Chapter 5

Comprehensive hospital care improvement strategies reduce time to treatment in ST-elevation acute myocardial infarction

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ABSTRACT

Background: Delay in treatment of patients with ST-elevation acute myocardial infarction (STEMI) has an adverse effect on patient outcomes. Limited data are available on the effectiveness of hospital care improvement strategies (HCIS) to reduce time to reperfusion by percutaneous coronary intervention (PCI). This study evaluated the combined effect of HCIS implementation to reduce door-to-balloon time in patients with STEMI.

Methods: Retrospective chart review was done for 95 consecutive patients with STEMI who underwent PCI at Charleston Area Medical Center. Patients with non-STEMI and patients transferred from other medical centers were excluded. Door-to-balloon time was defined as time from emergency department arrival to first PCI balloon inflation. 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 inhouse catheterization laboratory team. Patients were separated into groups before (n = 46), during (n = 18), and after (n = 31) HCIS implementation.

Results: Mean age was 60.3 ± 13 years and 74% were male. The majority (64%) arrived by ambulance; 29% had a prehospital electrocardiogram done. Most patients presented during the day (68%) on weekdays (75%). Symptom onset-to-door time was 289 ± 393 minutes. No significant differences were found between the groups for these variables. Door-to-PCI time in minutes was reduced in the group after versus the group before HCIS implementation (94.3 ± 37 vs 133.5 ± 53; P < 0.0001).

Conclusion: Implementation of HCIS shortened door-to-PCI time for patients with STEMI by 39.2 ± 10 minutes. Thus, HCIS may be effective in improving patient outcomes.
INTRODUCTION

Myocardial salvage is increased by reducing treatment delay for patients with ST-elevation acute myocardial infarction (STEMI) (1,2). Many causes for prehospital delay have been identified, including patient misinterpretation of symptoms and inability to obtain or transmit prehospital 12-lead electrocardiograms (ECGs) (3–5).

Inhospital delays between admission and administration of thrombolytic therapy have been associated with factors such as female gender, older age, and an increased prehospital delay have been identified (6), and measures have been found to be effective in reducing the time to thrombolytic therapy, including fast-track admission procedures as well as earlier ECG and enzyme testing for patients with suspected acute myocardial infarction (AMI) (7). However, the effectiveness of inhospital interventions has not been studied on reducing time to percutaneous coronary intervention (PCI).

The aim of the current study was to evaluate the effect of a combination of 3 hospital care improvement strategies (HCIS) on treatment time to reperfusion by PCI: 1) catheterization laboratory staffing during off hours (8), 2) individualized feedback on treatment times to cardiologists on a quarterly basis, and 3) a fast-track protocol for patients with AMI using a “cardiac alert” paging system (similar to a trauma call).

METHODS

This study was approved by the West Virginia University Institutional Review Board. From January 1, 2003, through May 18, 2004, AMI was identified in 96 patients from the Centers for Medicare & Medicaid Services (CMS) database (9) at Charleston Area Medical Center (CAMC). The inclusion criteria were STEMI at admission as determined by ECG or emergency department (ED) physician diagnosis followed by PCI. Patients transferred from other hospitals and patients undergoing thrombolytic therapy or bypass surgery were not included in this study. One patient with an outlying door-to-balloon time of >12 hours as a result of an incorrect initial diagnosis by the ED physician was excluded. Chart review was done for all patients to verify the clinical data and to validate the time parameters.

The call system at CAMC has been in place for more than 5 years and included 33 cardiologists in 6 call groups for their own patients and in 5 call groups for the unassigned patients. Thirteen of the cardiologists were interventionalists. When a noninterventionalist was on call, there would be an interventionalist assigned as backup.
Interventions

The 3 interventions were done over a 60-day period (Figures 1 and 2).

1. Fast-track protocol for patients with AMI (September 17, 2003). For all patients eligible for emergency reperfusion therapy, as determined by the ED physician, a "cardiac alert" code was to be called. The ED physician initiated the cardiac alert, sending a preset multiple pager message through the hospital operator to the on-call cardiologist, the catheterization laboratory coordinator, the ECG technician, the laboratory technician, the radiology technician, and the ED registration clerk. Before this intervention there was no protocol for activation of the catheterization laboratory, this was left to the discretion of the on-call cardiologist and the ED physician.

2. Individualized quarterly feedback on treatment times to cardiologists (November 11, 2003). The feedback included the times to treatment. Cardiologists had access to their own data and the average of all cardiologists practicing at CAMC.

3. Weekday 24-hour inhouse catheterization laboratory team (November 23, 2003). Before this, the catheterization laboratory was staffed from 7:00 AM to 7:00 PM on weekdays and catheterization laboratory personnel were on call offsite during offhours.

Figure 1: Hospital care improvement strategies. The “cardiac alert” simultaneous paging protocol is displayed on the right.

Increased catheterization laboratory scheduling for a radiation technician, a scrub nurse, a unit coordinator, and a registered nurse is estimated at $120,000 U.S. per year. Introduction of the first 2 initiatives required time from the hospital care quality director, but no extra costs because they involved reorganizing the care that was already available.
Evaluation of Effectiveness

Previously reported factors with the potential to affect times to treatment (4–8) were collected, including age, gender, mode of transport, prehospital 12-lead ECG, and time of symptom onset.

Door-to-balloon time was used as the primary outcome measure and was defined as the time between ED arrival to the time of first PCI balloon inflation. Additional outcome measures included death (assessed by review of the social security death registry at 3 months after the last patient was included), symptom onset to balloon time, and door-to-ECG time.

Outcomes of patients before \( n = 46 \) and after \( n = 31 \) implementation of the 3 HCIS was evaluated, excluding patients admitted during the implementation period \( n = 18 \). To evaluate the use and effectiveness of the cardiac alert, the paging log of the telephone operator was used to compare the door-to-balloon time of study patients with and without initiation of the cardiac alert system.

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<th>2003</th>
<th>Jan</th>
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<td>2004</td>
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The effect of the 24-hour inhouse catheterization laboratory during weekdays was evaluated by comparing outcomes for patients arriving during weekday nights before and after implementation of inhouse catheterization laboratory personnel.

Statistical Analysis

SPSS (version 12.0, SPSS Inc.) was used for all analysis. Student t test was used to compare continuous variables between the patient groups. Chi-square test was used for the categorical variables. Multivariate linear regression was done to account for differences in the baseline characteristics when present, and logistic regression was used to determine significant predictors of less treatment delay. \( P<0.05 \) was considered statistically significant. Results are presented as mean ± standard deviation (SD), frequencies, or percentages. Time differences are presented as mean ± standard error (SE).
RESULTS

Data were analyzed for 95 consecutive patients from January 1, 2003, to May 18, 2004. Baseline characteristics are displayed in Table 1: Average age was 60.3 ± 13 years, 24.2% were 70 years or older, and 73.7% were male. Patients arrived by ambulance in 64.2% of the cases; a prehospital ECG was done in 29.5%. Retrospective ECG analysis revealed a total ST deviation of 16.0 ± 10 mV, the mean heart rate was 75 ± 20, and QRS duration was 95 ± 17 ms.

Most patients arrived between 7 AM and 7 PM (68.4%) and from Monday through Friday (74.7%). The mean time from symptom onset to ED presentation was 289.5 ± 393 minutes.

Mean door-to-balloon time for all patients was 123.1 ± 61 minutes and mean time from door to first ECG was 10.7 ± 12 minutes. Three patients (3.2%) died in the follow-up period (July 2004).

Forty-six patients admitted from January 1, 2003, through September 16, 2003, were compared with 31 patients admitted from November 23, 2003, through April 18, 2004. The 3 HCIS were implemented during the transition period (September 17 through November 22). The results are displayed in Table 2. Mean door-to-PCI time in minutes and mean door-to-ECG time were reduced in the patients after HCIS implementation compared with

<table>
<thead>
<tr>
<th>Table 1: Baseline characteristics</th>
<th>All patients (n=95)</th>
<th>Before HCIS (n=46)</th>
<th>After HCIS (n=31)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>60.3 ± 13</td>
<td>61.4 ± 12</td>
<td>57.1±12</td>
<td>0.13</td>
</tr>
<tr>
<td>Age &gt;70 (%)</td>
<td>24.2</td>
<td>28.3</td>
<td>12.9</td>
<td>0.16</td>
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<tr>
<td>Male (%)</td>
<td>73.7</td>
<td>67.4</td>
<td>77.4</td>
<td>0.44</td>
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<tr>
<td>Prehospital electrocardiogram done (%)</td>
<td>29.5</td>
<td>21.7</td>
<td>35.5</td>
<td>0.20</td>
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<tr>
<td>Self-transport (%)</td>
<td>35.8</td>
<td>41.3</td>
<td>29.0</td>
<td>0.34</td>
</tr>
<tr>
<td>Weekend arrival (%)</td>
<td>25.3</td>
<td>23.9</td>
<td>25.8</td>
<td>1.00</td>
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<tr>
<td>Nighttime arrival (%)</td>
<td>31.6</td>
<td>30.4</td>
<td>22.6</td>
<td>0.60</td>
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<tr>
<td>Onset to emergency department (min)*</td>
<td>289.5 ± 393</td>
<td>263.4 ± 375</td>
<td>340.7 ± 445</td>
<td>0.45</td>
</tr>
<tr>
<td>Door-to-balloon (min)</td>
<td>123.1 ± 61</td>
<td>133.5 ± 53</td>
<td>94.3±37</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Door-to-electrocardiogram (min)</td>
<td>10.7 ± 12</td>
<td>13.7 ± 14</td>
<td>5.7 ± 8</td>
<td>0.007</td>
</tr>
<tr>
<td>Death (%)</td>
<td>3.2</td>
<td>2.2</td>
<td>3.2</td>
<td>0.78</td>
</tr>
</tbody>
</table>

*data were available for 82 of the 95 patients.
HCIS, hospital care improvement strategies; SD, standard deviation. Continuous variables are expressed as mean ± SD.

<table>
<thead>
<tr>
<th>Table 2: Study outcomes</th>
<th>Before HCIS (Mean ± SD)</th>
<th>After HCIS (Mean ± SD)</th>
<th>P value</th>
<th>Difference (Mean ± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Door-to-balloon (min)</td>
<td>133.5 ± 54</td>
<td>94.3 ± 37</td>
<td>&lt;0.0001</td>
<td>39.2 ± 10</td>
</tr>
<tr>
<td>Door-to-electrocardiogram (min)</td>
<td>13.7 ± 14</td>
<td>5.7 ± 8</td>
<td>0.007</td>
<td>8.0 ± 3</td>
</tr>
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</table>

HCIS, hospital care improvement strategies; SD, standard deviation; SE, standard error.
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the patients before HCIS implementation (94.3 ± 37 minutes vs 133.5 ± 53 minutes; P < 0.0001; and 13.7 ± 14 vs 5.7 ± 8; P = 0.007, respectively).

Forty-eight patients met the criteria for the cardiac alert protocol; it was used in 25% of these patients; all of these arrived by emergency medical services. In patients for whom the cardiac alert was called, the door-to-balloon time and the door-to-ECG time was shorter than in patients that did not have the cardiac alert called (78.3 ± 18 minutes vs 124.8 ± 73 minutes; P = 0.001 and 4.7 ± 3 minutes vs 8.8 ± 11 minutes; P = 0.05, respectively).

Patients that had a cardiac alert called had a shorter time from symptom onset to ED (112.7 ± 75 minutes vs 392.5 ± 458 minutes; P = 0.003). Multivariate linear regression was used to account for the shorter symptom onset to ED presentation time. Onset to ED presentation time (as a continuous variable) and initiation of cardiac alert (as a categorical variable) were entered as simultaneous covariates for door-to-balloon time. Cardiac alert remained a significant predictor (P = 0.029) after controlling for the shorter symptom onset to ED presentation time.

Four patients who presented after the offhours catheterization laboratory was in place were compared with 17 patients presenting before. The door-to-balloon time was lower after implementation (78.8 ± 17 vs 118.5 ± 38 minutes), implicating a trend (P = 0.057).

Further univariate analysis showed emergency medical services transport and presence of prehospital ECG predictive of a reduced door-to-balloon time (mean ± SE) by 38.8 ± 14 (P = 0.009) and 23.7 ± 12 (P = 0.043) minutes, respectively.

Lastly, a multivariate logistic regression model was constructed to determine the significant predictors of less delay (defined as submedian door-to-balloon time). Baseline variables (age and gender), timing variables (day/nighttime, weekday/weekend, and pre-/ post-HCIS implementation) along with type of transport and whether or not a prehospital ECG was received were all entered as potential predictors into a backward stepwise regression equation. It was found that patients admitted after HCIS implementation (odds ratio [OR], 4.62; confidence interval [CI], 1.6 –13.0; P = 0.004) and patients with a prehospital ECG (OR, 3.83; CI, 1.4 –10.7; P = 0.01) were more likely to experience less delay.

DISCUSSION

After implementation of 3 hospital care improvement strategies (cardiac alert protocol, individualized feedback on treatment times and a 24-hour inhouse catheterization laboratory on weekdays, door-to-PCI time [mean ± SE]) for patients with STEMI was reduced by 39.2 ± 10 minutes. The mean door-to-balloon time after initiation of HCIS was 94.3 ± 37 in this study, reducing it to less than the national median door-to-balloon time of 100 minutes (10) and within the 90 ± 30-minute range advised by the American Heart Association/ American College of Cardiology (AHA/ACC) for facilities providing primary PCI as treatment of AMI (11).
Shorter door-to-balloon times were associated with implementation of the cardiac alert protocol (difference: 46 ± 13 minutes; P < 0.001) and a trend for improvement using 24-hour inhouse catheterization laboratory staffing (difference: 39.7 ± 20 minutes; P = 0.057). However, the cardiac alert was initiated in only 25% of the patients eligible. Increased utilization, also in patients not presenting by emergency medical services, may further improve times to treatment. Unfamiliarity of the ED physicians and cardiologists with the protocol, combined with the busy ED setting, may have contributed to this low-protocol implementation rate.

In patients presenting during weekday nights, the door-to-balloon time was shorter (78.8 ± 17 vs 118.4 ± 38 minutes) after 24-hour catheterization laboratory staffing was implemented; however, because of limited numbers in these groups, the difference was not statistically significant. Patients presenting at offhours with STEMI have been reported to have a longer door-to-balloon time (12). The National Registry of Myocardial Infarction reported an increment in nocturnal door-to-balloon time of 22 minutes (13); thus, the data trend seen in the current analysis supports the effectiveness of a 24-hour inhouse catheterization laboratory in preventing offhour delays.

Interestingly, the door-to-ECG time was reduced after implementation of HCIS (5.7 ± 8 vs 13.7 ± 14 minutes). The first of the 3 HCIS to be implemented was the cardiac alert. As part of the cardiac alert protocol, crosstraining was done of ED nurses in ECG acquisition; additionally, the ECG technicians were included in the paging list, explaining the shorter time in the patients for whom the cardiac alert was called. Overall heightened awareness among ECG personnel during implementation of the cardiac alert initiative may have attributed to the shorter door-to-ECG time also for patients for whom the cardiac alert was not called.

The effect of a shortened door-to-balloon time in patients with a prehospital ECG has been described previously; furthermore, it may improve the utilization of the HCIS described in this article; having a diagnostic prehospital ECG could improve implementation of the cardiac alert by reducing time to diagnosis (5). Additionally, implementation of a prehospital ECG transmission system to the cardiologist may prove effective in reducing time to treatment (14).

There were no statistically significant differences in mortality between the patient groups; however, the study was not powered to detect such differences. The study was designed and executed to evaluate the effectiveness of the inhospital measures to reduce time to treatment, measured as door-to-balloon time.

Symptom onset-to-balloon time has been shown to be a better predictor of outcome than door-to-balloon time (1,2). Patient treatment delay is a difficult issue to address. In this population, the mean symptom onset-to-ED time was nearly 5 hours (289.5 ± 393 minutes), which may in part be attributed to demographic characteristics; the prevalence of diabetes in West Virginia is one of the highest in the nation (16), the associated atypi-
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cal symptom presentation in diabetic patients may have contributed to the delay. The potential for reducing prehospital delays through patient/population education should be emphasized.

One limitation of this study is that it was a retrospective review; however, confounding factors, including age, mode of transportation, time of symptom onset, gender, and prehospital ECG, were taken into account. Nevertheless, there may have been other factors affecting the door-to-balloon times that were not accounted for in this study. The findings could be the result of the fact that the healthcare team was aware of changes being made to the treatment process. However, at the time of implementation, no knowledge existed that this research project would be conducted.

The patient group was limited, and because it only included patients with STEMI who received PCI treatment, the results are not applicable to non-STEMI patients. Furthermore, it was a single-center study; local patient characteristics, community health care facilities, and patient care practices limit the generalization of the results.

SUMMARY

Comprehensive HCIS, including a cardiac alert protocol, individualized feedback on cardiologist treatment times, and implementation of a 24-hour inhouse catheterization laboratory during weekdays, were effective in reducing door-to-balloon time by 39 minutes for patients with STEMI.

REFERENCES


