risk patients that can be considered for ED.

2. Methods

2.1. Setting

This was a single-center retrospective study that took place at Mohammed bin Khalifa Cardiac Centre in the Kingdom of Bahrain; it is the only tertiary cardiac center in Bahrain with 24/7 PPCI service.

2.2. Study population

All patients who underwent PPCI for acute STEMI between January 2018 and March 2019 were included. Inclusion criteria were patients admitted with acute STEMI, treated with PPCI and discharged successfully from the cardiac center. Exclusion criteria were the following: (1) STEMI treated with first-line thrombolytic therapy; (2) rescue PCI after failed thrombolysis; (3) those who died during index admission; (4) patient's refusal of informed consent to participate in the study; and (5) high probability of non-adherence to follow-up requirements (e.g. visitors from abroad).

Acute STEMI was defined as persistent chest pain within 12 hours of presentation to the first medical contact with new ST-segment elevation on the surface ECG in at least two contiguous leads. All patients had cardiac rhythm monitoring for at least 24 hours post PPCI via telemetry and haemodynamic parameters were recorded every 4 hours, in the absence of complications. Patients with Thrombolysis in Myocardial Infarction-III (TIMI-III) flow in the culprit 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. Follow up appointments were made for all patients at our cardiac outpatient department at day-30 post discharge. The local ethics committee approved the study, and all patients gave informed consent in compliance with the Declaration of Helsinki.

2.3. Left ventricular ejection fraction

Comprehensive transthoracic echocardiography was performed with commercially available ultrasound systems in accordance with the cardiac chamber quantification guidelines published in 2015 [6]. The left ventricular ejection fraction (LVEF) was quantified by the biplane method of disks (modified Simpson's rule). Ultrasound-enhancing agents were used in patients with suboptimal acoustic windows.

2.4. Outcomes

Endpoints at 30 days follow-up comprised cardiac re-admission, cardiovascular death, non-fatal myocardial infarction, stroke, and major adverse cardiovascular and cerebrovascular events (MACCEs).

Cardiac re-admissions included any hospitalization that could be attributed or considered related to indexed admission: for example, post MI angina, acute decompensated heart failure, and arrhythmia. Cardiovascular death was defined as all-cause cardiovascular mortality in addition to unwitnessed death and death of unknown causes after discharge from hospital. Myocardial infarction was defined based on the 2018 universal definition. Stroke was defined as an acute episode of focal or global neurologic dysfunction caused by brain, spinal cord, or retinal vascular injury as a result of hemorrhage or infarction. MACCEs were defined as the composite of cardiac death, non-fatal MI, and stroke.

2.5. Statistical analysis

Most of the study's variables were dichotomous; therefore, they were summarized by calculating the frequency and percentages of their categories. Descriptive analysis of the continuous variables was carried out by calculating their means and standard deviations.

To investigate the association between two dichotomous variables (such as gender (male and female) and discharge group (<48 h and >48 h), Fisher's exact test (an extension of the chi square test) was performed. To explore the association between an independent categorical variable such as

discharge categories and a dependent numerical variable such as LVEF, the t-test was used to compare both groups' means and assess any significant difference. Direct binary logistic regression was used to explore the predictive value of certain variables in predicting the subjects' probability of ED (<48 h). The cutoff significance level was set to 0.05 as a criterion to accept or reject the statistical significance of any association or difference in the mentioned test.

3. Results

3.1. Baseline characteristics

Of the 301 patients included in our study, 74 (24.5%) were discharged within 48 h (group 1) compared with 227 (75.5%) hospitalized for more than 48 h after PPCI (group 2) (<0.0001). Both groups were quite comparable in all the demographic characteristics and in most of the illness-related features. On average, subjects in both groups were middle age individuals with a negligible difference in their mean ages, which turned out to be statistically insignificant (55 ± 11.5 vs. 53.4 ± 11.32 years, $p = 0.316$). In addition, both genders were almost equally represented across both groups.

In terms of comorbidities, patients in group 2 had a marginally and significantly higher proportion of chronic kidney disease as compared with their group 1 counterparts [23(10.1%) vs. 2(2.7%), $p = 0.051$]. Another difference was observed in the magnitude of glycemic control as reflected by HbA1c. On average, subjects in group 2 had a

significantly higher mean HbA1c than those in group 1 (7.7 ± 2.6 vs. 7 ± 1.8 , $p = 0.016$). A similar difference was also detected in their CPK levels. Group 2 had a significantly higher mean CPK than group 1 (2676 ± 2581.9 vs. 1645 ± 1967.5 , $p < 0.0001$). The full analysis of the baseline characteristics of the study population is depicted in (Table 1).

3.2. Patients and procedural characteristics

The two groups showed some distinctive features in some of their clinical and procedural details. In term of patients' characteristics: group 2 had a significantly lower ejection fraction than their group 1 counterparts (39.6 ± 9.3 vs. 49.8 ± 8.9 , $p < 0.0001$). In the same vein, a lower proportion of group 2 had preserved left ventricular systolic function (36(16.8%) vs. 52(71.2%), $p < 0.0001$) when compared with group 1 (Fig. 1). The prevalence of anterior STEMI was twice as high among group 2 patients than in group 1 patients (127(55.9%) vs. 18(24.3%), $p < 0.0001$).

In terms of procedural details: a significantly larger proportion of group 2 required inotropic therapy compared with group 1 (30(13.2%) vs. 3(4.1%), $p = 0.031$) with a significantly higher prevalence of LMCA stenting (14(6.1%) vs. 0(0%), $p = 0.025$). Again, in terms of procedural complications, group 2 recorded a significantly higher proportion compared with group 1 (20(8.8%) vs. 0(0%), $p = 0.005$). Acute kidney injury (AKI) secondary to hypotension, nephrotoxicity or cholesterol embolization was the most commonly encountered peri-procedural complication (9 (45%) out of 20

Table 1. Baseline characteristics of study population.

Demographic/comorbidities	Group 1 ischarged <48h	Group 2 Discharged >48h	p-value
Number of cases n(%)	74(24.5%)	227(75.5%)	<0.0001
Age (Mean \pm SD)	55 \pm 11.5	53.4 \pm 11.3	0.316
Gender: males n(%)	62(83.7%)	202(88.9%)	0.301
Gender: females n(%)	12(16.2%)	25(11.0%)	0.301
Hypertension n(%)	31(41.8%)	117(51.5%)	0.180
Diabetes mellitus n(%)	29(39.1%)	103(45.4%)	0.418
Dyslipidemia n(%)	39(52.7%)	129(56.8%)	0.590
Smoking n(%)	28(37.8%)	99(43.6%)	0.496
Coronary artery disease n(%)	11(14.8%)	40(17.6%)	0.721
Chronic kidney disease n(%)	2(2.7%)	23(10.1%)	0.051
Peripheral vascular disease n(%)	1(1.3%)	4(1.7%)	0.999
Chronic obstructive pulmonary disease n(%)	1(1.3%)	3(1.3%)	0.968
Stroke n(%)	1(1.3%)	7(3.0%)	0.684
Hemoglobin g/L (Mean \pm SD)	142.4 \pm 21.4	142.5 \pm 21	0.987
Creatinine μ mol/L (Mean \pm SD)	95.7 \pm 137	101.4 \pm 110.4	0.721
Hemoglobin A1c % (Mean \pm SD)	7 \pm 1.8	7.7 \pm 2.6	0.016
Cholesterol mmol/L (Mean \pm SD)	4.5 \pm 1.1	4.6 \pm 1.3	0.594
Low-density lipoprotein mmol/L (Mean \pm SD)	3.1 \pm 1	3.2 \pm 1.3	0.523
Triglyceride mmol/L (Mean \pm SD)	1.9 \pm 1.5	2.6 \pm 13.7	0.649
Creatine phosphokinase U/L (Mean \pm SD)	1645.4 \pm 1967.5	2676.3 \pm 2581.9	<0.0001

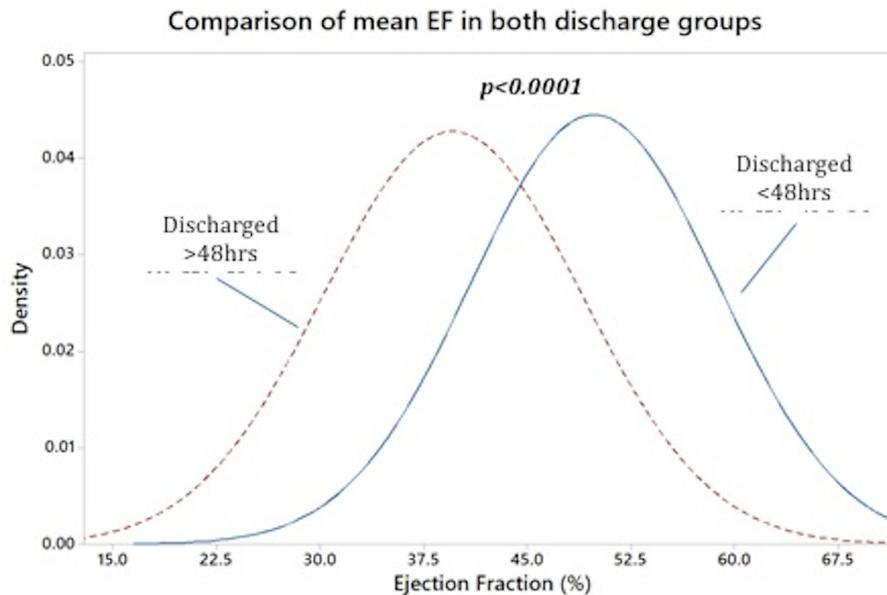


Fig. 1. Comparison of mean ejection fraction among subjects discharged $<48h$ and $>48h$.

Table 2. Clinical presentation and procedural details.

Clinical presentation and procedural details	Group 1(74 patient) Discharged $< 48h$	Group 2 (227 patient) Discharged $> 48h$	p-value
Cardiogenic shock	3(4.1%)	21(9.2%)	0.216
Inotropic support	3(4.1%)	30(13.2%)	0.031
Intra-aortic balloon pump	2(2.7%)	19(8.3%)	0.120
Cardiopulmonary resuscitation	1(1.3%)	17(7.5%)	0.085
Mechanical ventilation	2(2.7%)	13(5.7%)	0.536
Life threatening arrhythmia	0(0%)	1(0.4%)	0.180
Ejection fraction	49.8 \pm 8.9	39.6 \pm 9.3	<0.0001
Preserved left ventricular systolic function	52(70.2%)	36(15.8%)	<0.0001
Anterior ST-elevation myocardial infarction	18(24.3%)	127(55.9%)	<0.0001
Radial access	67(90.5%)	189(83.2)	0.186
Thrombectomy	18(24.3%)	67(29.5%)	0.458
Atherectomy	0	0	-
Intravascular imaging	2(2.7)	7(3.0)	0.899
Drug eluting stent	68(91.8%)	194(85.4%)	0.229
Drug eluting balloon	1(1.3%)	5(2.2%)	0.999
Plain old balloon angioplasty (POBA) only	4(5.4%)	11(4.8%)	0.765
Left main coronary artery	0(0%)	14(6.1%)	0.025
Multi vessel percutaneous coronary intervention	5(6.7%)	28(12.3%)	0.281
Residual syntax score after primary PCI	4.4 \pm 4.5	7.8 \pm 3.8	0.255
Procedural complications	0(0%)	20(8.8%) ^a	0.005
Glycoprotein IIb/IIIa inhibitors	8(10.8%)	32(14.0%)	0.558
Aspirin	74(100%)	222(97.7%)	0.340
Brilinta	27(36.4%)	79(35%)	0.779
Plavix	46(62.1%)	146(64.3%)	0.888
Oral anticoagulation	1(1.3%)	28(12.3%)	0.005

^a The types of procedural complications were as follows (NB. some patients experienced more than one complication and all complications occurred in group 2): Acute kidney injury 9 patients, distal embolization or no reflow with TIMI flow <3 or side branch occlusion 3 patients, upper GI bleeding 2 patients, retroperitoneal hematoma 2 patients, contrast allergy 2 patients, stent thrombosis 1, pesudoanurysm 1 patient, coronary dissection 1 patient, Stroke 1 patient.

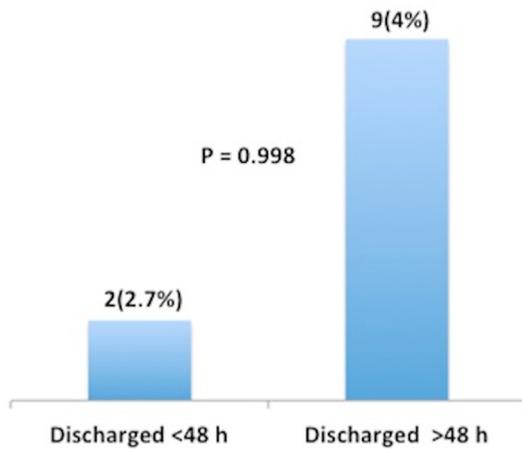


Fig. 2. Comparison of prevalence of cardiac re-admissions among subjects discharged < 48h and > 48h at 30-day follow up.

cases), but no one required hemodialysis and all patients recovered completely during follow up. Finally, a significantly larger percentage of group 2 required oral anticoagulation (OAC) (28(12.3%) vs. 1(1.3%), $p = 0.005$). Post myocardial infarction LV-Thrombus was the main indication for oral anticoagulation, followed by atrial fibrillation.

The clinical presentation and procedural details are shown in (Table 2).

3.3. 30-day outcomes

The two groups recorded fairly similar clinical outcomes despite some occasional differences, which were proved to be statistically insignificant. For instance, even though group 2 had a slightly higher cardiac re-admissions rate than group 1 (9(4%) vs. 2(2.7%), $p = 0.998$), this difference was not statistically significant (Fig. 2). The clinical outcomes are summarized in (Table 3 and Fig. 3).

3.4. Predictors of ED

Direct binary logistic regression was performed to assess the impact of a number of factors on the likelihood that subjects would have ED (<48 h). The

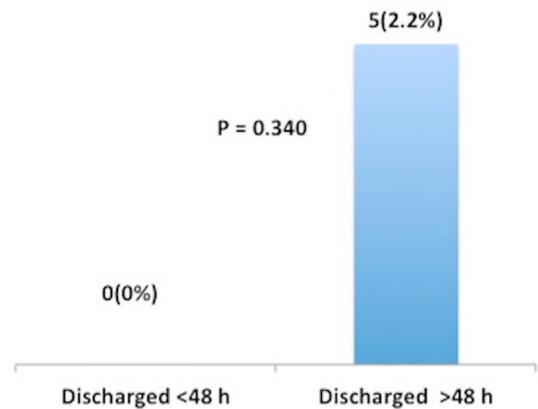


Fig. 3. Comparison of prevalence of major adverse cardiovascular and cerebrovascular events (MACCE) among subjects discharged < 48h and > 48h at 30-day follow up.

model contained nine independent variables: CKD, HbA1c, CPK, inotropic support, LVEF, anterior STEMI, LMCA, procedural complications, and oral anticoagulation. None of these predictors was statistically significant, except for LVEF. Re-estimating the model with only LVEF as a predictor indicated a statistically significant model overall ($X^2 = 66.6$, $df = 1$, $p < 0.0001$, OR(1.14)). LVEF exerts a large effect on ED, as reflected by a high deviance $R^2 = 20.4\%$, and was able to correctly classify the subjects into their pertaining discharge group with an accuracy of 80.4%, a specificity of 82.7%, and a sensitivity of 71.2%. According to the fitted LVEF values using the logistic equation, each 1% increase in LVEF is associated with a 3.5% increase in the chance of ED, as illustrated in the logistic curve in (Fig. 4).

4. Discussion

The main finding of our study is that low-risk patients can be safely discharged within 48 h after PPCI. There are several factors that influence the length of hospital stay, such as non-cardiac comorbidities and economic and home circumstances. However, the decision for ED is at the discretion of the treating physician.

Table 3. 30-day comparison of clinical outcomes between subjects discharged <48h and >48h.

Outcomes	Group 1 Discharged <48 hrs	Group 2 Discharged >48 hrs	p-value
30 days Cardiac re-admission n(%)	2(2.7%)	9(3.9%)	0.998
30 days Cardiovascular Mortality n(%)	0(0%)	2(0.8%)	0.999
30 days Myocardial infarction n(%)	0(0%)	2(0.8%)	0.999
30 days Stroke n(%)	0(0%)	1(0.4%)	0.978
30 days MACCE n(%)	0(0%)	5(2.2%)	0.340

MACCE: major adverse cardiovascular and cerebrovascular events.

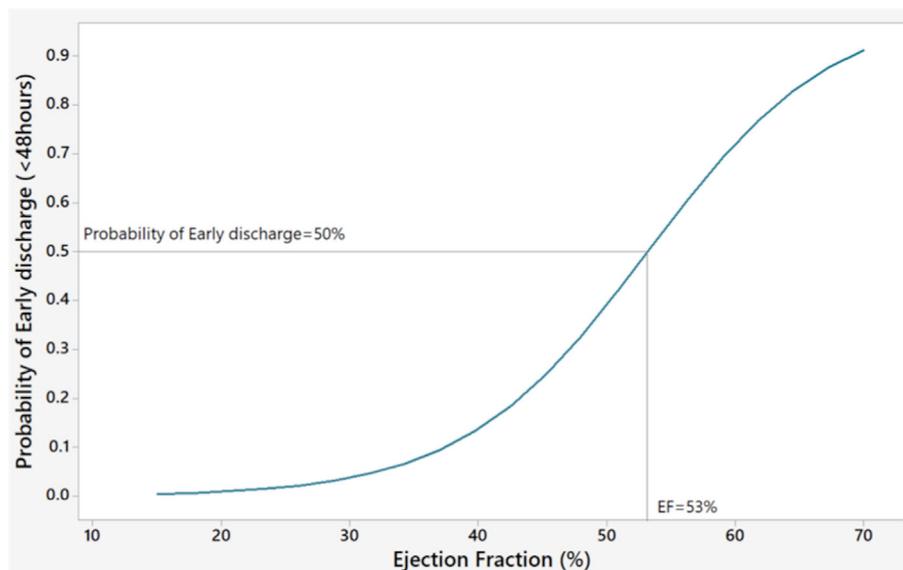


Fig. 4. Ejection fraction (EF) as independent predictor of safe early discharge. Each 1% increase in EF is associated with 3.5% increase in the chance of early discharge as illustrated in the logistic curve.

Overall in our study, the mortality and clinical outcomes at 30 days follow-up are similar between both groups and consistent with previously reported data. There was a small increase in the cardiac re-admission rate among patients in the ED group; however, this difference was statistically insignificant (4% vs 2.7%, $p = 0.998$). All these emphasize the safety of the ED of patients with uncomplicated STEMI within 48 h after PPCI.

The safety and feasibility of ED from hospital following an AMI has long been debated, triggered by increasing economic pressure within the healthcare system [7, 8]. In early days patients were hospitalized for several weeks after an AMI [9]. In the past half century, there has been a drastic decline in the length of stay, possibly secondary to transition from passive care to active contemporary care [10]. The 2017 ESC STEMI guidelines have considered ED with 48–72 h in select low-risk patients treated with PPCI (COR IIa; LOE A) [5, 10]. This recommendation is largely based on small trials and observational studies. Recent meta-analysis with data from seven randomized controlled trials and 1780 patients suggested the ED strategy after successful PPCI in selected low-risk patients [4, 11]. These data are encouraging because included studies in this meta-analysis stretched over a period of 20 years, and we know that STEMI care significantly transited during this period with new potent P2Y12 inhibitors, generalization of PPCI after STEMI, and changes in stent design and drug coatings [12]. In the GUSTO trial, “uncomplicated”

myocardial infarction is defined as the absence of death, re-infarction, ischemia, stroke, shock, heart failure, bypass surgery, intra-aortic balloon pumping, emergency catheterization, or cardioversion/defibrillation during the first four hospital days [13].

In the present era, there are several risk scores to risk-stratify patients. In the PAMI II trial, low risk was defined as age <70 years, LVEF >45%, one- or two-vessel disease, successful PCI, and no arrhythmia [11, 14]. De Luca et al. developed the most validated and accepted ZRS risk score (Zwolle risk score) for risk stratification in low-risk STEMI patients [15, 16]. Sharkawi et al. demonstrated that low-risk patients after uncomplicated STEMI managed successfully with PPCI identified using the CADILLAC risk score have low adverse events on the third day or later of hospitalization [17, 18]. Although these studies and several other studies carried out in the past showed that the ED of patients 48–72 h after uncomplicated STEMI treated with PPCI is safe, feasible, and cost-effective, large-scale randomized controlled trials are still scarce.

In our study with only LVEF as the predictor, we were able to correctly classify patients into their specific discharge group with an accuracy of 80.4%, a specificity of 87.7%, and a sensitivity of 71.2%. Our study also predicted that each 1% increase in LVEF is associated with a 3.5% increase in ED. Hence, with this simple tool, a large proportion of patients could be targeted for safe and ED with very few re-admissions. LVEF is a potent determinant of subsequent complications after PPCI, such as

arrhythmia and heart failure, which extends the length of hospital stay.

Length of hospital stay is one of the most important factors that add to the cost of in-hospital treatment after STEMI, and several studies have shown cost savings with a reduced length of hospital stay. Despite the fact that cost effectiveness was not evaluated in our study, a reduced length of hospital stay has the capacity to reduce healthcare costs among patients undergoing PPCI.

5. Conclusions

Preserved LV systolic function (LVEF > 50%) is a good predictor of early and safe discharge (within 48 h) after successful PPCI. The presented data support the practice of ED, with length of stay even shorter than current guidelines recommendation in selected low-risk patients defined as those with (1) non-anterior STEMI, (2) non-LM stenting, (3) no procedural complications, (4) no inotropic support, (5) no indication for oral anticoagulation, (6) no profound derangement of renal function or (7) glycemic control, and most importantly those with relatively (8) small infarct size based on maximum CPK level and LVEF. ED may help in reducing healthcare costs for providers of a PPCI service.

6. Limitations

As only 74 of the 301 patients were discharged early, the statistical power to define specific variables as independent predictor of early discharge was limited. Furthermore, the relatively small sample size and retrospective design precluded more extensive characterization of the cohort population and necessitates validation in a larger population prospective trial. Home support and distance from nearest medical centre is an important determinant of early discharge, which we did not include in our analysis. It is felt that in our small country where the access to health care system in the majority of cities is easy and fast, the impact of this factor is relatively low.

Author contributions

Conception and design of Study; Acquisition of data; Data preparation and presentation: Nooraldaem Yousif, Tarique S. Chachar. Literature review; Revising and editing the manuscript critically for important intellectual contents: Nooraldaem Yousif, Tarique S. Chachar; Suddharsan Subbramanyam, Vinayak Vadgaonkar, Husam A. Noor Analysis and interpretation of data; Research investigation and analysis: Nooraldaem Yousif.

Data collection: Tarique S. Chachar. Drafting of manuscript: Nooraldaem Yousif, Tarique S. Chachar; Suddharsan Subbramanyam, Vinayak Vadgaonkar. Supervision of the research; Research coordination and management; Funding for the research: Husam A. Noor.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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