Bypassing the Emergency Room to Reduce Door-to-Balloon Time and Improve Outcomes of Patients with ST Elevation Myocardial Infarction: The Acute Coronary Syndrome Israeli Survey Experience

Alla Lubovich MD[1], Hatem Hamood MD[1], Solomon Behar MD[2] and Uri Rosenschein MD[1]

[1]Department of Cardiology, Bnai Zion Medical Center, Haifa, Israel
[2]Neufeld Cardiac Research Institute, Sheba Medical Center, Tel Hashomer, Israel

ABSTRACT: **Background:** Rapid reperfusion of an infarct-related artery is crucial for the successful treatment of ST elevation myocardial infarction. Every effort should be made to shorten door-to-balloon time.

Objectives: To investigate whether bypassing the emergency room (ER) has a positive influence on door-to-balloon time in patients presenting with ST elevation myocardial infarction (STEMI) and whether the reduction in door-to-balloon time improves patients' clinical outcome.

Methods: We analyzed data of 776 patients with STEMI from the 2004 and the 2006 Acute Coronary Syndrome Israeli Survey (ACSIS) registry. The ACSIS is a biennial survey on acute myocardial infarction performed in all 25 intensive cardiac care units in Israel during a 2-month period. Twenty-five percent of patients (193 of 776) arrived directly to the intensive cardiac care unit (ICCU) and 75% (583 of 776) were assessed first in the ER. We compared door-to-balloon time, ejection fraction, 30 days MACE (major adverse cardiac and cerebrovascular events) and 30 days mortality in the two study groups.

Results: There was significantly shorter door-to-balloon time in the direct ICCU group as compared with the ER group (45 vs. 79 minutes, $P < 0.002$). Patients in the direct ICCU group were more likely to have door-to-balloon time of less than 90 minutes in accordance with ACC/AHA guidelines (88.7% vs. 59.2%, $P < 0.0001$). Moreover, patients in the direct ICCU group were less likely to have left ventricular ejection fraction < 30% (5.4% vs. 12.2%, $P = 0.045$) and less likely to have symptoms of overt congestive heart failure. Lastly, 30 days MACE was significantly lower in the direct ICCU group (22 vs. 30%, $P < 0.004$).

Conclusions: There is significant reduction of the door-to-balloon time in the direct ICCU admission strategy. This reduction translates into improvement in clinical outcome of patients. It is reasonable to apply the direct ICCU strategy to patients with STEMI.

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KEY WORDS: myocardial infarction, coronary angioplasty, coronary atherosclerosis, intensive coronary care, health policy

In the treatment of ST elevation myocardial infarction, rapid achievement of reperfusion of the infarct-related artery is beneficial for survival and myocardial salvage [1-3]. Primary percutaneous coronary intervention can achieve superior outcomes compared with fibrinolysis in the treatment of STEMI [4] and recent guidelines recommend primary PCI as the preferred reperfusion strategy in STEMI patients [5].

It was previously shown that a delay in door-to-balloon time of more than 2 hours results in both increased in-hospital and late mortality [6,7]. In contrast, rapid reperfusion results in improved myocardial salvage [8]. Based on the beneficial influence of rapid reperfusion on both short- and long-term outcomes, current American College of Cardiology/American Heart Association guidelines recommend a door-to-balloon time of < 90 minutes for patients with STEMI undergoing primary PCI [5]. Unfortunately, there are significant in-hospital delays for primary PCI, with < 40% of non-transferred patients achieving this goal [9]. Diverse strategies have been proposed to help decrease door-to-balloon time, including rapid acquisition and interpretation of 12-lead electrocardiogram, activation of the catheterization laboratory by an emergency room physician, and always having an attending cardiologist on site [10]. In the present study we wished to

STEMI = ST elevation myocardial infarction
ACSIS = Acute Coronary Syndrome Israeli Survey
ER = emergency room
MACE = major adverse cardiac and cerebrovascular events
PCI = percutaneous coronary intervention

determine whether direct admission of STEMI patients to an intensive cardiac care unit followed by immediate primary PCI system activation will result in reduced door-to-balloon time and improved clinical outcomes.

PATIENTS AND METHODS

THE ACUTE CORONARY SYNDROME ISRAELI SURVEY

Our study is based on data from the ACSIS registry, which is a prospective consecutive collection of national data from all acute coronary syndrome patients in Israel and is conducted biennially during a 2-month period in all 25 ICCUs in Israel. Data on all acute coronary syndrome patients are provided by each participating center by means of the pre-specified case report forms. The Central Data Coordinating Center is responsible for the collection of all case report forms and the Israel Heart Society is responsible for keeping the survey database. The 2004 and 2006 ACSIS included 4174 consecutive patients with acute coronary syndrome from the whole country. Of these, 1924 of the participating patients (46%) had STEMI and 793 of the STEMI patients (41%) were treated with primary PCI.

STUDY POPULATION

Our study population was taken from 793 consecutive STEMI patients treated by primary PCI at 25 ICCUs, located throughout Israel, who participated in the 2004 and 2006 ACSIS. We analyzed data from the 776 STEMI patients for whom the mode of transportation was available. There are several modes of patient transfer to hospital in Israel: direct transport to the ICCU by a mobile ICCU operated by physicians or paramedics who can establish an ECG diagnosis of STEMI, or transport to the emergency room by ambulance or private car. There is one major national emergency medicine care provider in all regions of Israel, known as Magen David Adom. Employees of the provider decide on the type of vehicle to be sent to a patient according to a strict protocol based on clinical symptoms and signs.

The catheterization laboratories in all 25 participating centers are located in close proximity to the ICCU. During work hours, the cath lab is available immediately; during off hours and weekends, a cath lab team is on call and can be recruited from home.

The patients were divided into two groups according to their mode of arrival to the ICCU. The direct-to-ICCU group included 193 patients who were brought directly to the ICCU by a mobile ICCU, and the ER group included 583 patients who arrived at the ER in a mobile coronary care unit (49%), ambulance (11%) or private car (40%) and were later referred to the ICCU after being seen by a consulting cardiologist. We compared the incidence of the primary and secondary endpoints in the two study groups.

DEFINITIONS

Door-to-balloon time was defined as the time from arrival at the hospital until the first balloon deflation. Pain-to-door time was defined as the time from the onset of chest pain until presentation to the hospital. Congestive heart failure was defined as Killip class 2 or higher; 30-day MACE (major adverse cardiac and cerebrovascular events) was defined as a composite measure of 30-day death, congestive heart failure, reinfarction, cerebrovascular accident or transient ischemic attack, and urgent revascularization.

ENDPOINTS

Primary endpoints were door-to-balloon time and 30-day MACE. Secondary endpoints were left ventricular ejection fraction before discharge, development of congestive heart failure during the hospital stay, and 7-day and 30-day mortality.

STATISTICAL ANALYSIS

The SAS Software (Version 8.2, SAS Institute Inc., Cary, NC, USA) was used for statistical analysis. Continuous variables were presented as mean ± standard deviation or median and interquartile range in cases of skewed distribution. Categorical variables were presented as percentages and were compared with the chi-square test. Continuous variables were compared with the unpaired Student *t*-test or Wilcoxon rank sum test if data were skewed. All tests were two-sided and P values < 0.05 were considered statistically significant.

RESULTS

The baseline characteristics were well balanced between the two groups. There was no significant difference in the demographic and clinical characteristics of the patients in the two groups [Table 1]. Furthermore, there was no difference in the

Table 1. Basic demographic and clinical characteristics of the direct-to-ICCU group and the ER group upon presentation

	Direct-to-ICCU group (n=193)	ER group (n=583)	*P*
Mean age (yrs, mean ± SD)	60.3 ± 12.0	60.9 ± 13.1	0.72
Gender: Female	22%	19%	0.35
Acute MI in the past	18%	16%	0.55
CABG in the past	2.1%	1.7%	0.75
PCI in the past	14%	15%	0.61
Dyslipidemia	48%	48%	0.98
Current smoking	48%	47%	0.80
Diabetes mellitus	24%	23%	0.94
Hypertension	43%	44%	0.77

CABG = coronary artery bypass graft, PCI = percutaneous coronary intervention, MI = myocardial infarction

Table 2. Prevalence of anterior STEMI, Killip class on presentation, and pain-to-door time in the direct-to-ICCU and ER groups

	Direct-to-ICCU group (n=193)	ER group (n=583)	*P*
Prevalence of anterior STEMI	48%	55%	0.37
Killip class 1	84%	81%	0.56
Killip class 2	9 %	12%	0.49
Killip class 3	3%	4%	0.81
Killip class 4	4%	3%	0.78
Pain-to-door time	116 min	120 min	0.63

STEMI = ST elevation myocardial infarction

prevalence of anterior STEMI or Killip class upon presentation [Table 2] between the two groups. Lastly, there was no difference in pain-to-door time between the direct-to-ICCU group and the ER group [Table 2] (116 and 120 minutes respectively, $P = 0.63$).

PRIMARY ENDPOINTS

- **Door-to-balloon time**

There was a significant 43% reduction in median door-to-balloon time in the direct-to-ICCU group compared with the ER group (45 and 79 minutes, respectively) [Figure 1]. Moreover, 88.7% of patients in the direct-to-ICCU group achieved a door-to-balloon time of < 90 minutes, in agreement with ACA/AHA guidelines, compared with only 59.2% of patients in the ER group ($P < 0.0001$).

- **30-day MACE**

Patients in the direct-to-ICCU group had a significantly lower rate of MACE than patients in the ER group (22% vs. 30% respectively, $P = 0.038$) [Figure 2].

ACA/AHA = American College of Cardiology/American Heart Association

Figure 1. Door-to-balloon time in the direct-to-ICCU group and the ER group

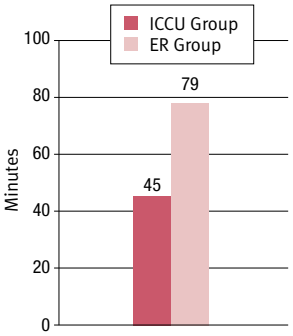
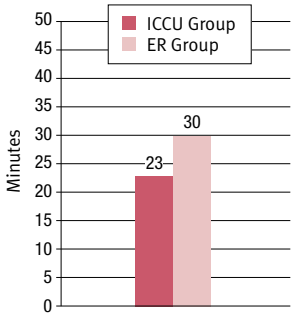


Figure 2. Thirty-day MACE in the direct -to-ICCU group and the ER group



SECONDARY ENDPOINTS

- **Left ventricular ejection fraction before discharge**

There was a significant difference in the distribution of LVEF between the two study groups ($P = 0.045$). More patients in the ER group had an LVEF < 30% than in the direct-to-ICCU group (12.2% vs. 5.4%, respectively). In contrast, more patients in the direct-to-ICCU group had LVEF ≥ 30% (94.6% vs. 87.8%, respectively).

- **Congestive heart failure**

Patients in the ER group experienced a higher incidence of congestive heart failure during hospitalization than patients in the direct-to-ICCU group (23% vs. 15% respectively, $P < 0.03$).

- **Mortality**

There was no significant difference in 7-day mortality between the direct-to-ICCU and the ER groups (4.7% vs. 2.9% respectively, $P = 0.24$). There was no significant difference in 30-day mortality between the direct-to-ICCU and ER groups (6.2% vs. 5.3% respectively, $P = 0.64$).

DISCUSSION

In the current study we show that out-of-hospital ECG diagnosis of STEMI, established by mobile ICCU personnel, and direct transfer of patients to the ICCU significantly reduces door-to-balloon time and improves adherence to ACA/AHA guidelines regarding optimal door-to-balloon time in STEMI patients. We found that direct ICCU admission was associated with a 34-minute reduction in median door-to-balloon time compared with patients admitted through the ER. Moreover, we demonstrated that 89% of direct admissions achieved the 90-minute door-to-balloon time target, compared with 59% admitted through the ER. Our findings are in agreement with a recent report by Dorsch et al. [11], demonstrating a significant reduction in the door-to-balloon time in STEMI patients admitted directly to a cardiac catheterization laboratory after being diagnosed by a paramedic. These authors showed that 94% of direct admissions achieved the 90-minute door-to-balloon target time compared with 29% of ER referrals [11]. However, adherence to the ACA/AHA-recommended 90-minute door-to-balloon time target was much better in our study cohort than in a recent report by Gross and colleagues [12]., in which only 58% of direct admissions and 37.5% of ER referrals achieved the 90-minute door-to-balloon time target.

More importantly, we show that reducing the door-to-balloon time translates into better clinical outcomes among patients in the direct-to-ICCU group. These patients had significantly lower rates of 30-day MACE, were less likely to have severely reduced left ventricular heart failure, and were

LVEF = left ventricular ejection fraction

less likely to have overt heart failure. Our report is the first to show the clinical implications of reducing door-to-balloon time in patients admitted directly to the ICCU.

In order to rule out confounding factors, we compared pain-to-door time, prevalence of anterior wall myocardial infarction, and distribution of Killip class upon admission between the two study groups. We found no significant differences in these factors between the groups. We were unable to demonstrate any survival benefit in the direct-to-ICCU groups; one plausible explanation might be the small size of the study groups and the low overall 7-day and 30-day mortality.

LIMITATIONS

Although our study prospectively assessed the impact of direct-to-ICCU admission on door-to-balloon time and clinical outcomes, it was not a randomized controlled trial and we cannot rule out other factors that could have influenced the observed reductions in door-to-balloon time and the improvements in clinical outcomes. However, the fact that the two study groups (direct-to-ICCU and ER) had similar basic clinical characteristics and pain-to-door time strongly suggests that the improvements seen in door-to-balloon time and clinical outcomes were due to the mode of admission to the ICCU (direct vs. through the ER).

Lastly, the direct admission policy was successfully implemented in Israel, a small country with a relatively large number of primary PCI facilities that are a short distance from almost any region and one major national emergency medicine care provider. This policy might not be applicable in the suburban settings of many other areas, which might be hundreds of miles away from any primary PCI facility. In such settings, prompt thrombolytic therapy at the closest primary care facility might be the treatment of choice for a STEMI patient.

CONCLUSIONS

Primary PCI is the most effective reperfusion therapy for patients with STEMI; however, despite recent advances in coronary angioplasty techniques aimed at reducing distal embolization with a thrombus aspiration device [13], and adjunct anticoagulant pharmacologic therapy aimed at reducing bleeding complications and improving therapeutic efficacy with the direct thrombin inhibitor, bivalirudin [14], STEMI patients still experience substantial mortality and morbidity, and every effort should be made to improve the clinical outcomes of these patients.

In our study, we show that direct-to-ICCU admission is an effective method of reducing door-to-balloon time in STEMI patients, enabling almost 90% of patients to be treated within the 90-minute target time. This reduction in the door-to-balloon time has a highly beneficial effect on clinical outcomes. We believe that direct-to-ICCU admission strategy is a crucial element of optimal care of a STEMI patient, along with optimal angioplasty and pharmacological therapy.

Corresponding author:
Dr. A. Lubovich
Dept. of Cardiology, Bnai Zion Medical Center, Haifa 33394, Israel
Phone: (972-4) 835-9744
Fax: (972-4) 835-9745
email: alla.lubovich@b-zion.org.il.

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"The only constant is change"

Heraclitus (535–475 BCE), Greek philosopher