An Intervention to Reduce the Time Interval Between Hospital Entry and Emergency Coronary Angiography in Patients with ST-Elevation Myocardial Infarction

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ABSTRACT: **Background:** Outcomes of patients with acute ST-elevation myocardial infarction (STEMI) are strongly correlated to the time interval from hospital entry to primary percutaneous coronary intervention (PPCI). Current guidelines recommend a door to balloon time of < 90 minutes.

Objectives: To reduce the time from hospital admission to PPCI and to increase the proportion of patients treated within 90 minutes.

Methods: In March 2013 the authors launched a seven-component intervention program:

1. Direct patient evacuation by out-of-hospital emergency medical services to the coronary intensive care unit or catheterization laboratory
2. Education program for the emergency department staff
3. Dissemination of information regarding the urgency of the PPCI decision
4. Activation of the catheterization team by a single phone call
5. Reimbursement for transportation costs to on-call staff who use their own cars
6. Improvement in the quality of medical records
7. Investigation of failed cases and feedback

During the 14 months prior to the intervention, initiation of catheterization occurred within 90 minutes of hospital arrival in 88/133 patients (65%); during the 18 months following the start of the intervention, the rate was 181/200 (90%) ($P < 0.01$). The respective mean/median times to treatment were 126/67 minutes and 52/47 minutes ($P < 0.01$). Intervention also resulted in shortening of the time interval from hospital entry to PPCI on nights and weekends.

Conclusions: Following implementation of a comprehensive intervention, the time from hospital admission to PPCI of STEMI patients shortened significantly, as did the proportion of patients treated within 90 minutes of hospital arrival.

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KEY WORDS: door-to-balloon time, ST-elevation myocardial infarction (STEMI), quality intervention, primary percutaneous coronary intervention (PPCI)

Primary percutaneous coronary intervention (PPCI) has become the preferred method of reperfusion in patients with acute ST-elevation myocardial infarction (STEMI) [1]. U.S. and European guidelines recommend a door-to-balloon (D2B) time (the interval from a patient's arrival at the hospital to inflation of the balloon to restore flow) of less than 90 minutes, and encourage institutions to develop strategies aimed to reduce delays [2,3]. The care of patients from the emergency department (ER) to the catheterization laboratory and initiation of catheterization requires the active and coordinated involvement of multiple teams within the hospital [4,5]. Therefore, D2B can be considered as a reflection of the overall quality of care in a hospital. Analysis of our database at the Carmel Medical Center revealed that less than 85% of STEMI patients were undergoing catheterization within 90 minutes of hospital entry. This realization prompted the department management to initiate an intervention program. We analyzed the current process and identified delays that appeared to impair performance. A literature search revealed a number of interventions designed to shorten D2B time in STEMI patients [4-8] that were relevant to the processes at our center. We also identified unique features of our health system and working laws that required novel interventions.

Since 2012 our administrative computer system has documented the time interval from the patient's arrival at the hospital to initiation of coronary catheterization (door-to-catheterization, D2C) but not to device insertion within the coronary culprit lesion. In this report we describe the implementation

and evaluation of the intervention we developed to reduce D2C time. Since only patients who presented with STEMI and underwent PPCI were included in the quality measurement that prompted this intervention we report only these patients and do not report data of patients with ST elevation who did not undergo angioplasty.

PATIENTS AND METHODS

From analysis of data regarding the D2C interval, available since January 2012, we identified seven points of the process critical to performance, which could serve as focal points for an intervention:

1. Communication with out-of-hospital emergency medical services (EMS)
2. Time required for diagnosis in the ER
3. Decision to initiate PPCI
4. Activation of the catheterization team
5. Transportation of the catheterization team to the hospital
6. Medical record accuracy and compliance with International Classification of Diseases, Ninth Revision (ICD-9) diagnoses
7. Investigation of failed cases and feedback

In March 2013 we launched an intervention program aimed to reduce the D2C time for STEMI patients. Our program comprised the following interventions to address the seven points of the process that were found to be critical to performance.

- **Direct communication with the EMS** and encouragement to direct evacuation of STEMI patients with the cardiology division and catheterization laboratory, bypassing the ER and eliminating ER related delays.
- **Education program for the ER staff.** We observed that ER-related delays occurred mainly in the afternoon, at night, and on weekends, so we introduced an education program to the ER medical and nursing staff to improve the triage process, with emphasis on the younger staff. Frontal lectures were presented and the staff was encouraged to accompany patients with STEMI and watch the management at the catheterization laboratory.
- **Dissemination of information** that emphasizes the urgency of the decision to perform emergency PPCI, a decision that is usually taken by the cardiology fellow on-duty and the interventional cardiologist on call. We noticed that for patients with atypical presentations, long delays occurred before the decision to pursue PPCI. We addressed this issue specifically by providing feedback to the involved physicians, both during the morning departmental meetings and at individual sessions.
- **Simplification of the activation process** of the catheterization team. Prior to the intervention, the cardiology fellow had to personally contact the on-call members of the catheterization team and hospital security. This procedure was done in parallel with patient management. We changed this process by introducing a mechanism by which team activation was performed by a single call from the cardiologist on duty to the central page operator who received on-call team lists every month.
- **Payment for travel costs to on-call staff** who used their own vehicles to arrive at the hospital. Prior to the intervention, the catheterization team staff would arrive at the hospital by taxis sent to their homes from different taxi companies. The hospital administration was involved in the change in the method of reimbursement for transportation. There was no change in payment to participating staff, including physicians, other than reimbursing technicians and nurses for using their own vehicle.
- **Improvement in the quality of medical records.** Performance measurements are partially based on catheterization reports and discharge summaries. We realized that some STEMI patients were not included in the quality measurements while other non-STEMI patients were included in the measurements. These errors occurred due to incorrect diagnoses recorded by the physicians involved. We explained the process to all the physicians and instructed them to use only ICD-9 format in catheterization reports and discharge summaries.
- **Case investigation and feedback.** A standard investigation format was established, which included a written report for each patient with D2C more than 90 minutes. Time-intervals were measured and feedback was sent to department staff and other staff members who were involved in the specific patient management.

STUDY POPULATION

We analyzed data of all consecutive patients with STEMI who underwent PPCI during the 14 months prior to initiation of the intervention (1 January 2012 to 28 February 2013) and the 18 months afterward (1 March 2013 to 31 August 2014). Major intervention efforts were incorporated during the first 3 months of the intervention but several components of the intervention were maintained throughout the period of this report (and thereafter). Data were included in the analysis of patients who arrived to the hospital with acute symptoms and electrocardiogram (ECG) showing ST-segment elevation in two contiguous leads, measured at the J point, with ≥ 0.25 mV in men below the age of 40 years, ≥ 0.2 mV in men over age 40 years, and ≥ 0.15 mV in women, in leads V_2–V_3 and/or ≥ 0.1 mV in other leads (in the absence of left ventricular hypertrophy or left bundle branch block [LBBB]). Data were excluded from the analysis of patients for whom STEMI developed after the hospital entry, no PCI was performed after the diagnostic coronary angiography or if no myocardial infarction was diagnosed during the index hospitalization. To further study the effects of the intervention on D2C time, we analyzed the data

of patients arriving during working hours (Sunday to Thursday, 0700–1900, Friday 0700–1300) and compared their data to that of patients arriving at night or during weekends.

ENDPOINTS

The primary endpoint was the proportion of STEMI patients undergoing PPCI with D2C ≤ 90 minutes. Secondary endpoints were the mean and median D2C, with separate workup for patients who passed through the ER and those who bypassed the ER.

STATISTICAL METHODS

For parametric data we used the chi-square test, and for continuous data we used Student's *t*-test. $P < 0.05$ was considered statistically significant.

RESULTS

PPCI was performed in 133 STEMI patients prior to the study period and in 200 patients following initiation of the intervention. For the respective periods, D2C was ≤ 90 minutes for 88 (65%) and 181 (91%) of the patients, respectively, $P < 0.01$. Prior to the intervention the percent of STEMI patients with D2C time of < 90 minutes was inconsistent, and only reached the 85% threshold during 2/14 months. After intervention the threshold of 85% was achieved in all months but the first month of intervention (17/18) [Figure 1A and 1B].

Before the intervention 52/133 (39%) patients arrived after working hours, while after the intervention 105/200 (52%) patients arrived after working hours. This change in the proportion of patients arriving after working hours, with a majority arriving during nights and weekends following the intervention, is probably due to our center becoming the preferred site for EMS referral of STEMI patients. This resulted from the first step in our intervention, namely, direct communication with EMS. Rebranding our hospital as a center of excellence for treating STEMI patients was a secondary result of the intervention to improve D2C time.

The mean and median D2C times were significantly shortened after intervention [Table 1]. The number of patients who bypassed the ER increased from 25% to 42% from the pre- to post-intervention period. Mean D2C times decreased after initiation of the intervention for both patients who arrived at the ER and those who bypassed the ER [Figure 1B]. The mean D2C times for patients who bypassed the ER were 41 minutes and 29 minutes, for the respective periods. The proportion of patients for whom D2C time was > 180 minutes was significantly lower after the intervention, 1% vs. 14%. D2C improved in patients arriving both during working hours and during nights and weekends. Improvement after the intervention was pronounced in patients arriving at the ER but was also apparent (> 15 minute reduction) in patients bypassing the ER, although it did reach statistical significance [Table 2 and Table 3]. When we grouped all patients bypassing ER (working hours, nights and weekends), D2C time was reduced from 41 ± 37 to 29 ± 20 minutes ($P < 0.03$) after intervention, which attests to the success of all of the steps of our intervention.

DISCUSSION

Quality measures in medicine are instrumental in closing the gap between scientific medical research and daily, real world

Figure 1A. The monthly percent of STEMI patients for whom door to catheterization (D2C) was ‹ 90 minutes. STEMI = ST-elevated myocardial infarction, D2C = door-to-catheritzation

The pink arrow indicates the date of initiation of the intervention. The dotted grey line indicates the threshold of 85% of patients with D2C ‹ 90 minutes. Prior to the intervention, the percent of STEMI patients with D2C time of ‹ 90 minutes was inconsistent with only 2/14 months reaching the threshold of 85%. After intervention the threshold of 86% was achieved in all months but the first month of intervention [17/18]

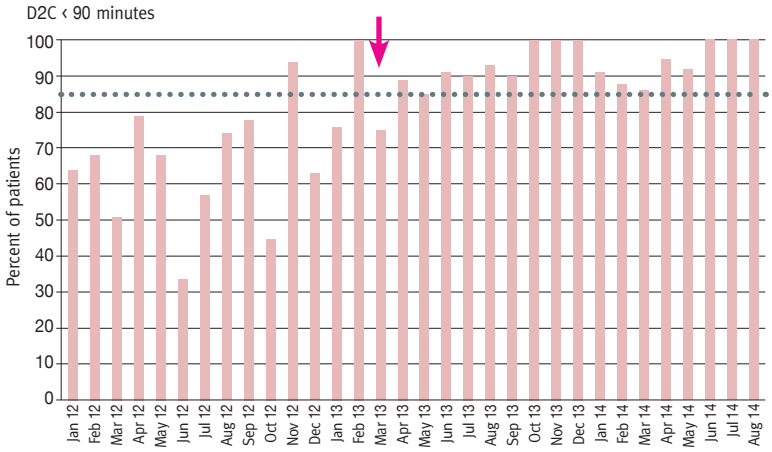
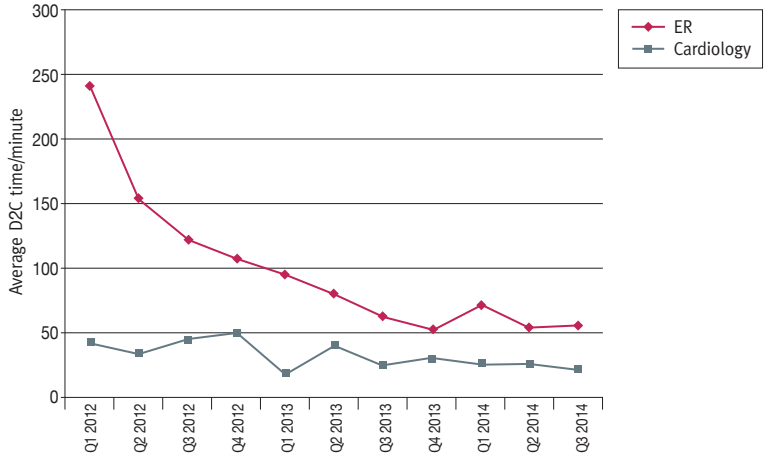


Figure 1B. Quarterly mean door to catheterization (D2C) times for patients who arrived to the emergency department and those who bypassed the emergency department. After initiation of the intervention, marked reductions in mean D2C times were observed for both of these groups



ER = emergency department

Table 1. Comparisons between the periods before and after initiation of the intervention, in data related to D2C (hospital arrival time to initiation of catheterization)

	Before intervention (n=133)	After intervention (n=200)	*P* value
D2C time, mean ± SD (minutes)	126 ± 196	53 ± 57	0.00001
Median	67	47	
Proportion of patients for whom D2C ≤ 90 minutes	88/133 (66%)	181/200 (91%)	0.00001
Proportion of patients for whom D2C was › 180 minutes	19/133 (14%)	2/200 (1%)	0.00001
Proportion of patients who bypassed ER	33/133 (25%)	83/200 (42%)	0.0017
D2C time in patients who bypassed ER, mean ± SD (minutes)	41 ± 37	29 ± 20	0.00001
D2C time in patients who arrived initially to the ER, mean ± SD (minutes)	154 ± 228	69 ± 67	0.00001

SD = standard deviation, D2C = door-to-catheterization, ER = emergency department

Table 2. Patients that arrived through emergency department

	During working hours Number catheterized within 90 minutes*	Off working hours Number catheterized within 90 minutes*
Before intervention	39/59 (66%)	18/41 (44%)
After intervention	46/53 (87%)	52/64 (81%)
	D2C time (mean ± SD) (minutes)*	**D2C time (mean ± SD) (minutes)***
Before intervention	124 ± 23	171 ± 209
After intervention	59 ± 209	78 ± 86
All	68 ± 112	90 ± 130

*P ‹ 0.05 comparing before and after intervention

SD = standard deviation, D2C = door-to-catheritzation

Table 3. Patients that bypassed emergency department

	During working hours Number catheterized within 90 minutes	Off working hours Number catheterized within 90 minutes
Before intervention	21/22 (95%)	11/11 (100%)
After intervention	42/42 (100%)	37/37 (100%)
	D2C time (mean ± SD) (minutes)	**D2C time (mean ± SD) (minutes)**
Before intervention	37 ± 44	58 ± 12
After intervention	19 ± 20	38 ± 16

SD = standard deviation, D2C = door-to-catheritzation

practice [9]. The management of STEMI patients changed dramatically with the introduction of reperfusion therapy [10-12]. The transition from fibrinolytic treatment to percutaneous reperfusion resulted in further reduction of in-hospital mortality [13,14]. Improved outcomes of STEMI patients are strongly related to shortening the time intervals between symptom appearance and treatment [13-15]. While the time between symptom onset and hospital arrival depends mainly on the patient, the time lapse between hospital entry and reperfusion depends on the hospital team and resources. In a survey performed between 1999 and 2002 the U.S. National Registry of Myocardial Infarction (NRMI) investigators found that the D2B gold standard of 90 minutes was not achieved for many patients [11]. Several studies have shown that the focus on D2B time in STEMI management guidelines has reduced D2B time and improved patient prognosis [12-16]. Using D2B as a quality measure, as we have done, can further improve the management of STEMI patients. Implementation of quality measurements serves as a mirror that reflects actual performance – in the current case the performance in treating STEMI patients. After recognition that our performance was below expectations, we launched an initiative based on process analysis that took into account unique features of our system. As in other reports [4,5,6,17-19], the intervention improved the scores of our performance, as demonstrated by a significant rise in the proportion of patients for whom D2C was within 90 minutes.

In the period following the intervention, the proportion of patients who arrived directly to the catheterization laboratory or coronary care unit, bypassing ER, was increased. This was apparently due to the improved communication between out-of-hospital and in-hospital teams. The importance of such communication was also demonstrated in a study by McCabe et al. [19] and Sardi et al. [20].

To increase awareness of the ER team at our center to the urgency of STEMI diagnosis and treatment, close collaboration was required with the Department of Internal Medicine; the latter provides night and weekend ER physicians on duty. Effective collaboration between different departments within a hospital is a major factor of the quality of the hospital, which evidently manifests in such quality measurements as D2B time [4,5].

For 19 of the 133 patients in the pre-intervention period, D2C time intervals were longer than 180 minutes. We considered D2C > 180 minutes as an indication of failure to diagnose STEMI on presentation. Patients with extremely long time intervals usually had atypical clinical presentation or ECG patterns, such as LBBB and atrioventricular block. Patients with typical findings that had D2C > 180 were undiagnosed by the initial staff evaluating them. Thus, failure to diagnose STEMI on presentation was reduced from 19/133 to 2/200 after intervention. Similar delays in D2B time in patients with LBBB were described by Peterson and colleagues [21]. For such patients we identified the decision-making process as a point in time requiring intervention. In our department, the decision whether to catheterize a patient is usually made by the cardiology fellow on duty and the senior cardiologist on call. As part of the intervention we started emphasizing at departmental meetings the responsibility of making a prompt decision rather than

observing these patients. After the intervention, D2C intervals exceeded 180 minutes for only 2 of 200 patients. However, expediting decision making carries risks such as unnecessary catheterization, as elegantly described by Fanari et al. and Patel et al. [22,23]. With our real time feedback system we did not detect patients who underwent unnecessary catheterization as all patients had had either on-going chest pain or ECG, together with laboratory findings confirming myocardial infarction. The percentage of patients with ST-segment elevation and no need for PPCI did not change over the time of the intervention.

Our data does not enable us to assess the relative contribution of the simplified system for alerting the catheterization with a single phone call to the reduction in D2C. However, other groups reported the benefit of a similar components of interventions to reduce D2B time [4,24]. While hospitals that undertake interventions to improve quality may share certain features with our intervention, unique features in our center relate to the residency and fellowship programs in our country and to working laws. At night, ER physicians are internal medicine residents who do not have training in cardiology beyond the training received at the department of internal medicine. We therefore decided to implement compulsory lectures on myocardial infarction including ECG reading. Regarding working laws in Israel, employers must pay the employees for using their private vehicles; otherwise, it is the employer's responsibility to provide transportation during on-call shift hours. Therefore, reaching an agreement for payment for use of private cars was required to shorten the time of arrival of the catheterization on-call team.

An important limitation of the current study is that we assessed the time from the patients' arrival at the hospital to the initiation of the catheterization procedure (D2C), and not the time interval from the first medical contact to reperfusion. At our medical center, the administrative computing system is not connected to the clinical catheterization laboratory computing system. Since data retrieval for quality measurements should be independent of the team whose performance is measured, D2C is the most accurate measurement in our system. At our institution D2C time is defined as the interval between arrival at the hospital to patient transfer to the catheterization laboratory bed, which is reported by the X-ray technician using the computerized administrative system. We considered assessing self-reports of balloon inflation time but realized that this would produce noise and inaccuracies in quality measurements. Errors and self-reports can bias quality measurements and make such tools useless as measures for improvement. Obviously, non-system related delays such as finding an access site and crossing the lesion were not measured, but we assume that such delays occurred in similar proportions of patients before and after the intervention [25]. Thus, in the current study we think that D2C time is a valid measurement for assessment of a quality improvement intervention.

CONCLUSIONS

In summary, we used a quality improvement intervention that comprised a number of components that previously demonstrated benefit and several unique features. The result was significant reduction in the time from hospital arrival of STEMI patients to the time of initiation of catheterization.

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Capsule

Seven-year outcomes of the silicone arthroplasty in rheumatoid arthritis prospective cohort study

Rheumatoid arthritis (RA) causes destruction of the metacarpophalangeal (MCP) joints, leading to hand deformities, pain, and loss of function. Chung and co-authors prospectively assessed long-term functional and health-related quality-of-life outcomes in RA patients with severe deformity at the MCP joints. RA patients between ages 18 to 80 years with severe deformity at the MCP joints were referred to one of the three study sites. Subjects who elected to undergo silicone metacarpophalangeal joint arthroplasty (SMPA) while continuing with medical management were followed in the SMPA cohort. Subjects who elected to continue with medical management alone without surgery were followed in the non-SMPA cohort. Objective measurements included grip and pinch strength as well as arc of motion, ulnar drift, and extensor lag of the MCP joints. Patient-reported outcomes included the Michigan Hand Questionnaire (MHQ) and the Arthritis Impact Measurement Scales questionnaire. Radiographs of SMPA implants were assessed and graded as intact, deformed, or fractured. MHQ scores showed large improvements post-SMPA, and baseline-adjusted expected outcomes in the SMPA group were significantly better at year 7 in function, aesthetics, satisfaction, and overall score compared to non-SMPA. SMPA subjects did not improve in grip or pinch strength, but achieved significant improvement and maintained the improvement long term in ulnar drift and extensor lag.

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Capsule

Disease management in the treatment of patients with chronic heart failure who have access to universal healthcare: a randomized controlled trial

The efficacy of disease management programs in improving the outcome of heart failure patients remains uncertain and may vary across health systems. Katler-Laibovici et al. explored whether a country-wide disease management program is superior to usual care in reducing adverse health outcomes and improving well-being among community-dwelling adult patients with moderate-to-severe chronic heart failure who have access to universal advanced healthcare services and technologies. In this multi-center open-label trial, 1360 patients recruited after hospitalization for heart failure exacerbation (38%) or from the community (62%) were randomly assigned to either disease management or usual care. Disease management, delivered by multi-disciplinary teams, included coordination of care, patient education, monitoring disease symptoms and patient adherence to medication regimen, titration of drug therapy, and home telemonitoring of body weight, blood pressure, and heart rate. Patients assigned to usual care were treated by primary care practitioners and consultant cardiologists. During the follow-up, 388 patients (56.9%) assigned to disease management and 387 (57.1%) assigned to usual care had a primary endpoint event. The median (range) time elapsed until the primary endpoint event or end of study was 2.0 (0–5.0) years among patients assigned to disease management, and 1.8 (0–5.0) years among patients assigned to usual care (adjusted hazard ratio, 0.908; 95% confidence interval, 0.788–1.047). Hospital admissions were mostly (70%) unrelated to heart failure. Patients assigned to disease management had a better health-related quality of life and a lower depression score during follow-up.

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