Original Contribution

Timeliness of interfacility transfer for ED patients with ST-elevation myocardial infarction ☆

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A R T I C L E   I N F O

A B S T R A C T

Objectives: Most US hospitals lack primary percutaneous coronary intervention (PCI) capabilities to treat patients with ST-elevation myocardial infarction (STEMI) necessitating transfer to PCI-capable centers. Transferred patients rarely meet the 120-minute benchmark for timely reperfusion, and referring emergency departments (EDs) are a major source of preventable delays. We sought to use more granular data at transferring EDs to describe the variability in length of stay at referring EDs.
Methods: We retrospectively analyzed a secondary data set used for quality improvement for patients with STEMI transferred to a single PCI center between 2008 and 2012. We conducted a descriptive analysis of the total time spent at each referring ED (door-in–door-out [DIDO] interval), periods that comprised DIDO (door to electrocardiogram [EKG], EKG-to-PCI activation, and PCI activation to exit), and the relationship of each period with overall time to reperfusion (medical contact-to-balloon [MCTB] interval).
Results: We identified 41 EDs that transferred 620 patients between 2008 and 2012. Median MCTB was 135 minutes (interquartile range [IQR] 114,172). Median overall ED DIDO was 74 minutes (IQR 56,103) and was composed of door to EKG, 5 minutes (IQR 2,11); EKG-to-PCI activation, 18 minutes (IQR 7,37); and PCI activation to exit, 44 minutes (IQR 34,56). Door-in door-out accounted for the largest proportion (60%) of overall MCTB and had the largest variability (coefficient of variability, 1.37) of these intervals.
Conclusions: In this cohort of transferring EDs, we found high variability and substantial delays after EKG performance for patients with STEMI. Factors influencing ED decision making and transportation coordination after PCI activation are a potential target for intervention to improve the timeliness of reperfusion in patients with STEMI.

1. Introduction

Timely reperfusion of ischemic myocardium is an important predictor of clinical outcomes for patients with ST-elevation myocardial infarction (STEMI) [1]. The preferred reperfusion strategy is primary percutaneous coronary intervention (PCI) [2], yet most US health care facilities lack primary PCI capabilities necessitating interfacility transfer [3]. Unlike patients with STEMI who directly present to a facility with

PCI capabilities, transferred patients rarely achieve timely reperfusion due to delays in the transfer process.

Two process measures quantify the timeliness of care for patients with STEMI. Door-in door-out (DIDO) measures the length of stay at a transferring emergency department (ED). Maximum time goals are between 30 and 45 minutes, but neither was officially recommended in the latest STEMI guidelines [2]. Medical-contact-to-balloon (MCTB) measures the time from original contact at the transferring ED through myocardial reperfusion at the PCI center. The goal is for 90% of patients to achieve reperfusion within 120 minutes of first medical contact [2]. Although similar to the door-to-balloon process measure, which applies to direct presenters and has a 90-minute goal, MCTB only applies to transferred patients with STEMI [2].

Most patients presenting directly to primary PCI facilities meet the 90-minute door-to-balloon goal for timely reperfusion [4]. However, patients with STEMI requiring transfer, up to 45% in some regions [5,6], meet reperfusion goals for approximately 10% of transfers [7,8]. Compared with direct presenters, transferred patients experience significantly longer MCTB times and may benefit from targeted process improvement interventions designed to reduce delays to primary PCI [9].

The ED plays a central role in the timely care of patients with STEMI. Transferred patients who spent less than or equal to 30 minutes at a transferring ED (ie, DIDO) had a lower in-hospital mortality rate [10]. Most preventable delays occur at referring EDs (64%) rather than during transportation (13%) or the receiving PCI centers (16%) [11]. The 30-minute DIDO goal is only met for approximately 11% of transferred patients with STEMI [10,12]. Prioritizing process improvement efforts to reduce DIDO requires detailed measurements of the process steps at transferring EDs. However, collecting high-quality process data across multiple organizations can be challenging, further limiting analysis and process improvement efforts.

Large data sets (eg, ACTION Registry and the Center for Medicare and Medicaid Service Hospital Compare) collect limited process data on interfacility STEMI transfers. Detailed process timestamps enable the ability to pinpoint "where" and "when" delays occur and to better explain "why" delays occur in the transfer process. The ACTION Registry records only 3 timestamps of process steps at referring EDs: patient arrival, electrocardiogram (EKG) performed, and exit. As a result, only 2 time intervals (ie, door to EKG and EKG to exit) can be calculated to describe the referring ED length of stay. One of the activities and its associated interval, door to EKG, was already targeted by national process improvement efforts and is also part of the latest STEMI guidelines [2,13]. Efforts to quickly perform an EKG have improved the door-to-EKG interval and now represent a minor fraction of overall DIDO. The remaining time interval available in ACTION, EKG to exit, represents a large period that encompasses multiple processes including PCI center activation, patient preparation for transfer, transportation coordination, and exit from the referring ED.

The Centers for Medicare and Medicaid Services Hospital Compare database provides even less detail than the ACTION Registry. Hospital Compare reports OP-3B, "Median Time to Transfer to Another Facility for Acute Coronary Intervention," a measure equivalent to DIDO. No additional timestamps are available about referring ED length of stay. Therefore, these 2 data sets provide little detail to adequately describe the processes that occur at referring EDs.

Further dissection of the processes after the performance of an EKG in patients with STEMI may enhance our understanding of this period, better identify potential sources of delays, and prioritize process improvement efforts. To conduct such an analysis, we used an existing quality improvement hospital data set tracking patients with STEMI transferred to Vanderbilt University Medical Center (VUMC) for primary PCI. We then discuss implications for evaluating referring ED performance and intervening to improve it.

2. Methods

2.1. Study design and population

We used an existing cohort of patients with STEMI who was transferred to a single primary PCI center (VUMC), for our analyses. Originally developed in 2007 as part of an ongoing quality improvement initiative, the STEMI transfer database began data collection in the fourth quarter of 2007. We received separate institutional review board approval from the Vanderbilt University Institutional Review Board for this study.

Even if patients with STEMI bypassed the ED, the transfer database includes all patients with STEMI who were transferred to VUMC for primary PCI. For the present analysis, we included only patients with STEMI transferred between January 1, 2008, and December 31, 2012. We excluded patients who received fibrinolytics, which are recommended, when the anticipated delay to primary PCI is greater than or equal to 120 minutes [2]. We excluded "scene STEMI" patients transported directly to VUMC from the field bypassing a referring ED. Finally, we excluded patients who did not have complete referring ED time interval data (ie, DIDO).

2.2. Data collection

Documents providing details and timing of care before and at VUMC are regularly collected and scanned into the VUMC electronic health record. A clinical study nurse then uses the VUMC electronic health record to complete a data dictionary and case report form with Research Electronic Data Capture [14], a secure browser-based metadata-driven electronic data capture tool. If data were not available, the clinical study nurse attempted to collect records from the referring facilities and transporting agencies. Operational data included emergency medical services (EMS), referring hospital, cardiac catheterization laboratory, and transportation interval timestamps. Clinical data included presenting symptoms, demographics, medical history, procedures, in-hospital outcomes, originating facility, and distance (using Google Maps) to VUMC.

2.3. Data analysis

For the present study, data were provided as a deidentified data set. Time intervals were precalculated as the difference between 2 timestamps to remove protected health information. We deconstructed DIDO according to the following time intervals for care at the referring ED: door to EKG, EKG-to-PCI activation, and PCI activation to exit as seen in Fig. 1. Each time interval was calculated using the following approach. The door-to-EKG interval was calculated as the maximum of the door-to-EKG interval or zero. Values were set to zero if the door-to-EKG interval was negative suggesting that the EKG was performed before arrival at the ED. The EKG-to-PCI activation interval was calculated as the door-to-PCI activation minus the calculated door-to-EKG interval. Finally, the PCI activation-to-exit interval was calculated as the overall ED length of stay (ie, DIDO) minus the door-to-PCI activation interval. We did not perform imputation for missing transportation and cath laboratory values.

We used an established zone classification system to distinguish facilities by distance [15]. Zone 1 facilities are less than 60 miles from the PCI center, and zone 2 facilities are between 60 and 210 miles from the PCI center. We also quantified the number of STEMIs transferred by facilities for each year.

To evaluate whether transferred patient demographics and timeliness changed during the study period, we calculated and compared patient populations and timeliness performance using Kruskal-Wallis (for continuous variables) and Pearson χ^2 tests (for categorical variables). Significance was set a priori at 0.05. For the 7 time intervals, we corrected for multiple comparisons using the Bonferroni method with a revised significance level of 0.007 (0.05/7). Next, to quantify differences in referring ED timeliness, analyses included both numeric and graphic methods to detail
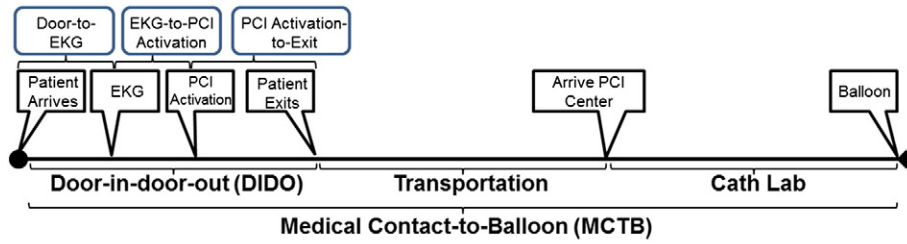
Fig. 1. A timeline of the period from initial medical contact through myocardial reperfusion including timestamps at the referring ED and resulting intervals.

the distribution of DIDO component intervals and total time. Quartiles, means, and SD were calculated to describe the distributions. Histograms and box plots were used to graphically compare the distribution of component periods to identify those with greater variability and those intervals accounting for a larger proportion of overall ED DIDO. To quantify variability, we calculated the coefficient of variation for time intervals [16]. We stratified our analyses by time (year) and distance (zone). To evaluate the effect of missing transportation and cath laboratory values on our results, we performed a sensitivity analysis, where only patients with complete data for every possible timestamp were included. Finally, rank-based Spearman correlation coefficients were calculated between patient-level factors (age, sex, body mass index [BMI], and race) and time intervals. Statistical analyses were conducted using *R 2.14.1*.

3. Results

3.1. Characteristics of study subjects and setting

Between 2008 and 2012, we identified 620 patients with STEMI from 41 facilities who were transferred from a referring ED to VUMC for primary PCI. Table 1 describes the patients and facilities. The distribution of patients transferred by facility is represented in Fig. 2. A flow chart of patients meeting inclusion/exclusion criteria can be seen in Fig. 3. Patients had a median age of 59.3 (interquartile range [IQR] 50.4, 69.0). Of the 620 patients, 21% were female, 45% were white, 31%

Table 1
Characteristics of transferred STEMI patients and facilities transferring patients

Patient characteristics (n = 620)	
Age, median (IQR), y	59.3 50.4,69.0
Sex (% female)	21.3
Race (% white)	45.0
Insurance	
Medicare (%)	20.8
Medicaid (%)	5.0
Private (%)	31.5
Self-pay (%)	9.7
Presentation by year	
2008 (%)	14.8
2009 (%)	23.4
2010 (%)	23.2
2011 (%)	19.7
2012 (%)	18.9
Time intervals, median (IQR), min	
MCTB	135 114,172
DIDO	74 56,103
Door to EKG	5 2,11
EKG-to-PCI activation	18 7,31
PCI activation to exit	44 34,56
Transportation	31 22,42
Cath laboratory	30 23,37
Initial presentation to zone 1 hospital (%)	64.1
Helicopter transportation to PCI center (%)	71.4
Facility characteristics (n = 41)	
Overall STEMIs transferred by ED, median (IQR)	6 2,22
Distance from PCI, median (IQR), miles	47.2 33.8,64.7

had private insurance, and 25% had government insurance (ie, Medicare or Medicaid). Most of our study population (69%) presented to facilities in zone 1 (<60 miles), and most of the study population (71%) was transported to the PCI center by helicopter.

Transferred patients arrived from a median distance of 47 miles (IQR 38, 64) in 2008, 47 miles (IQR 32, 65) in 2010, and 53 miles (IQR 38, 73) in 2012 (*P* < .001). There was no difference across years in the proportion of patients transported by helicopter with 75% in 2008, 66% in 2010, and 80% in 2012 (*P* = .1).

For patients with transfer distance recorded in the data set (n = 594, Table A1), fewer patients with STEMI presented to zone 2 (31.1%), were more likely to be white in zone 2 compared with zone 1 (56.2% vs 40.1%, *P* < .001) but were otherwise not different in age (*P* = .1) or sex (*P* = .2). Zone 2 patients were more likely to have private insurance (40.5% vs 27.4%, *P* = .001) and Medicare (25.9% vs 18.8%, *P* = .05) but were no different in the proportion of patients with Medicaid (*P* = .8), as compared with zone 1. Zone 2 patients were more likely to be transferred by helicopter (86.5%) compared with zone 1 (64.1%, *P* < .001).

3.2. Main results

Both overall and year-to-year performance of referring EDs is reported in Table 2 and is further depicted in Fig. 4. Median overall MCTB (Fig. 4a) was 135 minutes (IQR 114, 172). Among the time intervals that constitute MCTB (Fig. 4b), the median overall DIDO was 74 minutes (IQR 56,103), the median overall transportation time between the referring ED and PCI center was 31 minutes (IQR 22, 42), and the median cath laboratory time (ie, overall time spent at the PCI center until reperfusion) was 30 minutes (IQR 23, 37). Using means, DIDO composed the
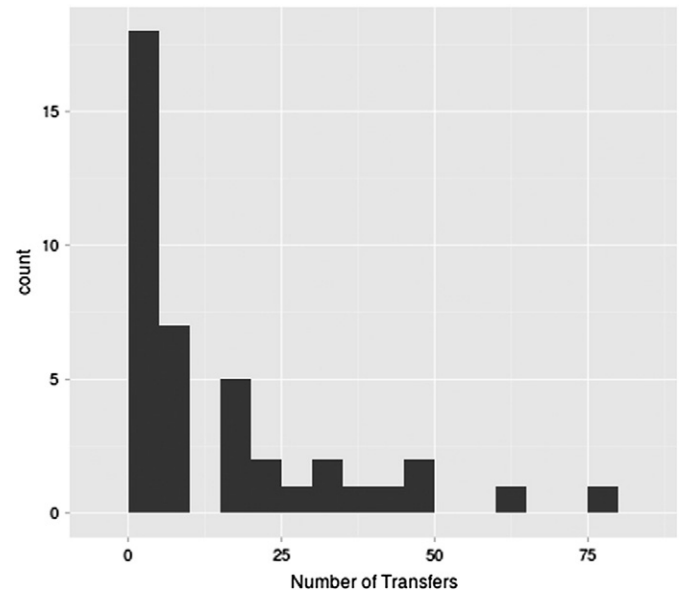

Fig. 2. The distribution of the number of STEMI transfers by referring ED to VUMC between 2008 and 2012.
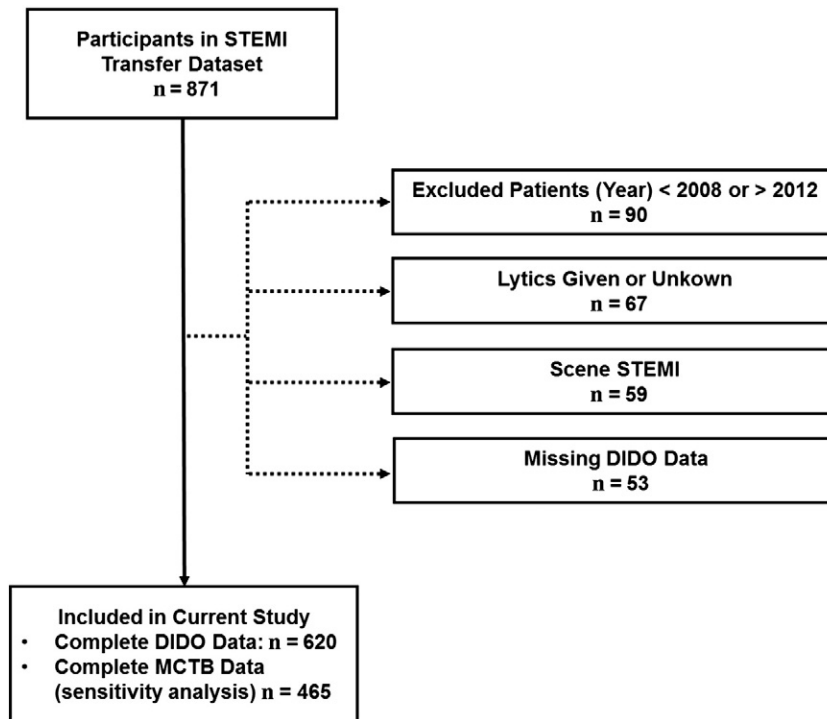
Fig. 3. Flow chart of patients who met inclusion/exclusion criteria for the study population. Note: Some cases may have been excluded for more than 1 reason.

largest proportion (60.0%) of MCTB compared with the transportation interval (21.1%) and cath laboratory interval (18.9%). Door-in door-out also had the largest variability among the 3 MCTB intervals with a coefficient of variation of 1.37 compared with 0.71 and 0.44 for the transportation and cath laboratory time intervals, respectively. Within the intervals that comprise DIDO at the referring EDs (Fig. 4c), the median door-to-EKG time interval was 5 minutes (IQR 2, 11), the median EKG-to-PCI activation time interval was 18 minutes (IQR 7, 37), and the median PCI activation-to-exit interval was 44 minutes (IQR 34, 56). Using means, the door-to-EKG interval was 16.0% of DIDO, EKG-to-PCI activation was 36.6% of DIDO, and the PCI activation-to-exit interval was the largest with 47.5% of overall DIDO.

When evaluating time intervals during the 5-year study period, several patterns emerge (Table 2 and Fig. 5). After correction for multiple comparisons with an adjusted level of significance of 0.007, MCTB ($P = .04$), DIDO ($P = .04$), and the door-to-EKG ($P = .03$) intervals were not different across the study period. However, the median EKG-to-PCI activation interval did change across the study period with a median of 24 minutes in 2008 (IQR 14, 42), 17 minutes in 2010 (IQR 8, 39) and 10 minutes (IQR 1, 27) in 2012 ($P < .001$). In addition, the median PCI activation to exit in 2008 of 42 minutes (IQR 32, 51), 43 minutes in 2010 (IQR 33, 55), and 50 minutes (IQR 38, 69) in 2012 ($P = .001$) and the median transportation time of 38 minutes (IQR 29,46) in 2008, 34 minutes in 2010 (IQR 23, 43), and 23 minutes (IQR 18,36) in 2012 ($P < .001$) all

changed across the study period. Finally, the median cath laboratory time changed from 25 minutes (IQR 21, 34) in 2008, 26 minutes in 2010 (IQR 20, 33), and to 37 minutes (IQR 32, 46) in 2012 ($P < .001$).

When analyzed with respect to zone (Table A1), using the adjusted significance level of 0.007, median MCTB was longer in zone 2 compared with zone 1 (156 [IQR 131, 200] vs 124 minutes [IQR 105, 155], $P < .001$). In zone 2, the median DIDO was longer (81 [IQR 61, 109] vs 69 minutes [IQR 53, 95], $P < .001$), the median PCI activation-to-exit interval was longer (49 [IQR 40, 64] vs 40 minutes [IQR 30, 53], $P < .001$), and the median transportation interval was longer (42 [IQR 36, 51] vs 26 minutes [IQR 19, 35], $P < .001$). However, the door to EKG ($P = .02$), EKG-to-PCI activation ($P = .08$), and the cath laboratory interval ($P = .02$) durations were no different for patients transferred from zone 2 facilities.

A sensitivity analysis of this data set including only subjects with complete data for every timestamp (n = 465) confirmed the findings using complete DIDO timestamp data. Last, we did not identify any significant correlations between patient factors (age, sex, race, and BMI) with time intervals (Table A2).

4. Discussion

Our investigation makes the novel contribution that the EKG-to-PCI activation and PCI activation-to-exit intervals at referring EDs exhibited high variability across the 5-year study period. These 2 intervals

Table 2
Time intervals by year. Times are medians with IQR reported in minutes

Time interval, min (IQR)	2008 (n = 92)	2009 (n = 145)	2010 (n = 144)	2011 (n = 122)	2012 (n = 117)	P^{**}
MCTB	140 (123,162)	143 (118,186)	130 (110,168)	128 (100,169)	138 (112,172)	.04
DIDO	77 (64,106)	79 (57,108)	70 (54,106)	66 (48,90)	75 (58,97)	.04
Door to EKG	6 (3,14)	5 (2,9)	6 (2,12)	4 (2,9)	5 (2,8)	.03
EKG-to-PCI activation	24 (14,42)	21 (11,42)	17 (8,39)	13 (5,35)	10 (1,27)	<.001
PCI activation to exit	42 (32,51)	45 (34,59)	43 (33,55)	41 (33,53)	50 (38,69)	.001
Transportation	38 (29,46)	37 (29,51)	34 (23,43)	24 (16,35)	23 (18,36)	<.001
Cath laboratory	25 (21,34)	26 (20,33)	26 (20,33)	32 (27,39)	37 (32,46)	<.001

Note: Sample size available by interval to calculate duration: MCTB (465), DIDO (620), EKG-to-PCI activation (620), PCI activation to exit (620), transportation (619), cath laboratory (465).
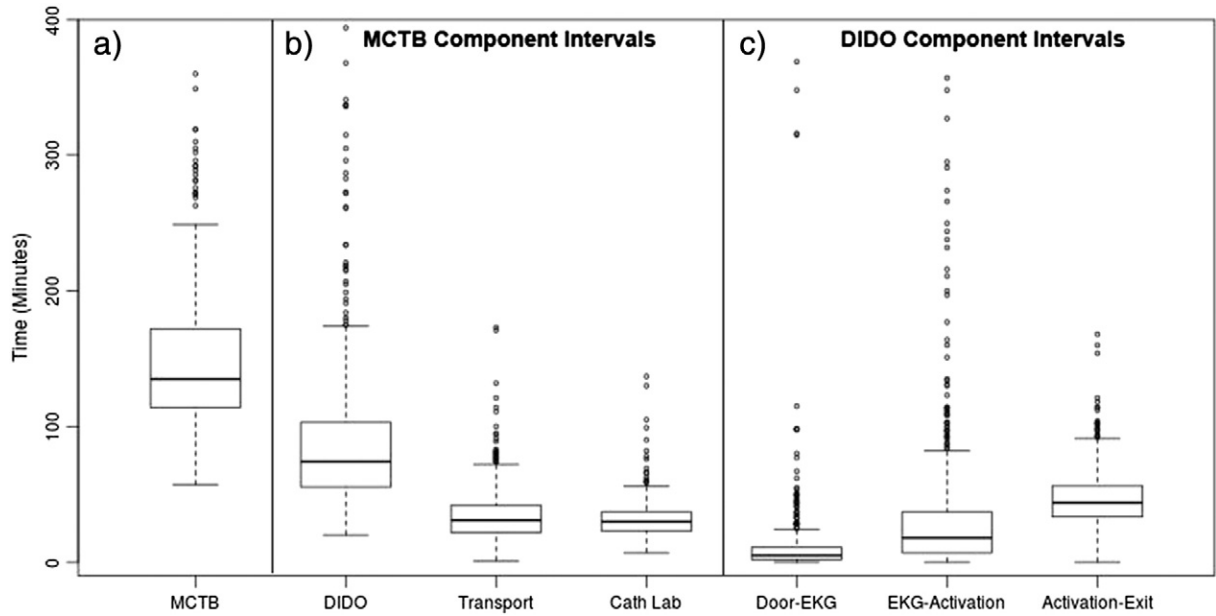** P value after multiple comparisons is .007.

Fig. 4. Box whisker plot of time intervals, in minutes, for patients transferred for primary PCI. Overall MCTB (a), MCTB component intervals (b), and component intervals that constitute DIDO times at the referring EDs (c). The boxes represent the IQR; the dark bar within the boxes represents the median value. The whiskers represent 1.5 times the IQR from the box. Outliers are values beyond the whiskers and are shown as circles (o). Outliers greater than or equal to 400 minutes were trimmed for better visualization.

encompass multiple tasks including STEMI diagnosis, activation of the cardiac catheterization laboratory, coordination with EMS and the PCI center, and departure from the ED. Although the EKG-to-PCI activation interval is shorter, it has more variability than the PCI activation-to-exit interval. Although distinct from each other, both intervals represent potential intervention targets to improve the timeliness of transfer for patients with STEMI.

Several factors may contribute to the high variability seen in the EKG-to-PCI activation interval. Shortly before our study period began, studies and guidelines formally recognized the critical role of the ED and emergency physicians in rapid myocardial reperfusion. Empowerment of the ED and its physicians to activate the cardiac catheterization laboratory was recommended as a strategy to improve reperfusion

timeliness [13,17]. Activating the cardiac catheterization laboratory applies to both transferred and nontransferred patients because they share similar processes. Implementing these recommendations combined with a delay in diffusion of knowledge may contribute to the variability seen in the EKG-to-PCI activation interval during the 5-year study period [18]. In addition, the degree to which the included hospitals empower their EDs and emergency physicians may also affect the variability we identified.

The next time interval, PCI activation to exit, includes processes that occur after the activation of the PCI center. Unlike the preceding interval, the time after PCI center activation differs between facilities with and without PCI capabilities. The time after PCI center activation for transferred patients involves coordination of care among the referring ED,
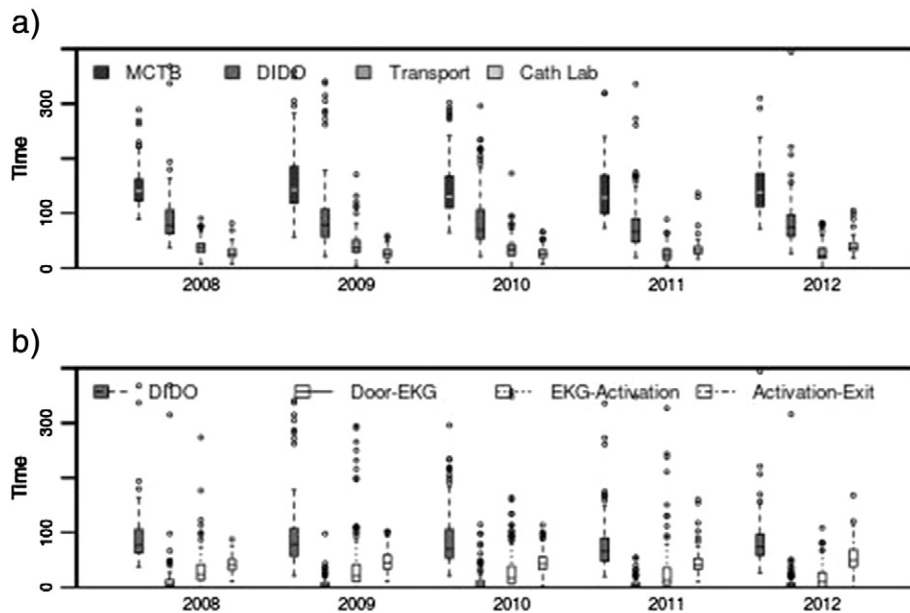

Fig. 5. Intervals for referring ED performance by year for medical contact to balloon (MCTB), DIDO at the referring ED, transportation to the PCI center, and time spent at the PCI center before reperfusion (a); intervals that comprise referring ED performance (b).

the transporting EMS agency, and the receiving PCI center. If not already present, the transferring EMS agencies must dispatch and subsequently arrive at the referring ED. Further complicating this process is the physical distance between the referring ED and the PCI center. Facilities in zone 2 (ie, 60-210 miles from PCI center) had a 10-minute longer PCI activation-to-exit interval representing the entire difference in DIDO between the 2 zones. This difference may be explained by the longer distance from the PCI center and the increased use of helicopters. The use of helicopters for transport of patients with STEMI is associated with increased delays in interfacility transfer for primary PCI [19-21]. Although helicopters can travel faster, deployment time including both start-up and shut down of helicopters may outweigh the faster travel time.

The variability and delays after PCI activation may also be affected by the substantial investment needed to coordinate patient care with EMS, a complex, yet necessary activity among high-performing health systems. [22] Delays associated with EMS deployment time may affect the reliability and time to response at transferring EDs. The substantial differences in the structure and performance of EMS systems of STEMI care in the United States may also inhibit optimal performance [23]. Given the variability and magnitude of duration, the time after PCI activation likely represents the largest opportunity for process improvement.

Although the interval after PCI activation may be the largest in magnitude, the physical distance between 2 facilities is fixed. Therefore, interventions that enhance the efficiency and coordination of the transferring ED and transporting EMS agencies are needed. Multiple strategies hold promise. For example, activating EMS transportation before PCI center activation [24], using the 911 system to transfer patients [25], using operations research tools to enhance the operational flexibility of the ED [26,27], enhancing regionalization efforts to reduce EMS response times [28,29], standardizing the initial interaction with EMS (eg, patient staying on the stretcher) [24], enhancing hospital-EMS relationships [22], and appropriate use of ground-based (rather than helicopter) EMS [19,20].

Reducing variability at referring EDs may also be complicated by fewer STEMIs being seen in US EDs. A study using the national ED sample found that STEMI is decreasing in US EDs [30]. How this affects timeliness performance, as emergency providers see fewer STEMIs, is unknown. However, less experience may result in more variability and subsequently more delays at referring EDs. In addition, fewer STEMIs in US EDs may also affect an ED's decision to transfer a patient with STEMI. As providers are less experienced in handling such patients, they may be more inclined to transfer to specialized centers of care, further affecting their proficiency in handling the transfer process.

In summary, among patients transferred to a single PCI center for STEMI care, there was high variation and lengthy time durations within the referring community hospitals' EDs both after the performance of an EKG before PCI activation and after PCI activation until ED exit. These results suggest that ED decision making and coordination of transportation after PCI activation are potential targets for improving care. The identification and sharing of current best practices, utilization of quality improvement methods, and additional studies to better understand causal factors for delays and the effectiveness of interventions to minimize delays should be pursued.

5. Limitations

Our results must be considered in light of several limitations. The current study was a secondary analysis on a data set that was established for the primary purpose of quality improvement on interfacility STEMI transfer timeliness. Consequently, although the analysis explores timeliness of transfers and generates hypotheses about the variability and duration of time intervals at referring EDs, the data have shortcomings, when used for research on the timing of processes at referring EDs. Confirmation of our findings is needed using rigorous prospective data collection on timing of events and the patient, provider, and ED- and patient-level (eg, case mix) factors contributing to patient care, transfer decisions, along with clinical outcomes for these patients.

In addition, only the time duration and not the actual timestamps was available in this data set. The use of time durations might interfere with accurate calculation of specific time intervals. For example, 12 negative values ranged from -8 to -1 were observed for door-to-EKG time interval. This might be explained as a result of the EKG being performed by EMS before the patient arrival. Because the EKG-to-PCI activation interval was not provided and had to be calculated as door-to-PCI activation (provided in the secondary data) minus door to EKG, negative values of door-to-EKG time interval were set to zero during data cleaning. However, the effect of this operation on the accuracy of specific time interval is minimal due to the sample size, the magnitude of negative values, and the lack of change in our results, when we conducted a sensitivity analysis using complete timestamp data for all process.

Last, our study involved only a single PCI center limiting the generalizability of our findings. Other settings may have a distinct patient population, processes that differ by PCI center, may use helicopter transportation to a different degree, or may have a different relationship with their referring EDs. However, our study included a broad group of referring EDs, and our results are consistent with national findings of interfacility transfer delays for PCI. Thus, we are encouraged that our findings are indicative of national trends on the timeliness performance of interfacility transfers for patients with STEMI. Considering that the original purpose of this study was to explore the use of more granular operational data, future studies will need to be conducted in other settings to examine the representativeness of our findings.

6. Conclusions

In a single catchment area, the time after PCI activation at referring EDs was a substantial source of variability and delay in transfer of patients with STEMI. More granularity in the time after PCI center activation refines our understanding of when delays occur during the STEMI transfer process and may represent an opportunity to measure and to understand how facilities differ in their performance during this time. Additional studies are needed to identify why these delays occur and the effectiveness of interventions to minimize delays.

Appendix

Table A1
Patient and Facility Demographics by Zone from PCI Center

Patient Characteristics					
	<60 Miles N = 409		≥60 Miles N = 185		p value
Age, median (IQR), y	59	(50,68)	61	(51,70)	0.1
Sex (% Female)	19.6		24.3		0.2
Race (% White)	40.1		56.2		<0.001
Insurance (%)					
Medicare	18.8		25.9		0.05
Medicaid	4.89		5.4		0.8
Private	27.4		40.5		0.001
Self Pay	9.53		10.3		0.8
Helicopter Transportation (%)	64.1		86.5		<0.001
Time Intervals, median (IQR), minutes[*]					
MCTB	124	(105,155)	156	(131,200)	<0.001
DIDO	69	(53, 95)	81	(61,109)	<0.001
Door to EKG	5	(2,12)	5	(2,9)	0.1
EKG-to-PCI Activation	16	(6,36)	19	(9,36)	0.08
PCI activation to exit	40	(30, 53)	49	(40,64)	<0.001
Transportation	26	(19,35)	42	(36,51)	<0.001
Cath laboratory	29	(22,36)	32	(24,39)	0.02
Facility Characteristics					
Distance from PCI, median (IQR), miles	45	(32,53)	79	(68,90)	<0.001

* Sample size available by interval to calculate duration: MCTB (465), DIDO (620), EKG-to-PCI Activation (620), PCI activation to exit (620), Transportation (619), cath laboratory (465).

Table A2
Correlation matrix for time intervals and patient factors at the patient level. Values in the upper right (dark gray) represent correlations. Values in the lower left (light gray) are p values

Variable	MCTB	DIDO	Transport	Cath laboratory	Door to EKG	EKG-to-Activation	Activation to exit	Number of Transfers	Sex	Age	White	BMI
MCTB	1	0.90	0.41	0.37	0.25	0.58	0.53	−0.32	−0.15	0.08	−0.11	0.09
DIDO	<0.001	1	0.16	0.21	0.37	0.61	0.57	−0.21	−0.15	0.00	−0.04	0.03
Transport	<0.001	<0.001	1	−0.18	−0.02	0.18	0.13	−0.38	−0.13	0.14	−0.06	−0.06
Cath laboratory	<0.001	<0.001	<0.001	1	0.06	0.08	0.18	−0.06	−0.03	0.10	−0.16	0.03
Door to EKG	<0.001	<0.001	0.58	0.20	1	0.64	−0.02	0.00	−0.06	0.02	0.03	0.01
EKG-to-Activation	<0.001	<0.001	<0.001	0.08	0.64	1	−0.06	−0.17	−0.05	0.01	0.06	0.09
Activation to exit	<0.001	<0.001	0.00	0.00	<0.001	0.13	1	−0.18	−0.08	0.00	−0.12	−0.01
Number of Transfers	<0.001	<0.001	<0.001	0.22	0.97	<0.001	<0.001	1	0.05	−0.02	0.03	0.06
Sex	0.00	0.00	0.00	0.54	0.12	0.20	0.04	0.18	1	−0.19	0.06	0.09
Age	0.12	0.92	0.00	0.05	0.56	0.77	0.93	0.59	<0.001	1	−0.03	−0.20
White	0.02	0.36	0.11	0.00	0.53	0.11	0.00	0.40	0.13	0.48	1	0.00
BMI	0.14	0.52	0.22	0.56	0.85	0.08	0.88	0.28	0.08	0.00	0.93	1

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