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International Journal of Current Research
Vol. 7, Issue, 04, pp.14518-14522, April, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

ACTIVATION OF CARDIAC CATHETERIZATION LABORATORY BY EMERGENCY PHYSICIANS REDUCES DOOR TO BALLOON TIME FOR ACUTE MYOCARDIAL INFARCTION

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ARTICLE INFO

Article History:
Received 20th January, 2015
Received in revised form
15th February, 2015
Accepted 22nd March, 2015
Published online 28th April, 2015

Key words:

Acute Myocardial Infarction,
Primary Coronary Intervention,
American Heart Association,
Door to balloon time,
False alarm activation,
Emergency department.

ABSTRACT

Patients with typical cardiac chest pain and electrocardiographic evidence of an Acute Myocardial Infarction (AMI), new left bundle branch block or a true posterior Myocardial Infarction are all eligible candidates for timely reperfusion by percutaneous coronary intervention (PCI) (ACC/AHA/SCAI, 2005). According to the American College of Cardiology, American Heart Association and European Society of Cardiology it is recommended that procedure should be performed in a timely manner (balloon inflation or stent placement or both within90 minutes after the first medical contact.

Aim: Purpose of review is to evaluate strategies to reduce door to balloon time by activation of cardiac catheterization laboratory by emergency physician and to evaluate the false alarms activation.

Methods: A comprehensive computerized search was conducted using Cochrane, Pub Med, Ovid and EBSCO to identify relevant studies.

Results: 11 studies were found which examined the relationship between activation of Cardiac catheterization laboratory by Emergency physician to reduce the Door to Balloon time. One (Bradley *et al*., 2006) was a multivariate analysis surveying 365 hospitals, which showed that having emergency medicine physicians determine whether a myocardial infarction with ST-segment elevation is present and activate the catheterization team without involvement of a cardiologist was strongly associated with a reduced DTBTbut was used in only about 23% of hospitals during weekdays and in 27% of hospitals at night or on weekends (Bradley *et al*., 2006).

Two (Bradley *et al*., 2006, Bradley *et al*., 2005) were qualitative studies which showed that the best practices to reduce the DTBT includes assigning the emergency physicians the responsibility for deciding to call in the catheterization team. Eight (Khot *et al*., 2007; Kurz *et al*., 2007; Thatcher *et al*., 2003; Zarich *et al*., 2004; Jacoby *et al*., 2005; Singer *et al*., 2007; Kraft *et al*., 2007 and Lipton *et al*., 2006) were pre and post cohort studies conducted in single hospitals, which showed reduced DTBT when Emergency physicians activated the Cardiac Catheterization laboratory without a cardiology consultation.

Conclusion: The activation of the cardiac catheterization laboratory by the Emergency physician in cases of ST-elevation AMI shortens the DTBT and does so without using additional resources or costs. This study that has reviewed all relevant literature, supports the development of systems that enable and promote early Emergency Physician activation of cardiac catheter laboratories when patients with ST-elevation MI's present to the ED.

INTRODUCTION

Patients with typical cardiac chest pain and electrocardiographic evidence of an Acute Myocardial Infarction (AMI) manifested by elevation of the ST segments (>1 mm in two contiguous leads) are considered to be candidates for reperfusion therapy. Patients with typical and persistent symptoms in the presence of a new or presumably new left bundle branch block or a true posterior Myocardial Infarction are also considered eligible(ACC/AHA/SCAI, 2005).Timely percutaneous coronary intervention (PCI) is the reperfusion therapy of choice in such patients. (ACC/AHA/SCAI, 2005)Primary PCI consists of urgent balloon angioplasty (with orwithout stenting), without the previous administration of fibrinolytictherapy or platelet glycoprotein IIb/IIIa inhibitors. After the identification by coronaryangiography of the site of recent thrombotic occlusion, a metalwire is advanced past the thrombus over which a balloon catheter(with or without astent) is positioned at the site of the occlusionand inflated, thereby mechanically restoring According to the guidelines of the American College of Cardiology, The American Heart Association and the European Society of Cardiology primary PCI is placed as a class I interventionin patients with ST- elevationMI who can undergo the procedure within 12 hours after the onsetof chest pain. (ACC/AHA/SCAI, 2005; The Task Force on the Management of Acute Myocardial Infarction of the European Society of Cardiology, 2003). It is recommended that the procedure is performed in a timelymanner (balloon inflation or stent placement or both within90 minutes after the first

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medical contact), by experienced operators (those who perform more than 75 interventional procedures peryear) in a facility in which more than 200 coronary interventionalprocedures are performed each year (at least 36 of them beingprimary in nature) and which has cardiac surgical capability,in case such surgery is required. (ACC/AHA/SCAI, 2005) In addition, a recent ruling by a coroner's jury in Illinois provided a reminder of the legal implications of treatment delays. In that ruling, it was found that the death of a patient who had spent nearly two hours in an Emergency department waiting room before proper diagnosis and treatment of a heart attack constituted a potential homicide (Bradley *et al*., 2007). Primary PCI restores normal flowin the previously occluded artery in more than 90% of patients, where as fibrinolytic therapy does so in only 50 to 60% (Mehta *et al*., 2003). In a meta-analysis of 23 randomized, controlled comparisonsof primary PCI (involving 3872 Patients) and fibrinolytic therapy (3867 patients), the rate of death at 4 to 6 weeks after treatmentwas significantly lower among those who underwent primary PCI(7% vs. 9%). Rates of nonfatal reinfarction and stroke were also significantly reduced (Keeley *et al*., 2003). Ante grade flow (Ellen *et al*., 2007). The importance of the door-to-balloon time (the intervalbetween the first medical contact and the procedure) is highlighted byits inclusion as one of the core quality measures collectedand reported by the Centers for Medicare and Medicaid Services(CMS) and the Joint Commission on Accreditation of Healthcare Organizations. The time from hospital arrival to primary PCI in the United States is decreasing slowly. In large surveys, the median door to balloon time (DTBT) fell from 120 minutes in 1994-1995 to 108 minutes in 1999-2002; however, between 1999 and 2002, only 35 percent of patients met the recommended goal of less than 90 minutes (McNamara *et al*., 1999, 2002). Data from National Registry for Myocardial Infarction show that improvement in Door to balloontime between 1999 and 2002 varies substantially among hospitals: only 26 percent of 421 hospitals in the survey improved the DTBT by more than 3 minutes per year. High annual PCI volume was associated with significantly greater improvement in DTBT (McNamara *et al*., 1999 2002).

The overall effect of the door-to-balloon time on the benefit from primary PCI was illustrated in a meta-analysis of trials comparing primary PCI and fibrinolysis: (Nallamothu and Bates, 2003). In 21 trials evaluating mortality at four to six weeks (7419 patients), every additional 10 minute delay in DTBT beyond the door-to-needle time for fibrinolytic therapy reduced the absolute benefit of primary PCI by 0.94 percent. The two strategies became equivalent with regard to mortality after a delay of 62 minutes (Nallamothu and Bates, 2003) 2. In 13 trials evaluating the combined end point of death, reinfarction, or stroke at four to six weeks (4946 patients), every additional 10 minute delay in Door to balloon time beyond the door-to-needle time for fibrinolytic therapy reduced the absolute benefit of primary PCI by 1.17 percent. The two strategies became equivalent with regard to the combined end point after a delay of 93 minutes (Nallamothu and Bates, 2003).The effect of DTBT on in-hospital mortality was further illustrated in a report published after the meta-analysis of 29,222 STEMI patients in the NRMI-3 and 4 registries (1999 to 2002) who were treated with PCI within six hours of presentation. The following findings were noted: [10] 1. Longer DTBT were significantly associated with increased in-hospital mortality (3.0, 4.2, 5.7, and 7.4 percent for DTBT of ≤90 minutes, 91 to 120 minutes, 121 to 150 minutes, and >150 minutes, respectively) (McNamara *et al*., 2006) 2.

Patients with DTBT >90 minutes had a significant increase in mortality compared to those with DTBT ≤90 minutes (odds ratio 1.42, after adjusting for patient characteristics). This relationship persisted after adjusting for differences in high-risk predictors such as blood pressure <100 mmHg or heart rate >100 beats/min (McNamara *et al*., 2006).

Performance improvement strategies

Studies of hospitals that have successfully implemented strategies resulting in DTBTs of less than 90 minutes have identified a number of quality initiatives which have minimized treatment delays. In a multivariate analysis of 365 hospitals, six strategies that reduced Door to balloon time were identified (Bradley *et al*., 2006)

- Emergency medicine physician ability to activate the catheterization laboratory (meanreduction in Door to balloon time, 8.2 minutes).
- Single call to a central page operator who activates the catheterization laboratory (13.8 minutes).
- Expectation that staff will arrive in the catheterization laboratory within 20 minutes after being paged compared to more than 30 minutes (19.3 minutes).
- Having an attending cardiologist always on site (14.6 minutes).
- Having staff in the emergency department and the catheterization laboratory use real-time feedback (8.6 minutes). 6. Emergency department activate the catheterization laboratory while the patient is en route (15.4 minutes).

MATERIALS AND METHODS

The purpose of the review is to evaluate the strategy to reduce the door to balloon time by activation of cardiac catheterization laboratory by emergency physician and to evaluate the false alarms activated.A comprehensive computerized search was conducted using Cochrane, PubMed, Ovid and EBSCO to identify relevant studies using the terms cardiac catheterization laboratory, activation of catheterization laboratory by emergency physician and faster door to balloon time.

Results of Literature Search

11 studies were found which examined the relationship between activation of Cardiac catheterization laboratory by Emergency physician to reduce the Door to Balloon time. One (Bradley *et al*., 2006) was a multivariate analysis surveying 365 hospitals. Two (Bradley *et al*., 2006; Bradley *et al*., 2005) were qualitative studies and eight (Khot *et al*., 2007; Kurz *et al*., 2007; Thatcher *et al*., 2003; Zarich *et al*., 2004; Jacoby *et al*., 2005; Singer *et al*., 2007; Kraft *et al*., 2007 and Lipton *et al*., 2006) were pre and post cohort study conducted in single hospitals.

Multivariate Study

Bradley and colleagues conducted a cross sectional study to identify hospital strategies that are associated with shorter Door to Balloon time. 365 acute care hospitals in the United States were surveyed using a questionnaire that included 32 closed ended items identifying 28 key hospital strategies that influence the care of patients with ST elevation myocardial infarction receiving primary PCI. Six strategies were found to be significantly associated with a faster Door to Balloon time (Bradley *et al*., 2006). These strategies included activation of the Catheterization laboratory by ER physician without consulting a cardiologist and it was associated with a shorter Door to balloon time (mean reduction in DTBT 8. 2 minutes).Other strategies included having a single call to a central page operator activate thelaboratory (13.8 minutes), having the emergency department activatethe catheterization laboratory while the patient is en routeto the hospital

(15.4 minutes), expecting staff to arrive inthe catheterization laboratory within 20 minutes after beingpaged (vs. >30 minutes) (19.3 minutes), having an attendingcardiologist always on site (14.6 minutes), and having staffin the emergency department and the catheterization laboratoryuse real-time data feedback (8.6 minutes). Despite the effectivenessof these strategies, only a minority of hospitals surveyed wereusing them (Bradley *et al*., 2006). The median number offalse alarms that was reported among hospitals in which emergencymedicine physicians activated the catheterization laboratorywas 2 (interquartile range, 1 to 4), as compared with one falsealarm (interquartile range, 0 to 3) for all other hospitals. (Bradley *et al*., 2006) Havingemergency medicine physicians determine whether a myocardialinfarction with ST-segment elevation is present and activatethe catheterization team without involvement of a cardiologistwas strongly associated with a reduced DTBTbut was used in only about 23% of hospitals during weekdaysand in 27% of hospitals at night or on weekends. (Bradley *et al*., 2006)

Pre/Post Interventional Cohort Study

All of the pre/post cohort studies showed reduced DTBT when Emergency physicians activated the Cardiac Catheterization laboratory without a cardiology consultation. Khot and Colleagues showed that the median DTBT decreased overall (113. 5 versus 75.5 minutes: p<0.0001), during regular hours (83.5 versus 64.5 minutes: p<0.005) during off- hours (123.5 versus 77.5 minutes: p<0.0001). The proportion of patients treated within 90 minutes increased from 28% to 71% (p<0.0001).

There was a more than two-fold increase in treatment within 60 minutes, and nearly ten-fold reduction in treatment requiring more than 120 minutes (Khot *et al*., 2007). They also evaluated hospital costs, length of stay, all cause in-hospital mortality and infarct size, measured by peak creatinine kinase which was shown to be decreased. During the period of emergency physician activation, there was one (total of 96 patients) false activation of the catheterization laboratory (Khot *et al*., 2007). A similar study was done by Kurz in which 107 patients presented to the Emergency Department with an ECG indicative of STEMI, and all were correctly recognized by the emergency physician. Only 1 false activation of the cardiac catheterization laboratory occurred during the 13-month emergency physician initiation cohort, yielding a sensitivity of 100% (95% confidence interval [CI] 97.3% to 100%) and a specificity of 99.6% (95% CI 97.7% to 99.9%) (Kurz *et al*., 2007). The mean DTBT improved 40 minutes (95% CI 26 to 54 minutes; $p<0.001$) throughout the study period, from 131 minutes before to 91 minutes after emergency physician initiation began. The difference in mean door-to-balloon time persisted when cohorts were stratified by peak (49-minute difference; 95% CI 22 to 77 minutes; *p*_.0007) and off-peak arrival (34-minute difference; 95% CI 19 to 49 minutes; *p*_.0001). The proportion of patients receiving PCI within the ACC/AHA guideline of 90-minute door-to-balloon time improved from 22.1% to 55.8%, as did the proportion of patients with prolonged door-to-balloon time (>120 minutes), from 50.5% to 13.0% (Kurz *et al*., 2007). De Luca *et al.* demonstrated that each 30 minutes of PCI delay is associated with a 7.5% relative increase in mortality (De Luca *et al*., 2004). In a study conducted by Thatcher and colleagues, Median DTBT improved from 88 minutes (95% CI, 80 96) to 61 minutes (95% CI, 57 70; p < 0.0001) before (n=206) and after (n=81) the initiation of Emergency physician activation of the cath lab respectively (Thatcher *et al*., 2003).

Zarich and colleagues in a pre/post cohort of study found the mean door to balloon times from the pre intervention cohort (n=91) and post intervention cohort (n=67) were significantly shorter (141 to 95 minutes: p<0.001) in bivariate analysis. Most of the improvements in door to balloon time in this study were related to less delay from ECG toactivation of the cath lab (38 to 21 minutes: p<0.001 in bivariate analysis) (Zarich *et al*., 2004).In the study conducted by Jacoby and colleagues, Door to balloon time reduced significantly from 118 to 89 minutes, p=0.039 (Jacoby *et al*., 2005). Two other similar studies (Singer *et al*. (2007), Kraft *et al*. (2007) had conclusions as above with reduced door to balloon time after implementation of activation of catheterization laboratory by the Emergency physician. In a retrospective before and after time series analysis of 88 patients at a single community hospital by Kraft Kraft *et al*. (2007), patients treated in the direct activation phase had shorter DTBTs than those in the cardiologist-mediated phase. There were no false activations.Singer reported a reduced door to balloon time for 97 patients with STEMI from 176 to 108 minutes, increasing the proportion of patients treated within 90 minutes from 3% to 29% (Singer *et al*., 2007).

A study conducted by Lipton and colleagues evaluated the combined effect of HCIS (hospitalcare improvement strategies) implementation to reduce door-to-balloon time in patients with STEMI. Retrospective chart review was done for 95 consecutive patients with STEMI whounderwent PCI in a single hospital. A program of 3 HCIS was implemented: 1) a fast-track catheterization laboratory protocol, 2) feedback to cardiologists on their treatment times, and 3) a weekday 24-hour in-house catheterization laboratory team. Patients were separated into groups before (n = 46), during (n = 18), and after (n = 31) HCIS implementation. Door-to-PCI time in minutes

was reduced in the group after versus the group before HCIS Implementation (94.3 +/- 37 versus 133.5 +/- 53; P < 0.0001). Implementation of HCIS shortened door-to-PCI time for patients with STEMI by 39.2 +/- 10 minutes (Lipton *et al*., 2006).

Qualitative Study

Bradley and colleaguesconducted twoqualitative studies (Bradley *et al*., 2006; Bradley *et al*., 2005) using in- depth interviews with clinical and administrative staff at 11 hospitals that were participating with the National Registry of Myocardial infarction. Table 1Members of the research team with extensive experience in performance improvement, cardiology, and qualitative interviewing conducted in-depth, open-ended interviews.From these hospitals, those with median door-to-balloon times of 90 minutes for their most recent 50 PCI cases were selected.In one of the qualitative analysis, 8 themes emerged that were recurrent and unifying ideas and characterized the experiences of improving door-to-balloon times in the study hospitals (Bradley *et al*., 2006).

team to beready to receive the patient. Another central aspect of the ideal process is the rapid activationof the catheterization team by emergency physicians, ratherthan by cardiologists. The best practices include assigningthe emergency physicians responsibility for deciding to callin the catheterization team. This practice circumvents the delayin contacting a cardiologist, who would then need to obtainand review patient data for a decision. Despite evidence that emergency physician activation of thecatheterization team can significantly reduce door-to-balloontime, establishing this best practice requires substantialeffort and interdisciplinary trust and communication (Bradley *et al*., 2005).

False positive catheterization laboratory activation

There are limited data on the frequency of false positive catheterization laboratory activation in patients undergoing primary PCI for suspected ST elevation myocardial infarction. A weakness of the strategy could be referral of patients who are not candidates for PCI by practitioners who are potentially less skilled in ECG interpretation.

Table 1. Description of Study Hospitals (n=11)

ID	Region	No. of Beds	Teaching Status	STEMI Annualized Volume*	Annualized PCI Volume* for Patients With STEMI	Median PCI Time (min) for Last 50 PCI Cases in Patients With STEMI
1	Northeast	770	Teaching	68	64	85.5
2	Midwest	176	Teaching	33	29	75.5
3	South	870	Teaching	187	151	55.5
4	Midwest	426	Teaching	85	70	70.5
5	South	350	Nonteaching	94	68	69.0
6	West	204	Teaching	89	80	82.0
7	West	277	Teaching	41	34	89.0
8	South	633	Teaching	124	81	86.5
9	West	190	Nonteaching	43	41	89.5
10	West	111	Nonteaching	51	29	87.0
11	Midwest	276	Teaching	95	36	87.0

ID indicates identification number; AMI, acute myocardial infarction.
*Based on 1999–2002 volume.

These themes were apparent in all 11 hospitals The experiences of these hospitals strongly suggest that innovative protocol development does not occur in isolation but is most effective when integrated into an environment and the key themes include explicit goals of reducing door to balloon time; support of senior management and clinical leaders; innovative standardized protocols: flexibility in implementing standardized protocols: uncompromising individual clinical leaders: collaborative, interdisciplinary teams; detailed data feedback; and a non-blaming, patient-focused organizational culture. In the second qualitative analysis an ideal approach to reducing door-to-balloon timesfor patients with STEMI was proposed on the basis of experiences of top-performing hospitals. The approach reflects a compilationof best practices in each step of the process, thereby creatinga process in which hospitals can regularly achieve the 90-mindoor-to-balloon time standards set by the ACC/AHA in recentguidelines for the treatment of STEMI (Bradley *et al*., 2005). A critical part of the process is the rapid acquisition andinterpretation of the ECG. Ideally, before the patient arrives in the ED, this informationis obtained and transmitted by paramedics to the ED. This processenables earlier notification of the on-call catheterizationlaboratory staff and interventional cardiologist and thus canreduce delays in waiting for the catheterization

The frequency of false positive referrals and the associated diagnoses were evaluated by Larson and colleagues in a prospective registry of 1335 patients referred from 30 hospitals in Minnesota and Wisconsin between 2003 and 2006. False positive was defined as no culprit coronary artery (present in 14 percent), negative biomarkers (11.2 percent), or both (9.2%). In those patients, with negative biomarkers, the most common discharge diagnoses were early repolarization, nondiagnostic ECG, previous Myocardial Infarction, left bundle branch block, and pericarditis (Larson *et al*., 2007).

Conclusion

There are many advantages to adopting a strategy of Emergency physician activation of the catheterization laboratory when faced with an ST-elevation AMI: such a strategy will affect DTBT immediately, and will do so without cost or using additional resources. The data supporting the need to attain a 90 minute benchmark as a quality indicator in the management of ST-elevation AMI are extremely strong. The introduction of strategies that limit time-delays during all phases of pre-PCI management of these cases is essential. This study that has reviewed all relevant literature supports the

development of systems that enable and promote early Emergency Physician activation of catheter laboratories when patients with ST-elevation MI's present to the ED.

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