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Authors

Mumma, Bryn E
Eggert, James
Mahler, Simon A
et al.

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Association Between Hospital Practices and Door-in-door-out Time in ST-segment Elevation Myocardial Infarction

Bryn E. Mumma, MD, MAS,* James Eggert, BS,† Simon A. Mahler, MD, MS,‡ Michael C. Kontos, MD,§ and Deborah B. Diercks, MD, MSc¶

Background: Current guidelines suggest a “door-in-door-out” (DIDO) time of 30 minutes or shorter for patients with ST-segment elevation myocardial infarction (STEMI) who arrive at a STEMI referral hospital and are transferred to a STEMI-receiving center for primary percutaneous coronary intervention. Experts previously identified 18 system practices as critical for reducing DIDO times. The objective of this study was to describe how frequently these critical practices are used and to determine whether their use was associated with shorter DIDO times.

Methods: We surveyed 18 STEMI referral hospitals for 4 STEMI-receiving centers regarding their use of these 18 practices. The median number used was 14 practices (interquartile range 12–15). We then evaluated their association with DIDO times in all patients ($n = 93$) transferred from these STEMI referral hospitals to the 4 STEMI-receiving centers for primary percutaneous coronary intervention.

Results: In univariate linear regression analyses, system-wide quality improvement programs with leaders in the emergency medical services agencies and STEMI referral hospitals were associated with shorter DIDO times ($P < 0.001$ for all). Overall use of system practices was not associated with DIDO times ($P = 0.143$). The majority (76%, 95% confidence interval: 66%–85%) of DIDO times did not meet the 30-minute goal.

Conclusions: These findings highlight the difficulty in achieving the 30-minute DIDO goal and the need for continued focus on strategies for reducing DIDO time, including system-wide quality improvement programs.

Key Words: myocardial infarction, patient transfer, time-to-treatment, emergency medical services

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Approximately 250,000 patients suffer from an ST-segment elevation myocardial infarction (STEMI) each year in the United States.¹ Timely percutaneous coronary intervention (PCI) reduces morbidity and mortality, and many patients with STEMI require emergent transfer to a PCI-capable hospital.^{2,3} The American Heart

Association and American College of Cardiology (AHA/ACC) suggest a goal of 30 minutes for the time interval from arrival at the non-PCI capable STEMI referral hospital to departure for the PCI-capable STEMI receiving hospital (door-in-door-out time; DIDO) and a goal of 120 minutes for the time interval from first medical contact to PCI at the STEMI receiving hospital.^{4,5} However, these goals are met in only a minority of patients.^{2,6–9}

STEMI systems of care including emergency medical services (EMS), STEMI referral hospitals, and STEMI receiving centers have been developed to reduce these time intervals and improve outcomes for patients with STEMI. We previously identified 18 system practices recommended to minimize transfer times to STEMI-receiving centers.¹⁰ However, the association between these practices and DIDO time remains unknown. Our objective in this study was to describe the use of these 18 system practices and to characterize the association between their use and DIDO time for patients with STEMI who present to a non-PCI capable hospital and are transferred for primary PCI.

METHODS

Study Design

We conducted a retrospective cohort study including all patients with STEMI who presented to a STEMI-referral hospital and were transferred to 1 of 4 STEMI-receiving centers from January 1, 2012 to December 31, 2013 for primary PCI. We also surveyed key personnel at each of the STEMI-referral hospitals regarding their use of the previously identified 18 system practices to minimize transfer time during 2012–2013 (supplemental material, available at <http://links.lww.com/HPC/A204>). This study was approved by the institutional review board at each participating site.

Study Setting and Population

We included adult patients who presented to a STEMI-referral hospital and were transferred to 1 of 4 STEMI-receiving centers from January 1, 2012, to December 31, 2013, for primary PCI. The 4 STEMI-receiving centers are academic medical centers with 24/7 primary PCI capability. We excluded patients whose symptoms had been present for >12 hours and who were transferred for rescue PCI after receiving thrombolytic agents. Patients were also excluded if they were missing STEMI-referral hospital arrival or departure time or if survey data were not provided by the STEMI-referral hospital.

Eligible participants for the hospital survey included emergency department nursing director(s), medical director(s), and other key personnel identified by the affiliated STEMI-receiving center.

Study Protocol

We collected demographic and clinical data for all patients from each STEMI-receiving center’s local National Cardiovascular Data Registry database. These data were previously collected for submission to the National Cardiovascular Data Registry by trained data abstractors. These data were abstracted for the current study

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From the *Department of Emergency Medicine, University of California Davis, Sacramento, CA; †San Juan Bautista School of Medicine, Caguas, Puerto Rico; ‡Department of Emergency Medicine, Wake Forest Baptist Health, Winston-Salem, NC; §Division of Cardiology, Virginia Commonwealth University, Richmond, VA; and ¶Department of Emergency Medicine, University of Texas Southwestern, Dallas, TX.

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Reprints: Bryn E. Mumma, MD, MAS, 4150 V Street, PSSB #2100, Sacramento, CA 95819. E-mail: mummabe@gmail.com.

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by an analyst at each site who was blinded to the study's objective. Data are filtered through the registry-specific algorithms that require predetermined levels of completeness and consistency for submitted data fields as part of the data quality report. A recent report indicated a high degree of agreement.¹¹

To assess use of each of the 18 strategies at the STEMI-referral hospitals, we surveyed key personnel at each STEMI-referral hospital. We attempted to contact eligible participants via phone and email. Eligible participants were given the choice to complete the survey verbally via phone or to complete the survey electronically via a website link that was emailed to them. Up to 6 attempts were made to recruit each eligible participant.

Respondents were asked to indicate (yes/no) whether their hospital used each of the 18 system practices in 2012–2013. One point was assigned for each practice used. In the event that a practice was used by only some of the EMSs providers affiliated with the hospital, 0.5 points were assigned. Study data were collected and managed using Research Electronic Data Capture.¹²

Measurements and Key Outcome Measures

Our primary outcome measure was DIDO time, defined as the time interval from arrival at the STEMI-referral hospital to departure from the STEMI-referral hospital. Our secondary outcome was first door-to-balloon (first-DTB) time, defined as the time interval from arrival at the STEMI-referral hospital to primary PCI time at the STEMI-receiving center.

Data Analysis

Survey data were analyzed using descriptive statistics. Univariate linear regression was used to characterize (1) the association between individual practices and DIDO times and (2) the association between overall practice use and DIDO and first-DTB times.

RESULTS

We obtained data on 205 patients with STEMI who were transferred from 41 STEMI referral hospitals to a participating STEMI receiving center for primary PCI. Of the 41 STEMI referral hospitals recruited to participate in the survey, 18 (44%) completed the survey. Responding hospitals were smaller than nonresponding hospitals (mean 84 vs. 144 beds, $P = 0.035$) but were similar distance from the STEMI receiving centers (mean 50 vs. 38 beds, $P = 0.167$) and treated similar numbers of STEMI patients during the study period (mean 5.6 vs. 4.5, $P = 0.65$). The responding hospitals treated 100 patients during the study period. After excluding an additional 7 patients due to missing or outlying DIDO times, we studied 93 patients treated at 14 unique hospitals (Fig. 1).

The median number of system practices used by participating STEMI referral hospitals was 14 (interquartile range 12–15). All hospitals reported prehospital STEMI notification and obtaining an electrocardiogram within 10 minutes of patient arrival (Table 1). Fewer than half reported using a departmental STEMI alert or assigning ancillary staff to assist with paperwork and logistics.

Overall, median age of our study population was 61 years, and 66% were male (Table 2). Median DIDO time was 48 minutes (interquartile range 32–85 minutes), and the AHA/ACC goal of 30 minutes was met in 24% of patients. In univariate linear regression analysis, the system practices most strongly associated with shorter DIDO times were EMS agencies performing a prehospital electrocardiogram and notifying the STEMI referral hospital and the presence of a system-wide quality improvement program with leaders in the EMS agency and STEMI referral hospital (Table 1).

In univariate linear regression analyses, number of systems processes was not associated with DIDO time ($P = 0.143$) or first-DTB time ($P = 0.384$).

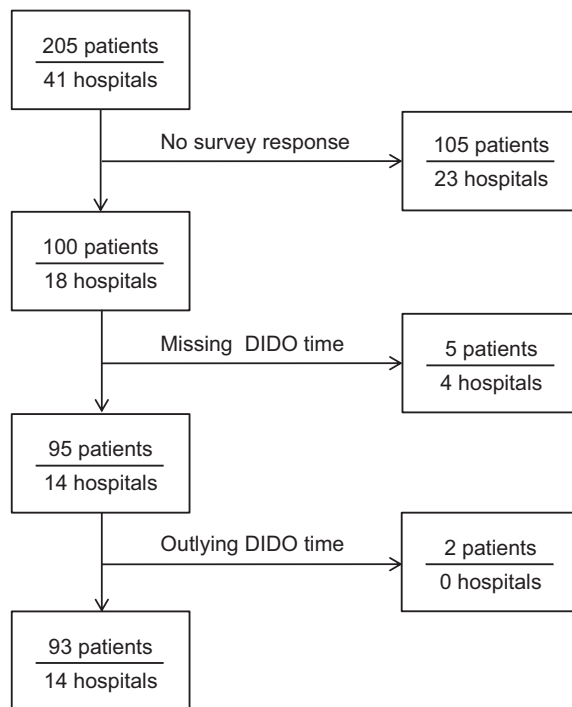


FIGURE 1. Inclusion and exclusion of patients and hospitals.

DISCUSSION

Overall, STEMI referral hospitals used many of the 18 system practices identified by expert consensus as important for minimizing DIDO time for patients with STEMI who require transfer from a STEMI referral hospital to a STEMI receiving center for primary PCI. The proportion of patients in our study who met the AHA/ACC goals for DIDO and first-DTB times is higher than previously reported.^{6–9} Shorter DIDO times may be due to inclusion of high-performing sites, or it may reflect a larger trend toward decreased DIDO times as STEMI referral hospitals focus on this metric. However, AHA/ACC goals were not met in majority of patients despite use of these system practices. This finding highlights the difficulty in achieving the suggested 30-minute DIDO goal and the need for continued focus on strategies for reducing DIDO time.

Furthermore, we did not find an association between use of the 18-system practices and DIDO or first-DTB times. Several possible explanations exist. First, the system practices may not have been implemented uniformly or as envisioned by the expert panel. Second, the list of system practices may be incomplete. Third, additional factors not captured in our survey—such as collaborative relationships between EMS agencies, STEMI referral hospitals, and STEMI receiving centers^{13,14} and decision-making processes at the STEMI referral hospital¹⁵—may influence DIDO and first-DTB times. Finally, our sample size may have been insufficient to detect a more subtle relationship between system practices and DIDO and first-DTB times.

Two of the least frequently used but most important practices were a departmental STEMI alert that activated staff resources and assignment of ancillary staff to assist with transfer paperwork and logistics. Inclusion of these 2 practices may indicate a more developed STEMI protocol at the STEMI referral hospital, or it may indicate that the STEMI referral hospital has these resources available to devote to a STEMI patient. STEMI referral hospitals with more resources may be able to achieve shorter DIDO times because multiple tasks can be completed simultaneously rather than sequentially.

TABLE 1. Prevalence of System Practices and Association With Door-in-door-out Times in Univariate Analyses

System Practice	Usage (n, %) N = 18 Hospitals	Coefficient (95% CI) N = 93 Patients
1. Our referring EMS agencies performed prehospital ECGs*	17 (95%)	-142 (-181, -102)
2. Our referring EMS agencies notified our hospital of a STEMI patient before arrival*	18 (100%)	-133 (-173, -92)
3. Our EMS agencies had a STEMI QI leader within their systems*	9 (50%)	-44 (-64, -25)
4. Protocols were in place for transfer of STEMI patients from our hospital to a STEMI-receiving center	17 (95%)	†
5. Our hospital has protocol for treatment and management of STEMI patients	17 (95%)	†
6. We had a single call transfer protocol or direct page to the interventional cardiologist (accepting physician) at the STEMI receiving center	14 (78%)	9 (-26, 44)
7. We had a protocol for rapid, 24/7 interfacility transfer of STEMI patients to the STEMI referral center	17 (95%)	†
8. We obtained an ECG within 10 minutes of patient arrival at our hospital	18 (100%)	†
9. Our transfer of STEMI patients to the STEMI receiving center was NOT dependent on bed availability/assignment	16 (89%)	20 (-6, 46)
10. When a STEMI patient was identified in our ED, a departmental STEMI alert was activated to engage extra nurse, ED physician, social worker, call to STEMI receiving center, etc.	5 (28%)	19 (-3, 41)
11. Our STEMI patients were transferred to the STEMI receiving center with pending lab results. (In other words, transfer was not held pending lab results.)	17 (95%)	†
12. Our hospital had protocols for the use of air transport when indicated for the transfer of STEMI patients to the STEMI receiving center.	12 (67%)	61 (41, 80)
13. Our hospital has adopted and promoted the 30-minute door-in-door-out time goal set by the American College of Cardiology and the American Heart Association	15 (83%)	-59 (-132, 15)
14. The STEMI receiving center personnel called the cardiologist, activated the cardiac catheterization lab, and ensured bed availability	16 (89%)	†
15. Our hospital referral process minimized transfer paperwork	13 (72%)	7 (-16, 31)
16. Our hospital had a STEMI QI leader	10 (56%)	-39 (-60, -19)
17. We assigned ancillary staff to assist with transfer paperwork and logistics at STEMI referral hospital	8 (44%)	51 (30, 72)
18. Our hospital participated in a systemwide quality improvement program including EMS and the STEMI receiving center that routinely reviewed, critiqued, and trended performance and patient outcomes	11 (61%)	-73 (-93, -52)

*Considered to be used if used by some or all referring EMS agencies.

†All patients were treated at a STEMI referral hospital that used system practice.

ECGs indicate electrocardiograms; ED, emergency department; QI, quality improvement.

Interestingly, the presence of a quality improvement program and leaders within the EMS system and the STEMI referral hospital were some of the least used practices. This finding is somewhat surprising, given that all participating STEMI-receiving centers tracked DIDO and DTB times and submitted data to the National Cardiovascular Data Registry. This lack of emphasis on quality improvement may indicate lack of collaborative relationships between some EMS agencies, STEMI referral hospitals, and STEMI receiving centers. This finding may indicate survey respondents' unawareness of QI leaders within their hospitals and EMS agencies, particularly if their efforts are not highly visible. Furthermore, the strong association between quality improvement practices and DIDO times suggests that they are important components of STEMI systems.

Until now, quality improvement efforts have focused primarily on DTB time rather than DIDO time. DTB times are a quality measure reported to the Centers for Medicare & Medicaid Services,^{16,17} giving STEMI systems financial incentive to reduce DTB times. STEMI-receiving centers have more control over the policies and procedures at their own site than at STEMI referral hospitals, making it easier for them to implement changes that will affect DTB time. Practices at STEMI-receiving centers, such as bypassing the emergency department and transporting a STEMI patient directly to the cardiac catheterization lab, may offset longer DIDO times and allow

the STEMI system to achieve its overall goal for first medical contact to PCI. STEMI patients requiring transfer for primary PCI are also relatively infrequent events at STEMI referral hospitals, and adherence to existing protocols may suffer. Our data indicate that quality improvement efforts should focus on DIDO time in addition to DTB time.

Our study has several limitations. Despite extensive efforts to recruit eligible participants, our survey response rate was 44% and we included only 93 patients. The relatively high numbers of patients with DIDO times under 30 minutes and first-DTB times under 120 minutes suggests selection bias, with our sample including hospitals whose performance is higher than average. Our survey data are subject to response bias, and actual practice may differ from protocols. We also noted relatively small variation between STEMI referral hospitals in the number of practices used. Combined with a small sample size, this limited our power for characterizing the relationship between time intervals and system practices.

CONCLUSION

Use of 18 system practices, previously identified as being important drivers for decreasing DIDO, is high among STEMI referral hospitals. Quality improvement programs appear to be important in achieving shorter DIDO times, but they were utilized less frequently than other system practices. Emphasizing quality

TABLE 2. Demographic and Clinical Characteristics of Patients

	N (%)
Demographic Characteristics	
Age (years)*	61 (51–70)
Male sex	61 (66%)
White race	80 (86%)
Hispanic ethnicity	1 (1%)
History and risk factors	
Diabetes	26 (28%)
Hypertension	67 (73%)
Hyperlipidemia	49 (53%)
Congestive heart failure	6 (7%)
Prior MI	20 (22%)
Prior PCI	18 (20%)
Prior CABG	5 (5%)
Time intervals	
Door-in-door-out interval*	48 (32–85)
DIDO <30 minutes	22 (24%)
First door-to-balloon interval*	102 (82–130)
First DTB <120 minutes	65 (70%)

*Data presented as median (interquartile range).

MI indicates myocardial infarction; CABG, coronary artery bypass graft.

improvement programs in STEMI systems of care may provide an opportunity to improve DIDO times.

DISCLOSURES

Nothing to declare.

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