

# Improving Door-to-Balloon Time of Patients with ST-Segment Elevation Myocardial Infarction (STEMI) in the Emergency Department

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**ABSTRACT:** **Background:** Door-to-balloon time (DTBT)  $\leq$  90 minutes has become an important quality indicator in the management of ST-elevation myocardial infarction (STEMI). We identified three specific problems in the course from arrival of STEMI patients at our emergency department to initiation of balloon inflation and determined an intervention comprised of specific administrative and professional steps. The focus of the intervention was on triage within the emergency department (ED) and on increasing the efficiency and accuracy of electrocardiography interpretation.

**Objectives:** To examine whether our intervention reduced the proportion of patients with DTBT  $>$  90 minutes.

**Methods:** We compared DTBT of patients admitted to the ED with STEMI during the year preceding and the year following implementation of the intervention.

**Results:** Demographic and clinical characteristics at presentation to the ED were similar for patients admitted to the ED in the year preceding and the year following intervention. The year preceding intervention, DTBT was  $>$  90 minutes for 19/78 patients (24%). The year after intervention, DTBT was  $>$  90 minutes for 17/102 patients (17%). For both years, the median DTBT was 1 hour. Patients with DTBT  $>$  90 minutes tended to be older and more often female. Diagnoses in the ED were similar between those with DTBT  $\leq$  90 minutes and  $>$  90 minutes. In-hospital mortality was 17% (13/78) and 14% (14/102) for the respective time periods.

**Conclusions:** An intervention specifically designed to address problems identified at one medical center was shown to decrease the proportion of patients with DTBT  $>$  90 minutes.

IMAJ 2018; 20: 476–479

**KEY WORDS:** door-to-balloon time (DTBT), electrocardiography (ECG), emergency department (ED), ST-elevation myocardial infarction (STEMI)

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During the last decade, door-to-balloon time (DTBT)  $\leq$  90 minutes has become an important quality indicator in the management of ST-elevation myocardial infarction (STEMI). A

landmark study that comprised 29,222 STEMI patients treated with percutaneous coronary intervention (PCI) at 395 hospitals demonstrated an additional 42% increased risk of in-hospital mortality among patients with DTBT  $\geq$  90 minutes compared to those with DTBT  $<$  90 minutes, after adjusting for patient characteristics. An increased risk remained even after considering symptom onset-to-door time and relevant risk factors [1]. In November 2006, the American College of Cardiology (ACC) and the American Heart Association (AHA) launched the Door-to-Balloon: An Alliance for Quality, in collaboration with 37 other organizations; 831 hospitals participated [2]. Among the strategies they proposed for improving DTBT were single-call activation and rapid preparation of the catheterization team. By 2008, the Alliance achieved its goal: DTBT of  $\leq$  90 minutes for at least 75% of non-transferred patients [3]. These findings demonstrate both the benefit and feasibility of DTBT  $\leq$  90 minutes. In the same year, ACC/AHA guidelines for the management of patients with STEMI included a recommendation for DTBT  $\leq$  90 minutes [4].

Carmel Medical Center is a university-affiliated hospital with over 400 beds located in Haifa, Israel. More than 80,000 patients present at the emergency department (ED) annually. In January 2014, as part of the hospital's quality assurance program, we assessed that 24% (19/78) of STEMI patients who presented to the ED during 2013 did not reach DTBT of  $\leq$  90 minutes. We aimed to identify possible reasons for the delay and implement an intervention to improve the DTBT of patients presenting to the ED.

The purpose of this study was to compare DTBT outcomes before and after implementation of the intervention.

## PATIENTS AND METHODS

### IDENTIFICATION OF REASONS FOR THE DELAY IN DTBT

We identified three main problems that might have caused a delay from arrival at the ED to the time of initiation of balloon inflation. First, some patients with chest pain were referred to the ambulant unit in the ED. Second, the time from electrocardiography (ECG) performance to physician interpretation

was sometimes delayed. Third, misinterpretation of the initial ECG by the nurse prevented immediate call to a physician. We determined four administrative and three professional steps to deal with these problems.

**Administrative steps:**

- All patients presenting with chest pain or dyspnea would be admitted to an in-patient unit
- ECG would be performed immediately and shown to a physician, without delay, in all cases (regardless of nurse interpretation)
- In analysis of ECG, physicians would be instructed to pay particular attention to the results of ST-segment changes and life-threatening conduction disturbances
- The attending physician would be required to document the ECG interpretation with his/her signature, official stamp, date, and time

**Professional steps:**

- Practical and theoretical training in ECG interpretation was initiated for all staff in the ED (physicians and nurses)
- Emphasis on the importance of quick interpretation and management would be presented at staff meetings
- The physician who reads the ECG would be responsible for immediate initiation of treatment and urgent cardiology consult according to patient presentation and ECG findings

We determined that implementation of these steps would be evaluated every 2 weeks.

**IMPLEMENTATION OF THE INTERVENTION**

In January 2014, we dedicated a staff meeting of ED physicians and nurses to the subject of DTBT. The specific topics discussed included the importance of achieving DTBT ≤ 90 minutes, the reasons identified for delays in DTBT at our emergency department, the administrative and professional steps that would be undertaken for the intervention, and the means determined to assess the intervention. Training in ECG interpretation was the subject of an additional staff meeting. Online material was also distributed on this subject. From January to December 2014, the intervention was addressed at staff meetings every 2 weeks.

**DATA COLLECTION**

We collected data from the medical records of patients who presented to the ED and who underwent primary PCI due to STEMI during two time periods: from January to December 2013, the year preceding the intervention; and from January to December 2015, the year following the intervention. The data collected included: age, gender, complaint at presentation, diagnosis in the ED, DTBT, and mortality during hospitalization. The main outcome measure was DTBT. A secondary outcome measure was in-hospital mortality.

**RESULTS**

During 2013, the year preceding the intervention, 78 patients presenting with STEMI were admitted to the ED. During 2015, the year following the intervention, 102 patients presenting with STEMI were admitted to the ED. Demographic and clinical characteristics at presentation were similar for the patients admitted to the ED before and after the intervention [Table 1]. Of the patients reaching the emergency department, 25% arrived by means of a mobile coronary care unit.

Both before and after the intervention, the median DTBT was 1 hour. Before the intervention, DTBT was > 90 minutes for 19 (24%) patients. After the intervention, DTBT was > 90 minutes for 17 (17%) patients. Patients with DTBT > 90 minutes tended to be older (58% and 59% were aged 65 years or older before and after the intervention, respectively, compared to 51% and 46%, respectively, among patients with DTBT < 90 minutes) and more often female (21% and 41% before and after the intervention, respectively, compared to 12% and 20%, respectively among those with DTBT < 90 minutes) [Table 2]. Diagnoses in the ED were similar between those with DTBT ≤ 90 minutes and > 90 minutes (data not shown). In the pre-intervention group, 13 (17%) died during hospitalization; of them, 6 (46%)

**Table 1.** Characteristics of patients admitted to the emergency department with STEMI before and after the intervention

Characteristic	Before the intervention	After the intervention
Participants	n=78	n=102
Median age, years	66	63.5
< 65 years	37 (47%)	53 (52%)
≥ 65 years	41 (53%)	49 (48%)
<b>Gender</b>		
Male	67 (86%)	78 (76%)
Female	11 (14%)	24 (24%)
<b>Diagnosis in emergency department</b>		
Intermediate coronary syndrome	24 (31%)	38 (37%)
Acute MI	22 (28%)	34 (33%)
Chest pain	12 (15%)	22 (22%)
Other	20 (26%)	8 (8%)
DTBT < 90 minutes	59 (76%)	85 (83%)
In-hospital mortality	13 (17%)	14 (14%)

DTBT = door-to-balloon time, MI = myocardial infarction, STEMI = ST-elevation myocardial infarction

**Table 2.** Demographic characteristics of patients with DTBT ≥ 90 and < 90 minutes

Characteristic	DTBT	Before the intervention	After the intervention
Age ≥ 65 years	≥ 90 minutes	11/19 (58%)	10/17 (59%)
	< 90 minutes	30/59 (51%)	39/85 (46%)
Female gender	≥ 90 minutes	4/19 (21%)	7/17 (41%)
	< 90 minutes	7/59 (12%)	17/85 (20%)

DTBT = door-to-balloon time

had DTBT > 90 minutes. In the post-intervention group, 14 (14%) died during hospitalization; of them, 5 (36%) had DTBT > 90 minutes.

## DISCUSSION

This study showed improvement in DTBT after a simple intervention that combined administrative and professional measures. At the start of the intervention, the proportion of patients with DTBT < 90 minutes (76%) already reached the target of the Door-to-Balloon Alliance (75%) [2]. Still, we demonstrated improvement following implementation of our intervention, with achievement of the target time in 83% of STEMI patients. While a recent publication showed decreased DTBT of all STEMI patients admitted to our medical center [5], the current report focused only on STEMI patients who were admitted to the ED.

The intervention we described and assessed focused on the particular problems identified in our management of STEMI patients; triage within the ED, and the efficiency and accuracy of interpretation of ECG. A small study conducted in Saudi Arabia divided DTBT into intervals, each with its own targeted time at their medical center [6]: door to ECG (goal ≤ 10 min), ECG to catheterization laboratory team activation (goal ≤ 5 min), catheterization laboratory activation to patient arrival at catheterization laboratory (goal ≤ 45 min), and arrival to catheterization laboratory to balloon inflation (goal 15 min). The researchers allowed 15 minutes for system delays. Our intervention focused on the first two intervals of this scheme: initiation of ECG and the time immediately following the ECG. While activation of the catheterization laboratory was a primary focus of the Door-to-Balloon Alliance [2], as well as of several other interventions [7-9], activation of the catheterization laboratory was not a bottleneck in our process. Rather, the decision for activation, as determined by timely performance and accurate interpretation of the ECG, was identified as a main problem. Our single-center study highlights the importance of focused analysis of the management of STEMI patients arriving at the EDs at specific centers, to identify particular areas for potential improvement. An example of an intensive process undergone by another single center is described for a hospital in the United Arab Emirates [9].

The single-center experience contrasts with the potential impact of large coalitions; the latter may influence quality measures even in centers with which they have no direct connection. Moreover, the findings of a nationwide analysis in the United States reported an increase in the proportion of patients with DTBT < 90 minutes from 44% to 91% from 2005 to 2010 [10]. However, although DTBT has become recognized as a quality indicator throughout the world, its achievement remains low in some regions, particularly outside the United States. A recently published study based on a prospective mul-

ticenter database in Japan reported that the DTBT for half of STEMI patients was > 90 minutes [11].

Our study was not large enough to conduct a statistical analysis of risk factors that may be associated with higher DTBT. However, patients with DTBT > 90 minutes tended to be older and more often female. A systemic review, comprising 90 articles, identified the absence of chest pain as a factor associated with longer DTBT [12].

Whether shortening DTBT improves patient outcome is unclear. Our study did not have the power to determine an association between DTBT and in-hospital mortality. However, a number of larger studies showed no change of in-hospital mortality [13,14] despite substantial shortening of DTBT. Among the few studies that examined an association between DTBT and mortality after hospitalization, the data are also inconclusive. An Australian study reported that DTBT < 90 minutes was associated with improved clinical outcomes, including survival, at 12 months [15]. However, a study conducted in Taiwan reported no association with DTBT and 1 year cardiovascular mortality [16]. A multi-centered study conducted in Israel showed a longer median DTBT for patients who were first evaluated in the ED, compared to patients who arrived directly to an intensive cardiac care unit or to the catheterization laboratory [14]; yet, similar 30 day and 1 year morbidity and mortality were observed for both groups. A study that analyzed data from 423 U.S. hospitals reported a lack of association of median annual DTBT with changes in mortality [17]; however, the investigators concluded that this finding may be due to an increase over the years of PCI procedures and to a consequently poorer risk profile of the patients undergoing PCI. A large Australian study that also addressed patient risk files, reported DTBT ≤ 90 minutes to be an independent predictor of long-term survival only in low-risk STEMI patients [18].

Clearly, factors unrelated to DTBT affect patient outcomes. Symptom-to-door time was not examined in the current study, and its impact remains controversial. Analysis of data from the prospective multi-centered HORIZON-AMI trial showed both symptom-to-door time and DTBT to be independent predictors of impaired myocardial perfusion [19]. A single center study in the United States found optimal ischemic time, defined as the time from symptom onset to device activation, to be a better predictor of 30 day mortality than DTBT [20]. Moreover, a Japanese study conducted in 26 hospitals reported an association of short DTBT with better 3 year clinical outcomes only in patients who presented to the hospital within two hours of symptom onset [21]. Compared to DTBT, symptom-to-door time is more difficult to assess and cannot serve as a hospital quality indicator.

Establishment of the 90 minute cutoff for DTBT has raised awareness worldwide to the importance of timely catheterization in STEMI patients. However, the optimal cutoff for DTBT

remains inconclusive. Data collected two decades ago showed that patients in nearly 330 U.S. community and tertiary care hospitals that were investigated had DTBT longer than 2 hours, and that this longer DTBT time was associated with increased in-hospital mortality [22]. Thereafter, 90 minutes became the target for DTBT in quality assurance; and numerous clinical studies and interventions assessed its achievement and outcomes. Fewer studies have investigated the achievement and outcomes of the 2012 ESC guidelines, which recommended DTBT of  $\leq 60$  minutes. A study in Taiwan showed that achievement of this guideline was associated with improved survival in STEMI patients who were younger than 65 years of age, but not those who were older [23]. Another Taiwanese study showed an association of DTBT  $< 60$  minutes with decreased 30 day mortality [24]. However, a number of publications have addressed the possibility that some attempts may go too far in reducing DTBT, thus yielding adverse consequence [25].

**STUDY LIMITATIONS**

The retrospective design is a limitation of this study. Moreover, due to the before and after design, we were not able to assess whether processes unrelated to our intervention may have impacted the outcomes. In addition, we were not able to evaluate the distinct effects of the various components of the intervention.

**CONCLUSIONS**

This study showed that an intervention that focused on the problems identified at one institution decreased the proportion of patients arriving at the ED with STEMI for whom DTBT  $> 90$  minutes.

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