Opening the Artery Faster in Myocardial Infarction: Parkland as a Model of Systems-Based Improvement

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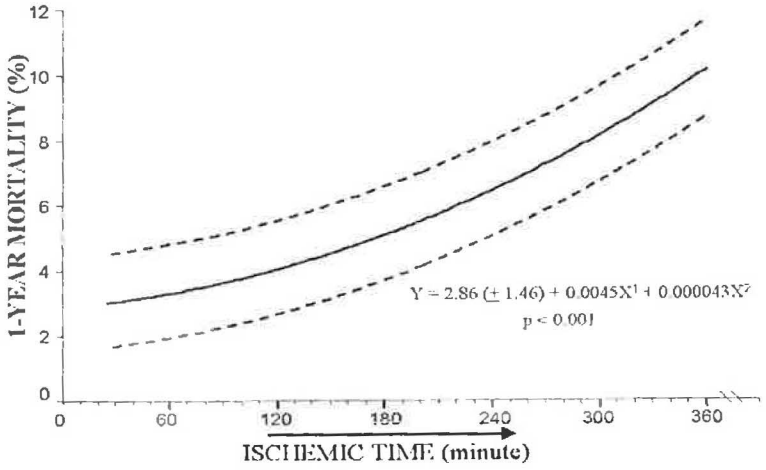
BACKGROUND

The estimated annual incidence of myocardial infarction in the US is 610,000 new and 325,000 recurrent events.[1] The importance of timely reperfusion in such patients who present with ST-elevation myocardial infarction (STEMI) is well-established. If performed by experienced operators, primary percutaneous coronary intervention (PCI) is the preferred method of reperfusion, with a 2% absolute reduction in mortality risk compared with thrombolytic therapy.[2] However, the benefits of primary PCI over fibrinolytic therapy are clearly time dependent, and faster reperfusion of the infarct related artery, as measured by a shorter door to balloon time (DBT), is associated with decreased rates of both in-hospital and long-term mortality,[3-5] (Figure 1) left ventricular dysfunction,[6] and smaller infarct sizes.[7]

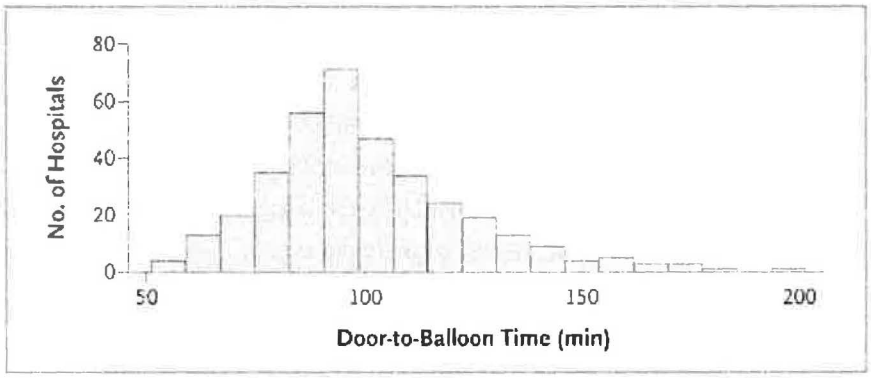
Figure 1: Relationship between door-to-balloon times and 1-year mortality, as continuous function. Dotted lines represent 95% confidence intervals of predicted mortality



De Luca, G. et al. Circulation 2004;109:1223-1225

Reflecting increased appreciation of the adverse consequences of delay in primary PCI, the most recent American Heart Association/American College of Cardiology Guidelines for STEMI recommend that the goal door to balloon time (DBT) be < 90 minutes (a class IA recommendation).[8] Although there has been a heightened awareness regarding the significance of timely reperfusion, only 30-45% of patients treated at US acute care hospitals receive care within this recommended time frame. [9-11] (Figure 2)

Figure 2: Frequency Distribution for Median Door-to-Balloon Times Among 365 surveyed US Hospitals. The mean (±SD) of these median times was 100.4 ±23.5 minutes.



Factors that have been associated with a longer DTB time include care at an urban teaching hospital, female gender, age greater than 65 years, presentation on weekends and evening hours, self arrival to the emergency department versus via an ambulance, and minority race. [12-14]

STRATEGIES TO IMPROVE DOOR-TO BALLOON TIMES

Because timely reperfusion of patients presenting with STEMI is critical to optimize patient outcomes, door to balloon time is now a national quality measure collected and reported by the Centers for Medicare and Medicaid Services (CMS) and the Joint Commission on Accreditation of Healthcare Organizations. However, the process of providing 24 hour catheterization team availability for STEMI care is complex given that multiple care provider teams and locations of care are involved. Several broad strategies have been proposed to improve DBT, and although highly effective, these strategies do not account for the unique individual differences between institutions. Some of these strategies include emergency department (ED) physician activation of the catheterization team, "single call" broadcast paging of the STEMI team by the page operator, immediate feedback to the emergency and cardiology departments after joint monthly Quality Improvement meetings to review every STEMI case, having a cardiologist on site continuously, and time expectations regarding catheterization team arrival to the hospital for off-hours cases. [15-18]

In a survey of 365 acute care hospitals in the US, the strategies significantly associated with a reduction in DBT as well as the mean time saved by each strategy were assessed.[11] Direct activation of the catheterization laboratory by the ED physicians was

associated with a mean reduction in DBT of 8.2 minutes. Activation of the catheterization laboratory by a single call to the page operator saved 13.8 minutes while activation of the catheterization laboratory while a patient was en route to the hospital saved 15.4 minutes. Expecting staff to arrive to the hospital in less than 20 minutes as compared to more than 30 minutes saved 19.3 minutes and having an attending cardiologist on site continuously saved 14.6 minutes. Using rapid data feedback to the ED and to the catheterization team saved 8.6 minutes. Additionally, it was demonstrated that the DBT decreases as the number of these strategies utilized increases. (Figure 3) There has also been an initiative aimed at the national level, the D2B Alliance for Quality[19], which gives hospitals across the country the assistance needed to improve their care of STEMI patients. This initiative was launched in November of 2006 by the American College of Cardiology and provides PCI hospitals with strategies, tools, and resources needed to achieve DBT<90 minutes. Currently, over 1000 hospitals have enrolled, including Parkland.

Figure 3: Door-to-Balloon Times According to the Number of Key Strategies to Reduce Times Utilized

Number of Key Strategies	Hospitals with the Number of Key Strategies (N=362)	Average of Median Door-to-Balloon Times†
	no. (%)	*minutes*
0	137 (37.8)	110
1	130 (35.9)	100
2	56 (15.5)	88
3	31 (8.6)	88
4	8 (2.2)	79

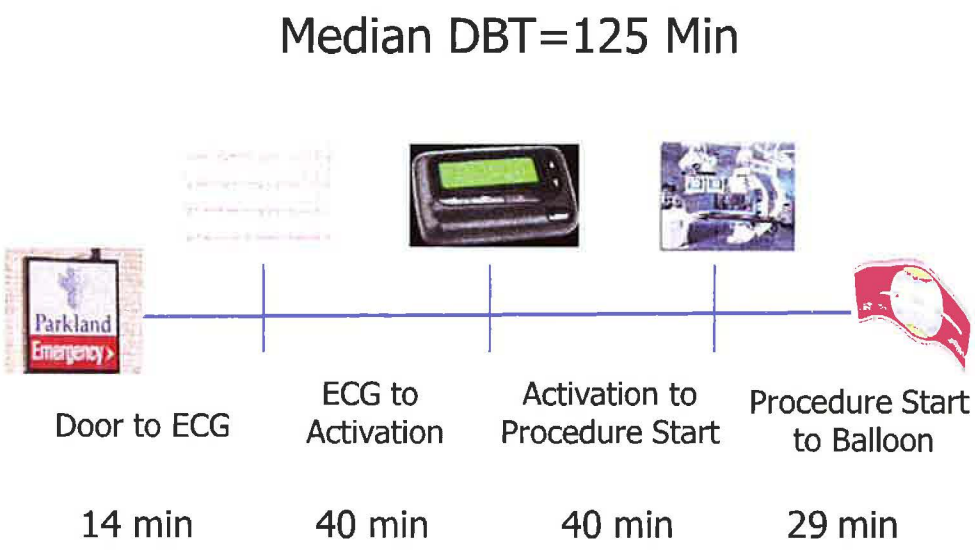
* Since the number of hospitals using three or four strategies was small, the precision of the estimates may be limited.
† P<0.001.

Bradley et al. NEJM 2006;355:2308-2320

PREVIOUS DOOR-TO-BALLOON TIME DATA AT PARKLAND

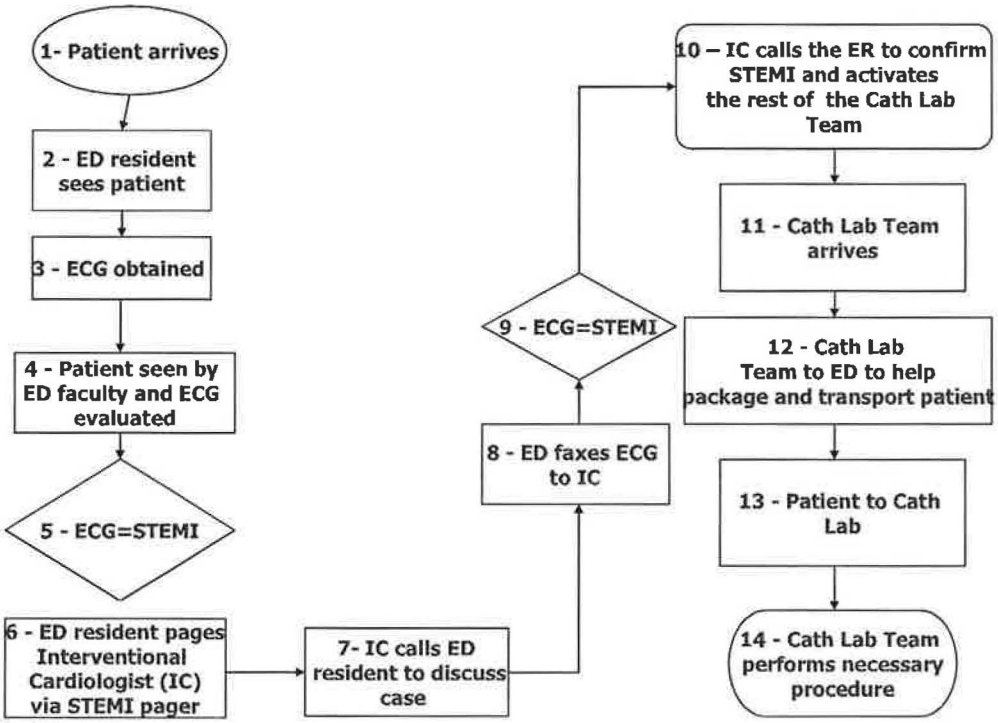
We previously reported a novel approach to better identify institution-specific sources of delay.[20] Among 184 consecutive patients with STEMI between 2000-2006 at Parkland Health and Hospital System, we divided DBT into the following component times: 1) ED presentation to initial 12-lead electrocardiogram (ECG), 2) initial ECG to activation of the on-call cardiac catheterization lab team, 3) catheterization team activation to start of the procedure, and 4) procedure start to first balloon inflation. We analyzed the component time intervals for 184 STEMI patients presenting between December 1st, 2000 to March 31st 2006 who were managed with our original STEMI protocol. Our median door-to- balloon time was 125 minutes, with the majority of delay contributing to our prolonged DBT occurring between ECG acquisition and catheterization team activation. (Figure 4)

Figure 4: Previous data regarding door-to-balloon times at Parkland by subinterval



The etiology of the delay during the time between the first ECG and the on-call cath team activation is evident in our old STEMI protocol (Figure 5). This earlier protocol was a sequential, 14 step algorithm.

Figure 5: Previous STEMI Protocol for Activation



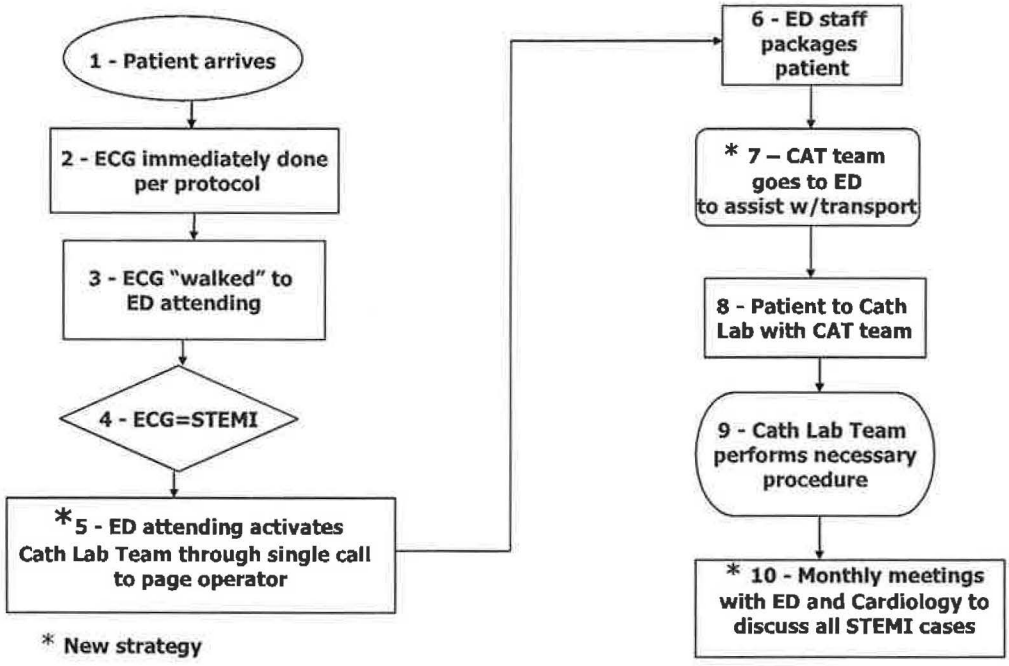
The majority of delay occurred between steps 6-9, which involved notification of the interventional cardiologist on call to activate the lab. In order to achieve a recommended DBT of <90 minutes, recommended time frames for each interval of care include obtaining an ECG on presentation in <10 minutes, taking the patient to the catheterization lab within 50 minutes of obtaining the ECG, and inflating a balloon within the occluded artery within 30 minutes of arriving in the catheterization lab.[21] However, these goal times were not previously being achieved regularly in our institution. The delay between activation of the catheterization team and procedure start was particularly significant during off-hours cases: a median of 45 minutes (interquartile range [IQR], 40 to 55) versus 20 minutes (IQR, 15 to 48) for patients who presented during the weekend compared with weekday presentation ($p<0.05$) and a median of 50 minutes (IQR, 45 to 56) versus 16 minutes (IQR , 15 to 40) for patients presenting between 6 PM and 6 AM compared with presentation between 6AM and 6 PM ($p<0.05$). [20] Additionally, a multivariate analysis was done of the factors responsible for the delays in the specific subintervals of the DBT process. Factors associated with an increase in the interval of arrival to ECG were self-transportation instead of ambulance arrival and lack of health insurance. Factors associated with delay in ECG to catheterization

team activation included previous angina, previous stroke, cardiogenic shock, and English speaking. Nighttime and weekend presentation were associated with a delay in the interval of catheterization team activation to procedure start time. Lastly, previous percutaneous coronary intervention, congestive heart failure, and peripheral vascular disease were associated with delay in the time from start of the procedure to first balloon inflation.

CREATING A NEW DOOR-TO-BALLOON TIME PROCESS

After identifying potentially modifiable delays in the time intervals between ED presentation to initial ECG and ECG to activation of the catheterization team, we targeted a specific quality improvement program to address the major sources of delay in our institution via processes that were possible in our large, urban, teaching hospital. In March of 2007 we implemented three proven strategies to reduce DBT into our STEMI protocol, including 1) emergency department (ED) physician activation of the catheterization team; 2) "single call" broadcast paging of the STEMI team by the page operator; 3) immediate feedback to the emergency and cardiology departments after joint monthly Quality Improvement meetings to review every STEMI case. The first two strategies reduced the number of steps within the STEMI protocol from 14 to 9 (Figure 6).

Figure 6: New STEMI Protocol for Activation



The goal of decreasing the time required for ED activation of the on-call catheterization team required extensive teaching of emergency medicine nurses and physicians. This education was provided by the emergency department medical director and the nurse managers. The education included instruction in the appropriate and rapid ECG identification of STEMI, procedural steps to activate the on-call catheterization team, and immediate paging of the cardiology fellow on-call to discuss cases when the diagnosis of STEMI was ambiguous or the decision to proceed with catheterization team activation was not clear. Education of the cardiac catheterization laboratory staff, cardiology fellows, and interventional cardiologists was provided by the medical director of the catheterization laboratory and the catheterization laboratory nurse manager. This focused on the appropriate identification and rapid response to the broadcast page by the page operator, and details on how to facilitate getting the patient to the catheterization lab. Another strategy included meetings between the ED, cardiology and paging system representatives to develop the text page verbage identifying patient name, diagnosis, and location which would be sent for on-call catheterization team activation, and a strategy for confirming interventional cardiology faculty response to the notification. The Performance Improvement and Clinical Safety team aided these efforts by compiling all of the time data on each STEMI patient to present at monthly multidisciplinary meetings, and providing continuous reporting of DBT time intervals on all patients. The ED implemented a process of streamlined triage for all patients with chest pain and a process of tracking times from ECG order entry for chest pain to ECG completion and each ECG technician was provided feedback regarding their own performance.

Our prior study highlighted a significant delay for patients who presented during off hours, primarily during the time interval of on-call catheterization team activation to procedure start: 45 min vs. 20 min for patients who presented during the weekend ($p < 0.05$) and 50 min vs. 16 min for patients presenting during 6PM to 6AM ($p < 0.05$). This has previously been reported as a contributor to delayed reperfusion.[12] While an in-house interventional cardiologist has been identified as a successful strategy in improving delays[15], this strategy was not a realistic option at our large, urban teaching hospital. We therefore developed an in-hospital catheterization lab activation team (CAT) in November 2007 to improve DBT for off hours cases. The CAT team is comprised of the medical intensive care unit charge nurse and the on-call cardiac care unit resident, who are also notified by the STEMI group pager. They assist with patient transport from the ED to the catheterization lab, placement of the patient on the procedure table and connection to monitoring equipment, and activation of the catheterization lab equipment, while the on-call catheterization team is en route. This process allows the on-call catheterization team to start the procedure immediately upon arrival to the catheterization lab. Data from our institution demonstrated a mean time of

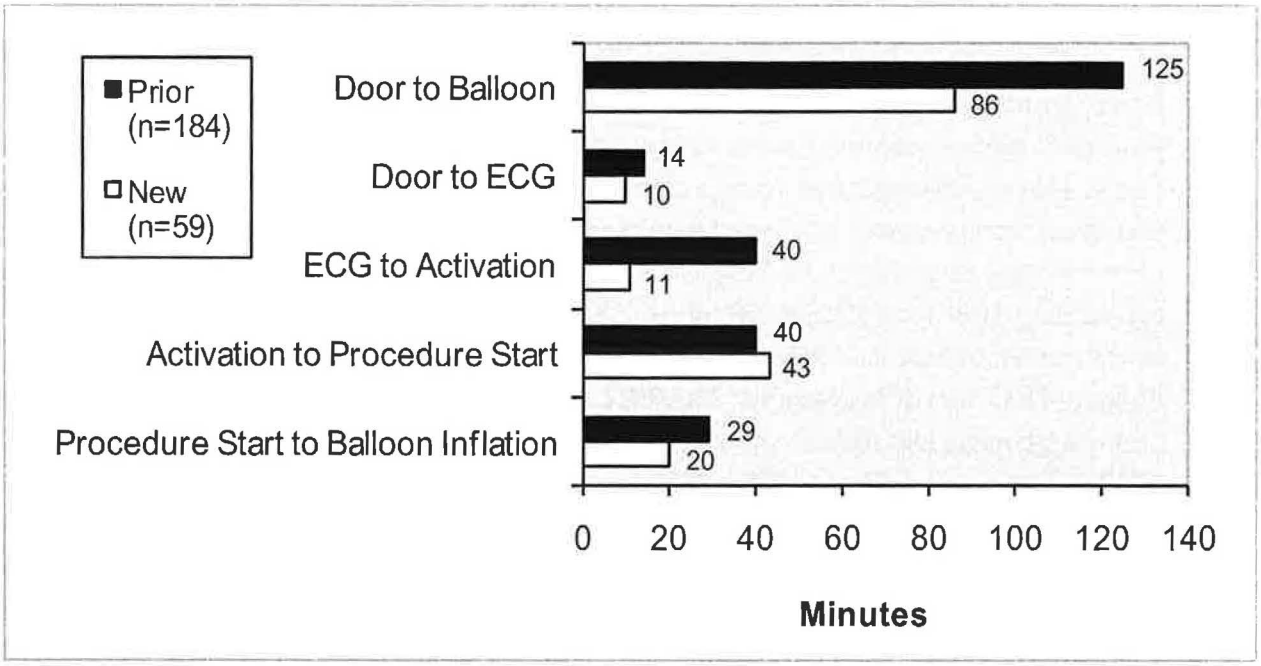
12-15 minutes utilized by catheterization team staff upon arrival when they would pick up a patient in the ED and transport them to the catheterization lab for the procedure.

RESULTS AFTER IMPLEMENTATION OF NEW DTB PROCESS

To assess the overall effects of implementing the steps detailed above, we examined the 1st 59 consecutive STEMI patients presenting between March 2007 and April 2008, after implementation of our new protocols. We divided door to balloon time into four distinct time intervals as we did in our prior study, including 1) door to initial ECG, 2) ECG to on-call catheterization team activation, 3) on-call catheterization team activation to start of the procedure, and 4) start of the procedure to first balloon inflation. STEMI was defined as ischemic chest pain of at least 30 minutes in duration with coexisting ECG criteria of ST segment elevation > 0.1 mV in >/- 2 contiguous precordial leads or a new left bundle branch block.

Our median DBT time significantly improved from a median of 125 (IQR, 100 to 166) to 86 minutes (IQR, 68 to 102) ($p < 0.0001$), largely driven by a decrease in the time interval between initial ECG acquisition to on-call catheterization team activation, from 40 minutes (IQR, 20 to 59) to 11 minutes (IQR, 7 to 18)($p < 0.0001$)[22] (Figure 7).

Figure 7: Parkland Door-to-Balloon Times after New Processes Implementation



The time interval between door and ECG acquisition also improved from 14 minutes (IQR 8, 28) to 10 minutes (IQR 3,18) ($p = 0.0006$). There was a slight increase from 40 minutes (IQR 15,50) to 43 minutes (IQR 32,52) in the time between catheterization team activation and start of the procedure ($p = 0.02$). Time between the start of the procedure to the first balloon inflation improved from 29 minutes (IQR 22,36) to 20 minutes (IQR 17,27) ($p < 0.0001$).

There was a significant improvement in time between catheterization team activation and procedure start for off-hours cases, from 52 minutes (IQR 49,64) to 45 minutes (IQR 39,48) , after implementation of the CAT team strategy ($p = 0.0003$). The median door-to-balloon time for off-hours cases also improved, from 101 minutes (IQR 89,125) to 86 minutes (IQR 68,99) ($p=0.008$). The fraction of off-hours patients at goal DBT also improved after CAT initiation, from 27.8% to 73.3% ($p=0.01$). Overall, the entire group of patients at goal DBT of less than 90 minutes increased from 17.4% to 61.0% after the implementation of our new strategies ($p<0.0001$).

CONCLUSIONS FROM THIS SYSTEMS-BASED IMPROVEMENT PROCESS

A multidisciplinary approach involving both the ED and cardiology departments has been crucial in our success of improving DBT at our institution. Therefore, we implemented a strategy of providing immediate feedback to both departments after joint monthly Quality Improvement meetings to discuss every STEMI activation case. To achieve success of such an interdisciplinary initiative regarding patient care outcomes, it is critical to recognize that for changes to be successful, continual interdepartmental collaboration between the emergency and cardiology departments is required, as both play essential roles in the care of the STEMI patient. All members of the ED, cardiology, and the paging system are encouraged to communicate difficulties with the process in between these monthly meetings. Lastly, streamlining triage for all chest pain patients and tracking times to first ECG for all ECG technicians with feedback was responsible for the improvement in time between the door to first ECG interval. While no specific intervention was performed to account for the significant reduction in the procedure start time to first balloon inflation, it is likely that physician awareness of the performance improvement process and continual tracking of data resulted in attention to more efficient performance of the angioplasty procedure.

We systematically identified the systemic component delays in our institution to detect the time intervals that would benefit the most from time saving interventions. Although other institutions have also reported their reduced door to balloon time[23-24], our data is unique in that is reveals the feasibility of doing so in a large, urban, teaching hospital, a setting which has previously been shown to be a predictor of delay itself. [13] Moreover, as our institution serves a largely indigent and multi-ethnic population, and has multiple

emergency medicine and cardiology providers involved in providing care of the STEMI patient, our data highlights the potential power of systems-based approaches to address health care disparities. Finally, our data highlights the speed with which improvement can be achieved: we have been able to report our systematic identification of delays and then report our significant improvements in DBT just one year after implementing several strategies targeted to our institution specific delays.

In conclusion, achieving a DTB time < 90 minutes is critical for improved patient care and is feasible with implementation of proven time saving strategies. Systematically identifying institution-specific areas of delay can help focus efforts on implementing appropriate strategies to decrease the delay.

FUTURE DIRECTIONS

There are multiple areas which are targets for future directions in this area at our institution. Firstly, there are continual attempts to strive for median door-to-balloon times of less than 60 minutes given that this is likely the next DBT that will be formally recommended. Secondly, the process of expediting STEMI care of transfer patients is undergoing process implementation as we are seeing an increasing number of patients transferred to Parkland for catheterization for STEMI. Thirdly, prehospital activation by EMS is a potential strategy which has been shown to result in significant reduction in DBT time[25-26] and thus there are initial discussions to begin such a program at Parkland. Our multidisciplinary group looks forward to keeping you updated regarding ongoing results.

ACKNOWLEDGEMENTS

This body of work truly represents the significant efforts over 2 years of multiple individuals in Cardiology, the Emergency Department, Parkland administration, Performance Improvement at Parkland, and Paging services at Parkland.

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