HHS Public Access

Author manuscript

Mayo Clin Proc. Author manuscript; available in PMC 2016 December 01.

Published in final edited form as:

Mayo Clin Proc. 2015 December ; 90(12): 1614–1622. doi:10.1016/j.mayocp.2015.08.021.

Aggressive Measures To Decrease Door To Balloon Time And Incidence Of Unnecessary Cardiac Catheterization: Potential Risks And Role of Quality Improvement

Zaher Fanari, M.D[1], **Niksad Abraham, MD**[2], **Paul Kolm, PhD**[3], **Jennifer Doorey, MS**[4], **Angela Herman, RN**[1], **Angela Hoban, RN**[1], **Vivek Reddy, MD**[1], **Sumaya Hammami, MD, MPH**[1], **Jennifer Leonovich, RN**[1], **Ehsanur Rahman, MD**[1], **William S. Weintraub, MD**[1,3], and **Andrew J. Doorey, MD**[1]

[1]Section of Cardiology, Christiana Care Health System, Newark, DE

[2]Section of Cardiology, North Oaks medical Center, Hammond, LA

[3]Value Institute, Christiana Care Health System, Newark, DE

[4]University of North Carolina, Chapel Hill, NC

Abstract

Objectives—To assess the impact of aggressive protocol to decrease door-to-balloon (DTB) time on the incidence of false-positive STEMI (FP-STEMI) and in-hospital mortality.

Patients—Consecutive patients with presumed STEMI with confirmed ST-segment elevation that underwent emergent catheterization.

Methods—In July 1, 2009 we instituted an aggressive protocol to further reduce DTB time. A quality improvement (QI) initiative was initiated in January 1, 2010 to maintain short DTB while improving outcomes. Outcomes were compared before and after aggressive DTB and similarly before and after the QI initiative. Outcomes were DTB time, the incidence of FP-STEMI and in-hospital mortality. A review of the emergency catheterization database over the last 10 years (January 2001-December 2010) was carried out for historical comparison.

Results—Between July 1, 2008 and December 1, 2012, 1031 consecutive patients with presumed STEMI were assessed. Of these 170 were considered FP-STEMI. The median DTB time decreased from 76 to 61 minutes with the aggressive DTB protocol (P=. 001), accompanied by an increase of FP-STEMI (7.7% vs. 16.5%, p=.02). While TP-STEMI in-hospital mortality witnessed non-significant reduction, this was associated with a significant increase of FP-STEMI in-hospital mortality. After the QI initiative, a shorter DTB time (59 minutes) was maintained while decreasing FP-STEMI in-hospital mortality.

Corresponding Author: Zaher Fanari, M.D., Section of Cardiology, Christiana Care Health System, 4755 Ogletown-Stanton Rd., Newark, DE 19718, USA., Tel: +1 (314) 808-1610, Fax: +1 (302) 733-4998, zfanari@gmail.com.

Conclusion—Aggressive measures to reduce DTB time were associated with an increased incidence of FP-STEMI and FP-STEMI in-hospital mortality. Efforts to reduce DTB time should be monitored systematically to avoid unnecessary procedures that may delays other appropriate therapies in critically ill patients.

Keywords

Door to balloon Time; ST-segment myocardial infarction; False Positive STEMI; Quality Improvement

INTRODUCTION

Management of acute ST-segment elevation myocardial infarction (STEMI) has undergone significant changes in recent decades. The introduction of primary coronary intervention (PCI) as the primary method of reperfusion resulted in decreased morbidity and in-hospital mortality.[1] The time from hospital arrival to onset of reperfusion therapy, [door-to-balloon (DTB) time), is an important determinant for outcomes. [2–8] The ACC/AHA guidelines were updated in 1999 to create a benchmark door-to-balloon time of less than 90 minutes for patients presenting with STEMI in a hospital capable of primary coronary intervention. [9] There has been marked improvement in recent years. [10, 11] However, the new concept of first medical contact to balloon time and the pressure to reduce this time to less than 90 minutes has led to additional effort to reduce the door to balloon even more, as shorter times may improve clinical outcomes, and they are being used as a measure of quality by many organizations. [12]

Efforts to reduce the door-to-balloon time require a rapid triage decision with faster dispatch to the catheterization lab. However, this may come at the expense of increased risk of incorrect triage decisions and an increased rate of false-positive STEMI (FP-STEMI), whereby a patient is taken emergently to the catheterization laboratory but no STEMI is found. Many of these patients with FP-STEMI are critically ill and triaging them to unnecessary procedures in the cardiac catheterization may lead to suboptimal outcomes due to delay of disease-appropriate therapy. Although many studies have reported the benefits of shorter door to balloon time, few data exists on the incidence and outcomes of FP-STEMI. [2–8, 13, 14] However, concerns about FP-STEMI and the effect on outcomes have been raised.[15, 16] The aim of this study is to calculate the rate of true positive and false positive STEMI in 1031 patients consecutively enrolled in the current study between July 2008 and December 2012 and to assess the association between an aggressive campaign to further reduce DTB times and median DTB time, the incidence of false-positive STEMI (FP-STEMI) and in-hospital mortality.

METHODS

Christiana Care Health System is a tertiary care center with nearly 1800 coronary interventions annually, including approximately 225 annual coronary interventions for STEMI. Emergency department physicians initiate the activation of the catheterization laboratory, but an interventional cardiologist must decide to proceed with emergent

angiography. With this strategy and a multidisciplinary effort we had achieved an excellent median DTB time under the national recommended guideline of 90 minutes.

In July of 2009, a more aggressive STEMI protocol was introduced at our institution with a goal of reducing DTB time to less than 60 minutes. The new protocol included more intense education efforts to instill the importance of shorter DTB time, and more aggressive quality assurance efforts, including positive feedback for shorter DTB time and negative feedback for delayed times.[13] Emergency department physicians still activated the catheterization laboratory, but immediate contact with interventionalists via cellphone was provided. Performance improvement goals consisted of: a door to electrocardiogram time of less than 5 minutes, immediate contact with interventionalist (<5 minutes), after hours arrival of staff to catheterization lab within 30 minutes and an overall DTB time of less than 60 minutes. Real-time feedback and notes of appreciation were given to all the staff involved in cases where the DTB time was less than 60 minutes. DTB time and FP-STEMI rates were measured.

Patient Selection

Consecutive patients presenting to our hospital with symptoms suggestive of STEMI, taken for emergency cardiac catheterization from July 1, 2008 to December, 1, 2010 were analyzed. Two attending cardiologists who were unaware of the patients' clinical course independently evaluated electrocardiograms. We excluded patients who did not meet electrocardiographic criteria for ST elevation from further analysis (i.e. high risk non ST elevation MI), leaving a study population of patients who underwent emergent catheterization and had electrocardiographic criteria for ST elevation. Among this group, the interventionalist who performed the procedure made interventional decisions. True positive STEMI (TP-STEMI) was defined as those patients where a culprit lesion was identified regardless if they underwent coronary intervention (PCI), coronary artery bypass grafting (CABG) or medical therapy. A culprit lesion was defined as an occluded or significant (>70%) coronary stenosis in a location that could produce the ST elevation. FP-STEMI was defined as those in the study population where no culprit lesion or no significant coronary artery disease was found on coronary angiography and no rise in cardiac biomarkers with the temporal characteristics of acute coronary syndrome occurred. We compared the DTB time, the incidence of FP-STEMI, the incidence of in-hospital mortality in TP-STEMI and FP-STEMI within 12 months before and 12 months after the implementation of new strategy to reduce DTB time. Similarly, the DTB time, the incidence of FP-STEMI, the incidence of in-hospital mortality in TP-STEMI and FP-STEMI were compared with the transitional period of 6 months, during which the efforts to reduce DTB were implemented. In-hospital mortality was assessed at the time of hospital discharge. Debriefings were usually carried out after FP-STEMI to elucidate factors responsible for the clinical misdiagnosis. During the time of this study, previous EKGs were not always readily available or sought by the emergency department staff before catheterization lab activation. No thrombolytics or antithrombotics with the occasional exception of low-dose heparin boluses were given before the catheterization laboratory.

A review of the emergency catheterization database over the last 10 years (January 2001-December 2010) was carried out to assess historical rates of FP-STEMI.

Quality Improvement Initiative

After reviewing our internal data, we decided to implement a more robust internal quality improvement (QI) process in January 2011. We identified the risk of FP-STEMI and associated potential adverse outcomes. While we accepted the risk of having a higher incidence of FP-STEMI, we wanted to ensure no increase in in-hospital mortality incidence in this group. We did an extensive review of the database of all catheterization laboratory activations and emergency catheterizations for presumed STEMI for the preceding ten-year period. TP-STEMI as well as FP-STEMI were identified as explained above. We identified potential patients with FP-STEMI that carry the highest risk of in-hospital mortality when appropriate care is delayed due to cardiac catheterization (i.e. pulmonary embolism, CNS event requiring hypothermia, sepsis, misinterpretation of chronic EKG changes as the cause of an acute illness, etc.). We used the lessons from reviewing these cases to develop a teaching intervention for all caregivers involved to encourage a higher quality, albeit rapid, clinical evaluation to exclude these possibilities before sending a suspected STEMI to the catheterization laboratory. Presentations of these cases were provided to ED attending and residents as well as interventional cardiologists and fellows. A monthly QI meeting displayed these presentations with slides showing potential suggestion to avoid such outcomes. The main goal was to maintain the shorter DTB for STEMI while avoiding those with other life-threatening disorders from diverting to the catheterization laboratory depriving them from early diagnosis and needed treatment. Diagnostic algorhythms for pulmonary embolism and intra-cerebral catastrpophe were reviewed and emphasized. Systematic comparison of presenting EKGs with previous tracings was strongly recommended, The Intense QI Initiative utilizing lessons learned from the previous 10 years of data were held between January 2011 and December 2012. We defined the first 12 months of this initiative as a transition time. The monthly QI afterward addressed new cases and new goals for quality improvement. DTB times, rates of FP-STEMI and in-hospital mortality before the transitional time were compared with those during the transitional time, and for 12 months after the QI initiative transition time (January 2011 to December 2011 and January 2012 to December 2012 respectively).

Statistics

Summary statistics included median door-to-balloon time; FP-STEMI and in-hospital mortality rates and odds ratios of FP-STEMI were compared in the intervals before, during the transition and after the implementation of the aggressive DTB protocol and before, during the transition and after the implementation of the aggressive QI initiative. Continuous variables were summarized using median (range) and categorical variables were summarized using frequency (%). Odds ratios were calculated for TP-STEMI, FP-STEMI, in-hospital mortality in all STEMI, in-hospital mortality in TP-STEMI, and in-hospital mortality in FP-STEMI. The student’s t-test for continuous variables and 2 test for categorical variables were used to compare univariate changes in outcomes between different groups. Logistic regression was used for multivariable analysis to control for confounders permitting adjusted comparison of outcomes. Covariates used for adjustment

were time of presentation (i.e. day time vs. night time and week day vs. weekend/holiday), years of experience of interventional cardiologist and years of experience of ER physicians. All tests are two tailed with P<. 05 considered significant. We used SPSS for Windows version 14.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

A total of 1031 STEMI patients were included; of these there were 861 TP-STEMI and 170 FP-STEMI.

The impact of aggressive shorter DTB time before QI Implementation

Data from 233 patients before the aggressive DTB protocol were compared to 123 patients during the transitional period and 224 patients afterward. Details about TP-STEMI and FP-STEMI in this cohort are displayed in table 1.

After the implementation of the new protocol to reduce DTB time, median DTB time decreased from the previous level of 76 minutes to 61 minutes (Figure 1). The decrease in observed median DTB time was accompanied by an increase in the percentage of FP-STEMI from 7.7% to 16.5% (Table-1). The aggressive DTB protocol was not associated with a significant change in in-hospital mortality in TP-STEMI. However in-hospital mortality in FP-STEMI increased from 5.6% to 21.6% from the time before the aggressive DTB protocol was initiated to after the aggressive DTB protocol was initiated (P=. 03). (Table-1).

Analysis of the 10 years data used for Quality Improvement Initiative

A review of the emergency catheterization database revealed that over the last 10 years (January 2001-December 2010), the in-hospital mortality of all patients with TP-STEMI undergoing emergent coronary intervention was 6.1 % (105 of 1721) while the in-hospital mortality of FP-STEMI was 12.2% (89 of 728).

Table-2 summarizes the Causes of ST Elevation in all FP-STEMI patients and deceased FP-STEMI patients in the historic 10 years and the 2008–2010 cohorts. The discrepancy in distribution of ST elevation etiology between the whole FP-STEMI cohort and the deceased cohort identified a higher risk group of disorders where early recognition may be essential to avoid unnecessary procedures that would delay appropriate care and may be harmful. Furthermore, the disorders leading to ST elevation in the deceased FP-STEMI are disproportionately represented in the 2008–2010 cohort when compared to the historical controls, possibly because the abbreviated clinical evaluation occurring in order to minimize DTB led to missed clinical clues to some of the high risk disorders causing ST elevation other than STEMI.

Debriefing after FP-STEMI usually revealed that clinical evaluation was abridged in part by concerns about not delaying DTB time if the patient was to be sent to the catheterization laboratory. All caregivers involved, paramedics, emergency department nurses and physicians as well as the interventionalists, expressed the same concerns.

The impact of aggressive shorter DTB time after QI Implementation

The QI process was carried out intensively from January 2011 to December 2011 and was continued afterward. Data from the transitional period (January 2011–December 2011) and after the intense QI initiative (January 2012–December 2012) including 234 and 217 STEMI patients respectively were compared to the aggressive protocol data prior to the QI initiative (Table-3). The results showed that the trend for shorter DTB was still successful (DTB was down to 59 min), The FP-STEMI rate remained high (there was still intense pressure to minimize DTB times). However the in-hospital mortality in FP-STEMI appeared to decline significantly (21.6% to 4.5%; P=. 03), while maintaining the low in-hospital mortality rate of 1% in TP-STEMI (Table 3). Figure 1 illustrates the DTB times and FP-STEMI rates in the three-comparator groups (baseline, after DTB time reduction protocol, and after QI project. Transition periods have been removed)

DISCUSSION

In this study, an intense effort to reduce DTB time led to an increase in unnecessary emergency cardiac catheterization and a trend towards an increase in in-hospital mortality in the FP-STEMI group. Debriefings after unnecessary catheterization showed that physicians, paramedics and nurses involved in the care of possible STEMI patients were aware of the need to avoid long door-to-balloon time and hurried clinical evaluations. A review of a ten-year database of inhospital mortality after unnecessary catheterization for suspected STEMI similarly revealed that this is a high-risk group. Focused efforts to exclude life-threatening causes of ST elevation that are not STEMI before proceeding with emergent catheterization may offer the opportunity to avoid an unnecessary procedure and provide more pertinent appropriate therapy. Special emphasis on excluding life-threatening causes of ST elevation other than STEMI (pulmonary embolism, intracerebral catastrophe, pre-existing ST elevation with a superimposed severe illness that is not a STEMI) is likely particularly important, as these patients gain no benefit, and may possibly deteriorate from an unnecessary trip to the catheterization laboratory. We believe this is why our FP-STEMI mortality dropped without a substantial change in the FP-STEMI rates.

Achieving shorter DTB time is difficult, but it is achievable as a result of numerous, hospital-wide efforts to encourage speed of diagnosis and treatment. [11, 17, 18] The pressure to expedite care might lead to excessive or inappropriate cardiac catheterization in patients with suspected STEMI.[15, 16, 19] Although cardiac catheterization is considered a relatively low risk procedure, catheterization of FP-STEMI patients, who often have serious disorders not related to STEMI, may carry increased risks. Although all of the FP-STEMI patients we report on before 2011 had independent confirmation of their ST-segment elevation, and were not ‘misread’ electrocardiograms, many serious medical conditions can present with ST-segment elevation in the absence of STEMI. [20, 21] These patients are then exposed to the small risk of the angiographic procedure as well as the more problematic risks of delayed diagnosis and specific treatment for their acute problems. In a number of our patients this delay was felt to play a role in their poor outcome. Once a FP-STEMI catheterization is concluded, an interventional cardiologist is not the optimal physician nor is the catheterization lab the optimal location for further evaluation and treatment of these patients.

Indeed, there may be uncertainty about which physicians should continue the emergency care, and in which hospital site, leading to treatment delays, which may have negative consequences. For instance, in patients with pulmonary embolism delays in treatment initiation are associated with in-hospital mortality increases.[22] Similarly, in patients with suspected STEMI post cardiac arrest, in whom simultaneous hypothermia and rapid catheterization are difficult to achieve, each hour delay in effective hypothermia increases in-hospital mortality 20%.[23] Treatment delay may also have increased in-hospital mortality for the other serious medical conditions seen in our FP-STEMI group.

Our statistical analysis suggested decreasing DTB time was associated with increased incidence of FP-STEMI and in-hospital mortality in this group. The increased risk of in-hospital mortality of FP-STEMI can be attributed to the fact that at least a subset of this patient group is at high risk from their acute condition, and any delay in specific treatment of that condition can be substantially harmful and should be avoided. Although our data comes from only a single center, large databases like the National Cardiovascular Data Registry (NCDR) cannot address this issue, as they do not track FP-STEMI catheterizations. [25]

Pressure to reduce DTB time can lead to suboptimal evaluation of the patient in the Emergency Department by cardiologists, paramedics, nurses and Emergency Department physicians, as all are very concerned about prolonging DTB time. In fact, vigorous efforts to decrease door-to-balloon times have been shown at times to increase FP-STEMI without having an effect on DTB time, a potentially serious unintended consequence. [26]. Our hospital, like many, consistently celebrates short DTB times, and vigorously investigates excessive DTB times to improve. However, there is no acknowledgement of efforts when a FP-STEMI is avoided.

Evaluation of the patient with suspected STEMI is at times difficult and it is likely that some of our FP-STEMI patients would have undergone catheterization, even with a more thorough clinical evaluation. But heretofore missing from any risk/benefit analysis of striving for shorter DTB time has been acknowledgement of any significant downsides of catheterization and the possible resulting delay of more appropriate care. [11, 17, 18]

There are also detrimental aspects of emergent cardiac catheterization for FP-STEMI not related to the patient. In addition to the taxing of limited medical resources, there is the significant disruption of catheterization laboratory workflow and the care of other patients awaiting catheterization procedures during the working day. During evenings and nights, emergency procedures are usually carried out by physicians and staff who will work the next day, potentially increasing fatigue-related errors.[27]

Finally the pervasive attention to shorter DTB times may be somewhat illogical for many hospitals that have achieved reasonable door-to-balloon times, as while the curve relating inhospital mortality benefits to DTB time is steeper >90 minutes (times relatively common when lowering DTB times became a priority) it is relatively “flat” at the 60–90 minute interval. [7, 8] Recent data even suggest that there is no benefit whatsoever in lowering DTB times further once it is less than 90 minutes.,[28, 29] The limited benefit of in-hospital mortality associated with more aggressive protocols coupled with the increased cost and

potential harms of unnecessacry cardiac catherizations and delay in care raises concerns, especially in hospitals that already have reasonable DTB time. The overutilization of resources, the potential costs and staff fatigue is especially worrisome as some centers have reported FP-STEMI rates as high as 36%. [26]

Limitations

This is a single center, retrospective study. Our numbers are relatively small, especially for inhospital mortality, so the findings must be approached with caution. We report on patients with suspected STEMI with subsequently validated ST-elevation. Other studies have used different definitions, often suspected STEMI by Emergency physician decision without cardiologist review. The latter system may give a higher 'false positive' rate, and have a somewhat different patient makeup.

CONCLUSIONS

Aggressive measures to reduce an already acceptable DTB time can increase the incidence of FP-STEMI. Efforts to reduce DTB time have to be monitored systematically to avoid unnecessary procedures and the associated delay in receiving appropriate care for life threatening non-cardiac conditions, as FP-STEMI may be associated with poor outcome. Some "balancing" by addressing both FP-STEMI and DTB times may be optimal.[15]

Acknowledgments

Funding Source:

Funded in part by an Institutional Development Award (IDeA) from the National Institute of General Medical Sciences of the National Institutes of Health under grant number U54-GM104941 (PI: Binder-Macleod).

References

1. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: A quantitative review of 23 randomised trials. Lancet. 2003; 361(9351):13–20. [PubMed: 12517460]
2. Berger PB, Ellis SG, Holmes DR Jr, et al. Relationship between delay in performing direct coronary angioplasty and early clinical outcome in patients with acute myocardial infarction: Results from the global use of strategies to open occluded arteries in acute coronary syndromes (gusto-iib) trial. Circulation. 1999; 100(1):14–20. [PubMed: 10393675]
3. Brodie BR, Gersh BJ, Stuckey T, et al. When is door-to-balloon time critical? Analysis from the HORIZONS-AMI (harmonizing outcomes with revascularization and stents in acute myocardial infarction) and CADILLAC (controlled abciximab and device investigation to lower late angioplasty complications) trials. J Am Coll Cardiol. 2010; 56(5):407–13. [PubMed: 20650362]
4. Brodie BR, Stuckey TD, Wall TC, et al. Importance of time to reperfusion for 30-day and late survival and recovery of left ventricular function after primary angioplasty for acute myocardial infarction. J Am Coll Cardiol. 1998; 32(5):1312–9. [PubMed: 9809941]
5. Cannon CP, Gibson CM, Lambrew CT, et al. Relationship of symptom-onset-to-balloon time and door-to-balloon time with mortality in patients undergoing angioplasty for acute myocardial infarction. JAMA. 2000; 283(22):2941–7. [PubMed: 10865271]
6. Lambert L, Brown K, Segal E, et al. Association between timeliness of reperfusion therapy and clinical outcomes in st-elevation myocardial infarction. JAMA. 2010; 303(21):2148–55. [PubMed: 20516415]

7. McNamara RL, Wang Y, Herrin J, et al. Effect of door-to-balloon time on mortality in patients with st-segment elevation myocardial infarction. J Am Coll Cardiol. 2006; 47(11):2180–6. [PubMed: 16750682]
8. Rathore SS, Curtis JP, Chen J, et al. Association of door-to-balloon time and mortality in patients admitted to hospital with st elevation myocardial infarction: National cohort study. BMJ. 2009; 338:b1807. [PubMed: 19454739]
9. Ryan TJ, Antman EM, Brooks NH, et al. 1999 update: ACC/AHA guidelines for the management of patients with acute myocardial infarction. A report of the american college of cardiology/american heart association task force on practice guidelines (committee on management of acute myocardial infarction). J Am Coll Cardiol. 1999; 34(3):890–911. [PubMed: 10483976]
10. Gibson CM, Pride YB, Frederick PD, et al. Trends in reperfusion strategies, door-to-needle and door-to-balloon times, and in-hospital mortality among patients with st-segment elevation myocardial infarction enrolled in the national registry of myocardial infarction from 1990 to 2006. Am Heart J. 2008; 156(6):1035–44. [PubMed: 19032997]
11. Bradley EH, Nallamothu BK, Herrin J, et al. National efforts to improve door-to-balloon time results from the door-to-balloon alliance. J Am Coll Cardiol. 2009; 54(25):2423–9. [PubMed: 20082933]
12. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of st-elevation myocardial infarction: Executive summary: A report of the american college of cardiology foundation/american heart association task force on practice guidelines. Circulation. 2013; 127(4):529–55. [PubMed: 23247303]
13. Rogers WJ, Canto JG, Lambrew CT, et al. Temporal trends in the treatment of over 1.5 million patients with myocardial infarction in the us from 1990 through 1999: The national registry of myocardial infarction 1, 2 and 3. J Am Coll Cardiol. 2000; 36(7):2056–63. [PubMed: 11127441]
14. Barnes GD, Katz A, Desmond JS, et al. False activation of the cardiac catheterization laboratory for primary PCI. Am J Manag Care. 2013 Aug; 19(8):671–5. [PubMed: 24304215]
15. Masoudi FA. Measuring the quality of primary pci for st-segment elevation myocardial infarction: Time for balance. JAMA. 2007; 298(23):2790–1. [PubMed: 18165675]
16. Grines CL, Schreiber T. Primary percutaneous coronary intervention: The deception of delay. J Am Coll Cardiol. 2013; 61(16):1696–7. [PubMed: 23500303]
17. Bradley EH, Herrin J, Wang Y, et al. Strategies for reducing the door-to-balloon time in acute myocardial infarction. N Engl J Med. 2006; 355(22):2308–20. [PubMed: 17101617]
18. Krumholz HM, Bradley EH, Nallamothu BK, et al. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-balloon: An alliance for quality. J Am Coll Cardiol Interv. 2008; 1(1):97–104.
19. Bates ER, Jacobs AK. Time to treatment in patients with stemi. N Engl J Med. 2013; 369(10):889–92. [PubMed: 24004114]
20. Thygesen K, Alpert JS, Jaffe AS, et al. Third universal definition of myocardial infarction. Circulation. 2012 Oct 16; 126(16):2020–35. [PubMed: 22923432]
21. Wang K, Asinger RW, Marriott HJ. ST-segment elevation in conditions other than acute myocardial infarction. N Engl J Med. 2003; 349(22):2128–35. [PubMed: 14645641]
22. Smith SB, Geske JB, Maguire JM, et al. Early anticoagulation is associated with reduced mortality for acute pulmonary embolism. Chest. 2010; 137(6):1382–90. [PubMed: 20081101]
23. Mooney MR, Unger BT, Boland LL, Burke MN, Kebed KY, Graham KJ, Henry TD, Katsiyiannis WT, Satterlee PA, Sendelbach S, Hodges JS, Parham WM. Therapeutic hypothermia after out-of-hospital cardiac arrest: Evaluation of a regional system to increase access to cooling. Circulation. 2011; 124(2):206–14. [PubMed: 21747066]
24. Larson DM, Menssen KM, Sharkey SW, et al. "False-positive" cardiac catheterization laboratory activation among patients with suspected st-segment elevation myocardial infarction. JAMA. 2007; 298:2754–2760. [PubMed: 18165668]
25. Anderson HV, Shaw RE, Brindis RG, et al. A contemporary overview of percutaneous coronary interventions. The american college of cardiology-national cardiovascular data registry (ACC-NCDR). J Am Coll Cardiol. 2002; 39(7):1096–103. [PubMed: 11923031]

26. McCabe JM, Armstrong EJ, Kulkarni A, et al. Prevalence and factors associated with false-positive st-segment elevation myocardial infarction diagnoses at primary percutaneous coronary intervention-capable centers: A report from the activate-sf registry. Arch Intern Med. 2012 Jun 11; 172(11):864–71. [PubMed: 22566489]

27. Gaba DM, Howard SK. Patient safety: Fatigue among clinicians and the safety of patients. N Engl J Med. 2002; 347(16):1249–55. [PubMed: 12393823]

28. Menees DS, Peterson ED, Wang Y, Curtis JP, Messenger JC, Rumsfeld JS, Gurm HS. Door-to-balloon time and mortality among patients undergoing primary pci. N Engl J Med. 2013; 369(10): 901–9. [PubMed: 24004117]

29. Flynn A, Moscucci M, Share D, Smith D, LaLonde T, Changezi H, Riba A, Gurm HS. Trends in door-to-balloon time and mortality in patients with st-elevation myocardial infarction undergoing primary percutaneous coronary intervention. Arch Intern Med. 2010; 170(20):1842–9. [PubMed: 21059978]

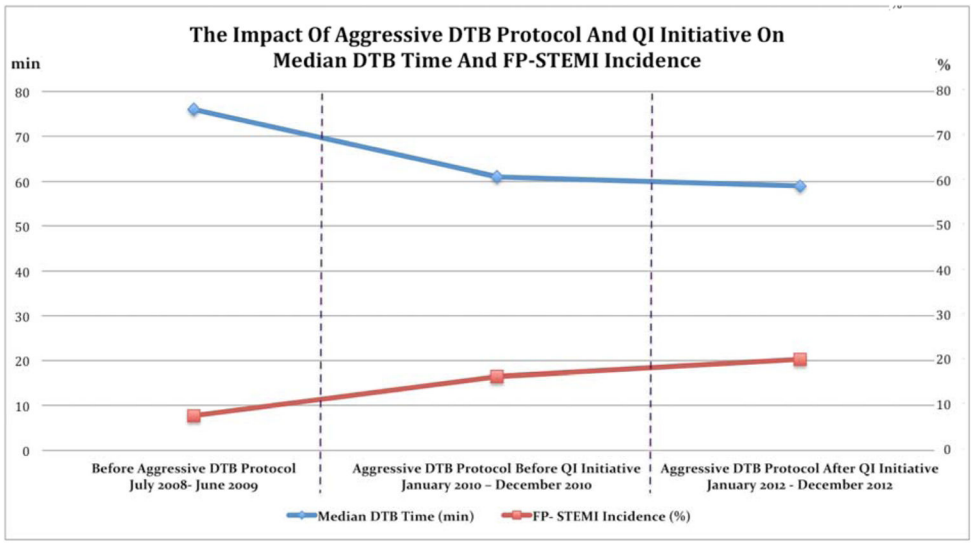

Figure 1.

The Impact Of Aggressive DTB Protocol On Median DTB Time, Incidence And FP-STEMI From The Three-Comparator Intervals (baseline, after DTB time reduction protocol, and after QI project. Transition periods have been removed).

Table 1

Decreasing door-to-balloon time, false-positive ST elevation Myocardial infarction (STEMI) and in-hospital mortality rate before, during the transition period and after the aggressive DTB Protocol.

	Before Aggressive DTB Protocol July 2008-June 2009	Transitional Period July –December 2009	After Aggressive DTB Protocol before QI Initiative January – December 2010	P Value
All STEMI	233	123	224	N/A
Median DTB (min)	76 (39–261)	67 (33–229)	61 (31–157)	.001
TP-STEMI	215 (92.7%)	112 (91%)	187 (83.5%)	.01*
Odds ratio of TP-STEMI	1.0 (Referent)	.9 (.4–1.9)	.4 (.2–.8)	
FP-STEMI	18 (7.7%)	11 (9%)	37 (16.5%)	.02*
Odds ratio of FP-STEMI rate	1.0 (Referent)	1.2 (.5–2.6)	1.8 (1.0–3.2)	
In-hospital mortality in TP-STEMI	8/225 (3.6%)	7/112 (6.3%)	2/187 (1.1%)	.6*
Odds ratio of in-hospital mortality in TP-STEMI	1.0 (Referent)	1.8 (.6–5.1)	.3 (.1–1.4)	
In-hospital mortality in FP-STEMI	1 /18 (5.6%)	3/11 (27 %)	8 /37 (21.6%)	.03*
Odds ratio of in-hospital mortality in FP-STEMI	1.0 (Referent)	6.3 (.6–71.3)	4.7 (.5–4.8)	

STEMI= ST Elevation Myocardial Infarction, FP= False Positive, TP= True Positive, DTB= Door to Balloon, min=minutes.

*P-value for the score test for trend of odds.

Table 2

Causes of ST Elevation and disorders leading to death in the historic 10 years and the 2008–2010 cohorts.

Causes of ST Elevation in the FP-STEMI historic 10 years cohort (N= 728)	**Clinical Disorders in the deceased FP-STEMI in the historic 10 years cohort (N= 89)**	**Causes of ST Elevation in the FP-STEMI 2008–2010 cohort (N= 66)**	**Clinical Disorders in the deceased FP-STEMI in 2008–2010 cohort (N= 12)**
• LVH: 32% (232) • Early repolarization: 18% (131) • Pericarditis: 19% (138) • Electrolyte abnormalities: 11% (86) • LBBB: 14% (109) • Takotsubos cardiomyopathy: 2% (16) • ST elevations secondary to other systemic illness (Pulmonary embolism, intracerebral catastrophe, etc.): 2%. (16)	• Out of hospital arrest: 30% (27) • Sepsis with LBBB: 14% (12) • Aortic dissection: 10 % (9) • Sepsis with takotstubo cardiomyopathy: 8 % (7) • Massive Pulmonary embolism: 7 % (6) • Intracerebral catastrophe: 6% (5) • Undetermined: 25% (23)	• LVH: 26% (17) • LBBB: 14% (9) • Early repolarization: 12% (8) • Pericarditis 12% (8) • Takotsubos cardiomyopathy: 12% (8) • Electrolyte abnormalities: 9 % (6) • ST elevations secondary to other systemic illness (Pulmonary embolism, intracerebral catastrophe, etc.): 15%. (10)	• Massive Pulmonary embolism 25% (3) • Intracerebral catastrophe 17% (2) • Severe sepsis with takotstubo cardiomyopathy 17% (2) • Out of hospital cardiac arrest 17% (2) • Aortic dissection 8% (1) • Undetermined 17% (2).

Table 3

Door to balloon time, FP-STEMI and in-hospital mortality in patients taken for emergency cardiac catheterization for the year before, during the transition period, and after the Quality Improvement (QI) Initiative:

	Aggressive DTB Protocol before QI Initiative January 2010 – Dec 2010	Aggressive DTB Protocol QI Initiative Transitional Period January 2011 – Dec 2011	Aggressive DTB Protocol after QI Initiative January – Dec 2012	P Value
All STEMI	224	234	217	N/A
Median DTB (min)	61 (31–157)	57 (29–154)	59 (28–163)	.03
TP-STEMI	187 (83.5%)	174 (74.4%)	173 (79.3%)	.3*
Odds ratio of TP-STEMI rate	1.0 (Referent)	.6 (04–.9)	.8 (.5–1.3)	
FP-STEMI	37 (16.5%)	60 (25.6%)	44 (20.3%)	.3*
Odds ratio of FP-STEMI rate	1.0 (Referent)	1.7 (1.1–2.8)	1.3 (.8–2.1)	
In-hospital mortality in TP-STEMI	2/187 (1.0%)	2/174 (1.1%)	2/173 (1.1%)	.9*
Odds ratio of In-hospital mortality in TP-STEMI	1.0 (Referent)	1.1 (.2–7.8)	1.1 (.2–7.8)	
In-hospital mortality in FP-STEMI	8 /37 (21.6%)	5/60 (8.3%)	2/44 (4.5%)	.03*
Odds ratio of In-hospital mortality in FP-STEMI	1.0 (Referent)	.3 (.1–1.1)	.2 (.1–.9)	

STEMI= ST Elevation Myocardial Infarction, FP= False Positive, TP= True Positive, DTB= Door to Balloon, min=minutes.

*P-value for the score test for trend of odds.