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Erin Troby

*University of Arkansas, Fayetteville*

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## RESEARCH NOTE: EXPLORATION OF FACTORS THAT IMPEDE DOOR-TO-BALLOON TIMES

By Erin Troby

Eleanor Mann School of Nursing

Faculty Mentor: Ellen Odell

Eleanor Mann School of Nursing

### Abstract

*When experiencing an acute myocardial infarction (AMI), more commonly known as a heart attack, patients need rapid treatment in order to open up and reestablish blood flow within the coronary artery. By far, the most common way to do this is an invasive procedure that allows a physician to inflate a tiny balloon into the plaque-filled area of the artery. The American College of Cardiology (ACC) and the American Heart Association (AHA) have established a 90-minute goal for this procedure, which means that, from the time a patient enters the door of the emergency department (ED), the medical team has 90 minutes to assess, diagnose, prepare, and treat the patient with the balloon inflation procedure. The purpose of this study was to determine whether the 90-minute benchmark goal was being met in patients presenting to the emergency room with an AMI in an urban acute care hospital in Northwest Arkansas. If the time was not met, factors that influenced the delay were explored. A retrospective chart review was conducted on patients (N = 70) admitted to the ED with an AMI and subsequently taken to the cardiac catheterization lab for balloon inflation between March 1, 2008 and March 31, 2009. Only 70% of the hospital's patients met the benchmark goal. Specific time intervals were studied to determine where delays were occurring, and demographic factors were examined to explore differences between groups meeting and not meeting the benchmark. Recommendations for additional research and changes in hospital procedures were made.*

### Introduction

Thirteen million Americans suffer from coronary artery disease, and 19% of the United States workforce is permanently disabled by the disease (Lamia, 2007). Approximately 865,000 people experience an ST-elevation myocardial infarction (STEMI) each year caused by a completely blocked artery (AHA, 2008; Lamia, 2007; Larson et al., 2007). This is a heart attack that is diagnosed by an area of elevation of more than 1 mm in the ST segment in two or more leads on the rhythm strip of an electrocardiograph (ECG). The most effective treatment for this type of myocardial infarction (MI) is a percutaneous coronary intervention (PCI) using a balloon to open the narrowed blood vessel and/or insertion of a metal device, called a stent, to keep the artery open (AHA, 2006; Pinto et al., 2006).

To improve mortality and morbidity, the American College of Cardiology (ACC) and the American Heart Association (AHA) have set a goal to reduce door-to-balloon (DTB) times from 120 minutes to 90 minutes or less (Lamia, 2007; McNamara et al., 2006; Pinto et al., 2006; Ting et al., 2008). The decrease in this time interval preserves the heart muscle, reduces the infarct size, saves lives, and lowers the number of people disabled by heart disease (Lamia, 2007; Ting et al., 2008). For every 30-minute increase in time, there

is a 10% increase in the risk of in-hospital death (Pinto et al., 2006). Thus, the 90-minute door-to-balloon (DTB) time is now the gold standard of care for health care facilities. Additionally, failure to reach the 90-minute DTB time goal in 88% of patients may affect an individual hospital's accreditation and Medicare reimbursement (Lamia, 2007). When the 90-minute DTB goal has been achieved, hospitals have experienced a decrease in hospital stay by two days and hospital costs by \$10,000 per admission (AHA, 2008). Nationally, between 33 to 40% of patients actually receive treatment within 90 minutes (AHA, 2008; Bradley et al., 2006; Rosamond, Flegal, & Friday, 2007).

Several events must occur in order to have a patient admitted through the emergency department to the cardiac catheterization laboratory in an expedient manner. Many hospitals have developed protocols to help guide this process and to reduce times and delays after identifying factors that impeded the ability to reach the 90-minute benchmark. These include (a) having a set protocol for chest pain patients, (b) having the ECG done within 10 minutes of arrival, (c) having the emergency physician initiate the order to move the patient to the cardiac catheterization laboratory, (d) having a single-call activation paging system, (e) having a cardiologist on site 24 hours a day, (f) setting a 20-minute time limit for cardiac catheterization laboratory staff to arrive, and (g) reviewing times and delays monthly with all staff involved in the appropriate departments (Bradley et al., 2008; Cadet, 2008; Lamia, 2007; Ting et al., 2008). Some hospitals are working to have emergency medical teams transmit the ECG to the hospital while still at the scene or en route, allowing activation of cardiac catheterization laboratory personnel before the patient arrives in the emergency department (Bradley et al., 2008; Lamia, 2007; Ting et al., 2008; UAMS, 2006). Another strategy is to have a cardiac/AMI box or cart put together with all the supplies, medications, and protocols that are needed to save time and expedite the procedures (Lamia, 2007; Bradley et al., 2006, 2008). Additional research is needed to identify opportunities for continued improvement (AHA, 2008; Bradley et al., 2006; Rosamond et al., 2007).

One urban hospital in Northwest Arkansas has already implemented several of these standards and benchmark interventions. The current study was conducted at this hospital. The purposes of this study were (1) to determine if care of patients diagnosed with an ST-segment elevation myocardial infarction met the national standard of receiving cardiac catheterization with balloon inflation within 90 minutes of arrival in the emergency department; and (2) to explore factors that impede reaching that goal. Specific research questions were the following:

Research Question #1: What proportion of patients admitted to the

emergency department with an ST elevation receive balloon inflation in the cardiac catheterization laboratory within 90 minutes?

Research Question #2: What factors differentiate the patient group meeting benchmark standards from the group not meeting standards?

Research Question #3: If there are delays in meeting the 90-minute benchmark, where do they occur?

**Methodology**

*Study Hospital and Protocol*

The study was performed at an urban acute care hospital in Northwest Arkansas. The hospital is licensed for 235 total beds, with 40 emergency department beds. The facility services approximately 50,000 patients annually and is rated as a level III trauma facility. The protocol used in this hospital is comparable to the national standards and recommendations for patients meeting the ST-segment myocardial infarction criteria. Upon admission to the emergency department, a STAT (immediate) 12-lead ECG along with a portable chest x-ray is to be completed in less than 10 minutes of arrival. When an ST-segment elevation is noted on the ECG, the cardiologist and cardiac catheterization laboratory team are notified through a paging system, and other simultaneous interventions are initiated. The following medications are administered: Aspirin, Plavix, Nitroglycerin, Metoprolol, Ondansetron, and Heparin. Additionally, blood is drawn for a complete blood count (CBC), electrolyte panel, brain natriuretic peptide (BNP), magnesium, troponin, protime (PT), partial thromboplastin time (PTT), and an international normalized ratio (INR). Nurses apply oxygen to the patient, initiate two intravenous lines, prepare the groin for the procedure by shaving the area, and ensure that operative consent forms are signed.

*Sample*

A probabilistic sample of certainty was used for this study. The records of all patients meeting criteria (presenting with chest pain and being transported directly from the ED to the CCL) from March 1, 2008 through March 31, 2009 were included in the study (N = 70). Patients excluded from the study were those that went to the CCL but were taken to the cardiovascular operating room in lieu of receiving balloon angioplasty due to the severity of their blockages. Another case was also eliminated because the subject experienced an ST-elevation myocardial infarction (STEMI) hours after admission to the emergency department with no complaints of chest pain or other traditional signs and symptoms upon initial presentation.

*Design*

The study used a retrospective chart review and a secondary data source. The secondary data source, accessed by the ED’s Clinical Nurse Specialist, was the list of patients meeting the sample criteria as described above. After initial descriptive statistics were collected on the entire sample, the data were broken into two groups according to whether or not subjects met the 90-minute benchmark, and further statistical analyses were conducted to determine factors that differentiated the two groups and time segments that were significantly delayed in the group not meeting the benchmark (when compared to the benchmark group). The study protocol was approved by the Institutional Review Boards (IRB) of the University of Arkansas and the study hospital. Patient confidentiality was maintained at all times.

*Variables and Analysis*

The dependent variable used to classify patient groups was either “yes” (met the 90-minute goal) or “no” (did not meet the 90-minute goal). The time variables included the following intervals: (a) the patient’s arrival to the emergency department to the performance time of the ECG, (b) the ECG time to when the cardiologist was paged, (c) the total time the patient spent in the ED, (d) the time the patient arrived in the CCL to the case start time, (e) the case start time to the actual balloon inflation, and (f) the total door-to-balloon time. Additional variables were gender, age, number of days spent in hospital (known as length of stay or LOS), and disposition after discharge (home, deceased, transferred to another facility, or left against medical advice). Finally, common risk factors and comorbidities associated with coronary artery disease, as identified by the AHA, were evaluated and identified for each patient. These included previous coronary artery disease, hypertension, tobacco use, dyslipidemia, family history, stroke, peripheral vascular disease, diabetes mellitus, cancer, arrhythmias, obesity, stress/anxiety/depression, presence of a coagulopathy, and renal failure.

Gender, age, length of hospital stay, number of co-morbidities, and disposition were compared between the two groups to determine whether any of these factors contributed to meeting or not meeting the goal. Differences between the two groups were then analyzed for each of the five time intervals using analysis of variance (ANOVA). The significance level for all analyses was established as  $p < 0.05$ .

**Results**

The sample of 70 patients treated with either a balloon angioplasty or a stent after an acute myocardial infarction was 67% male and 33% female. There was a wide range of ages, from 37 to 89 years; six subjects were between the ages of 18 and 39 years, 47 were between 40 and 64 years, and the remaining 17 were 65 years and older. Length of hospital stay (LOS) ranged from one to 14 days, with a mean of 3.34 days. Number of comorbidities ranged from zero to five, with a mean of 3.32.

Seventy percent (N = 49) of the patients met the benchmark 90-minute standard; the remaining 30% (N = 21) exceeded the 90-minute time frame. Distributions of gender and age clusters within each group are shown in Table 1, along with means, standard deviations, and ranges for LOS and comorbidities.

**Table 1.** Factors contributing to group differences.

Factor	Met Goal (N = 49)	Did not meet goal (N = 21)	Group differences
Gender (N, %)			$\chi^2=1.36$ , $df=1$ , $p=.244$
Male	35 (71%)	12 (57%)	
Female	14 (29%)	9 (43%)	
Age (mean, SD)	57.4 (11.8)	56.1 (11.6)	$t=.401$ , $df=68$ , $p=.689$
Age Range (N, %)			$\chi^2=.036$ , $df=2$ , $p=.982$
18-39	4 (8%)	2 (9%)	
40-64	33 (67%)	14 (67%)	
65+	12 (25%)	5 (24%)	
Comorbid/risk factors (mean)	2.2	2.4	$t=.538$ , $df=68$ , $p=.592$
LOS (mean)	3.55	2.8	$t=1.240$ , $df=68$ , $p=.219$

T-tests for independent samples were used to determine whether or not the two groups differed in age, length of stay, and comorbidities. There were no significant differences between the two groups. Chi square analyses were used to determine whether the

distribution of the two groups differed with respect to age group and gender. Again, there were no significant differences in group composition. Disposition of subjects upon discharge was not compared between groups since only four patients were not discharged to the home (two within each group). Statistical outcomes are summarized in Table 2.

The five segmented time intervals were compared using one-way ANOVA. For the group not meeting the 90-minute benchmark, all time intervals were significantly longer than those for the benchmark group (see Table 2). The average time for balloon inflation for patients reaching the goal was 68.2 (SD = 16.6) minutes, with a range of 32 to 90 minutes. On average, therefore, this group fell comfortably within the benchmark timeframe. In contrast, for patients not meeting the benchmark, the average time was more than one hour longer, 151.8 (SD = 58.8) minutes, and ranged from 91 to 279 minutes.

**Table 2.** Analysis of variance comparisons of time intervals from door to balloon for patients meeting benchmark and those not meeting benchmark.

Time Interval	Met Benchmark		Did Not Meet Benchmark		F (df)	p value
	Mean	SD	Mean	SD		
Door to ECG time	3.5	5.0	11.6	21.6	6.22 (1, 68)	.015
ECG to Doctor Paged	15.3	13.1	52.7	44.3	29.48 (1, 68)	.000
Total ED Time (goal < 45)	40.1	14.7	109.1	57.3	62.48 (1, 68)	.000
To CCL to Case Start	52.4	16.3	122.9	57.5	62.59 (1, 67)	.000
Case Start to Balloon Inflation	15.8	8.7	28.5	14.2	20.70 (1, 67)	.000
Total Door-to-Balloon Time	68.2	16.6	151.8	58.8	84.79 (1, 68)	.000

## Discussion

This study was designed to determine whether door-to-balloon times met national standards in an urban hospital in Northwest Arkansas and, if they did not, to identify areas needing improvement in order to improve patient outcomes. While the mean times from door-to-balloon for the benchmark group were well within the 90-minute target, the group failing to meet benchmark standards was significantly slower in every time interval in the process. Thus, improvement in treatment time is needed for all time intervals studied in order to attain compliance with the standard and achieve accreditation.

The study facility had 70% of their patients meeting the benchmark—better than the national average of 57% (Rathore, Curtis, Chen, Wang, Nallamothu, Epstein, & Krumholz, 2009). However, it is important to recall that the standard for accreditation is 88% of patients presenting with AMI meeting the 90-minute benchmark (Lamia, 2007). Explanations for the low national average include the disproportionately large number of patients presenting to hospitals that are not equipped with a CCL and thus are unable to perform PCI, which requires the patient to be transferred to another facility. However, this is not the case in the study hospital. Improvement in reaching the standard is still needed.

The fact that demographic variables did not distinguish the two groups in this study was somewhat surprising. For example, it would be expected that patients who are sicker (more comorbid diseases) would have a poorer outcome. It is also logical to believe that those patients with significant risk or history of cardiovascular disease would have more complications and an increased LOS and mortality rate. This was not found to be true. Another surprising finding was the factor of age. The elderly population in general does not present with the typical signs and symptoms of chest pain,

making it easier to “miss” the diagnosis. Signs and symptoms can be masked by other processes of normal aging or a dulled pain sensation. Despite these facts, age was not a significant factor in determining whether a patient was able to achieve the 90-minute benchmark. With respect to gender, there were again no significant differences between the groups. Although not part of the primary analysis in this study, it was noted that females took longer to arrive in to the cardiac catheterization laboratory (CCL), but once there, they were treated with the balloon inflation more quickly than men were. This finding is certainly worthy of further study.

Inconsistent with previous research, the average length of stay in this study hospital was actually longer by 0.75 days in the group of patients that did receive PCI within 90 minutes. Two patients who met the 90-minute benchmark had LOS of 13 and 14 days. Although they were quickly treated with a PCI, they later developed complications requiring surgery, which could have played a role in the non-significant findings of this study. Even though long-term outcomes were not measured, the delay in PCI did not influence the LOS in this study, as might have been expected.

## Recommendations and Future Implications

The American College of Cardiology has recently been discussing the additional benefits of reducing the benchmark even further to a 60 minute-or-less time frame. The time would still be a total of 90 minutes but would include a 30-minute allowance for emergency response teams in the field, giving only 60 minutes to the hospitals' portion of the process. In the current study, data showed only 22.5% of the patients would have reached the 60-minute goal, which establishes an even greater need for an increased speed of delivery of care for this facility should the standard change in the near future.

Several of the national suggestions for improvement have already been implemented in this facility. However, throughout the year of this study, two recurring delays were observed that might have influenced the facility's treatment of the patients experiencing AMI. First, there seemed to be a delay or hesitation between reading the ECG and the decision to call in the CCL personnel. Some ED physicians, despite seeing ECG changes indicating AMI, did not activate the paging system for the CCL personnel. Instead, they preferred to allow the cardiologist to read the ECG and determine whether or not to call in the CCL personnel. Second, in the CCL at the start of the case, there was a delay in actual balloon inflation time. When this delay was discussed with the cardiologists and CCL personnel, it became apparent that some cardiologists were performing a diagnostic cardiac catheterization prior to balloon inflation, whereas other cardiologists were proceeding directly to balloon inflation as soon as possible. These are now two areas being further monitored by the ED Clinical Nurse Specialist.

Suggestions for future studies include further detailed analyses of the charts of those patients who did not meet the benchmark, exploring for commonalities. A real-time prospective study in which persons presenting with AMI were actually followed through the system would also be valuable. Factors to consider in future research include time of day, day of the week, staff number and mix available, physician on duty, and CCL availability. It would be crucial to include the testing of different methods used to speed up the process after identifying specifically where a problem lies.

Since the research questions in this study were restricted to one specific hospital, the results can only be generalized to that facil-



ity. One possible limitation is the fact that the study hospital did not have synchronized digital computerized clocks. Although this lack would not affect the determination of whether or not a subject met the 90-minute benchmark, it might result in discrepancies in time due to two departments recording time based on clocks located in separate areas of the facility.

Given the 70% success rate of the study hospital, there is a need to improve patient morbidity and mortality rates resulting from heart disease and acute myocardial infarction, which are among the nation's largest killers. This study highlights the importance of future research into all factors influencing time to reperfusion locally and across the nation.

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**Mentor Comments:** Ellen Odell emphasizes the independence of Erin Troby's research and its potential importance clinically for one area hospital and for the lives of those served there.

*Ms. Troby recently concluded her research at one local hospital; and her project has impact and potential to save lives and improve the quality of medical care with regards to patients experiencing a heart attack. I will not go into detail about the research project itself or the results, but I will tell you that it was extremely successful and a valuable learning experience, not only for Ms. Troby, but also for the staff at the participating hospital agency. Many of the findings from the initial review of literature as well as findings from this study were implemented in the local Emergency Department (ED), and timeframes for treatment have improved over the past one and one-half years. Because of the improvement in patient care and the ability of the agency to meet the benchmark of 90 minutes, the hospital will be applying accreditation as a recognized Chest Pain Center by the Society of Chest Pain Centers. The work involved in the entire project was most definitely Mr. Troby's. She worked independently in most aspects and was totally responsible for getting the work completed. The hospital liaison involved, the Clinical Nurse Specialist (CNS), provided a list of potential subjects and was able to implement several of the findings in the ED. However, as a bonus, the liaison was a graduate of the very first Masters in Nursing CNS class from EMSON in 2007; and this added to the reward of working as a team on such a tremendous project. I have enjoyed working with Ms. Troby during the past year and a half; and although the research process can be tedious and lengthy (especially for students), her excitement for this project never dulled because she understood its importance. This past spring, Ms. Troby successfully completed and defended her research project; and because of her diligence and hard work, she graduated with Honors and Summa Cum Laude recognition. Prior to graduation, she was chosen to be a conference speaker for Sigma Theta Tau International Honor Society of Nursing Pi Theta Chapter at the 19th Annual Nursing Excellence Leadership & Evidence-Based Practice Conference and present her research findings. I am very proud of her and her work. With her solid background of the quality improvement process and her undergraduate experience with research, she will be a tremendous asset to the profession of nursing.*