Expansion of a Regional ST-Segment Elevation Myocardial Infarction System to an Entire State

Circulation. published online June 4, 2012;
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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Expansion of a Regional ST-Segment Elevation Myocardial Infarction System to an Entire State

Running title: Jollis et al.; Expansion of regional STEMI System to entire state

James G. Jollis, MD\(^1\); Hussein R. Al-Khalidi, PhD\(^1\); Lisa Monk, RN, MSN\(^1\); Mayme L. Roettig, RN, MSN\(^1\); J. Lee Garvey, MD\(^3\); Akinyele O. Aluko, MD\(^2\); B. Hadley Wilson, MD\(^4\); Robert J. Applegate, MD\(^5\); Greg Mears, MD\(^6\); Claire C. Corbett, MMS\(^7\); Christopher B. Granger, MD\(^1\) on behalf of the Race Investigators

1Duke Clinical Research Institute, Duke University, Durham; 2Dept of Cardiology, Presbyterian Hospital; 3Depts of Emergency Medicine, 4Cardiology, Carolinas Medical Center, Charlotte; 5Wake Forest Health Sciences University Winston-Salem; 6EMS Performance Improvement Center, University of North Carolina at Chapel Hill, Chapel Hill; 7New Hanover Regional Medical Center, Wilmington, NC

Correspondence:
James G. Jollis, MD
Duke Clinical Research Institute
Duke University
Box 3254 DUMC
Durham, NC 27710
Tel: 919-684-4015
Fax: 919-668-3575
E-mail: james.jollis@duke.edu

Journal Subject Codes: [4] Acute myocardial infarction; [100] Health policy and outcome research
Abstract:

**Background** - Despite national guidelines calling for timely coronary artery reperfusion, treatment is often delayed, particularly for patients requiring inter-hospital transfer.

**Methods and Results** - 119 North Carolina hospitals developed coordinated plans to rapidly treat patients with ST segment elevation myocardial infarction (STEMI) according to presentation: walk-in, ambulance, or hospital transfer. 6841 patients with STEMI (3907 directly presenting to 21 percutaneous coronary intervention (PCI) hospitals, 2933 transferred from 98 non-PCI hospitals were treated between July 2008 and December 2009 (age 59 years, 30% women, 19% uninsured, chest pain duration 91 minutes, shock 9.2%). The rate of patients not receiving reperfusion fell from 5.4% to 4.0% (P=0.04). Treatment times for hospital transfer patients substantially improved. First hospital door to device for hospitals that adopted a “transfer for PCI” reperfusion strategy fell from 117 minutes to 103 minutes (P=0.0008), while times at hospitals with a mixed strategy of transfer or fibrinolysis fell from 195 minutes to 138 minutes (P=0.002). Median door to device times for patients presenting directly to PCI hospitals fell from 64 to 59 minutes (P<0.001). EMS-transported patients were most likely to reach door to device goals with 91% treated within 90 minutes and 52% being treated with 60 minutes. Patients treated within guideline goals had a mortality of 2.2% compared to 5.7% for those exceeding guideline recommendations (P<0.001)

**Conclusions** - By extending regional coordination to an entire state, rapid diagnosis and treatment of STEMI has become an established standard of care independent of health care setting or geographic location.

**Key words:** acute myocardial infarction
Introduction

The ideal treatment of ST segment elevation myocardial infarction (STEMI) involves early diagnosis followed by rapid reperfusion therapy. Such treatment becomes more challenging when the activities of diagnosis and reperfusion span multiple, loosely connected hospitals and emergency medical services (EMS). To overcome these barriers and provide ideal reperfusion as a uniform standard of care regardless of health care setting or geographic location, we established coordinated regional care across the entire state of North Carolina. Specifically, we aimed to determine whether expanding our STEMI system to all hospitals and EMS agencies in North Carolina on a voluntary and “grass roots” basis would improve the rate and speed of myocardial reperfusion. According to protocols established in the Regional Approach to Cardiovascular Emergencies (RACE) project, we implemented processes to expedite care in 119 hospitals across a state with a population of 9.4 million residents and area of 53,000 square miles. Hospitals adopted synchronized strategies to expedite reperfusion for patients presenting by EMS, hospital transfer, and “walk-in.”

Methods

Our work was approved by the IRB at Duke University. Data Use Agreements for a HIPAA defined limited data set were established with all primary percutaneous coronary intervention (PCI) hospitals. We implemented our system by building on a model established in prior work and by using the principles outlined in the American Heart Association Mission: Lifeline and the American College of Cardiology D2B programs. First, we developed leadership composed of a state director, hospital system coordinators, and nursing, EMS, and physician leaders from multiple institutions across the state (see Supplemental Material). This leadership team
conferred in weekly conference calls and numerous regional and state meetings. Next, we instituted the Acute Coronary Treatment and Intervention Outcomes Network Registry -- Get With The Guidelines (AR-G) as our main data collection instrument, requesting that all participating primary percutaneous coronary intervention (PCI) hospitals participate and contribute to state-system reports. These data were maintained by the leadership team and were used to monitor and report treatment rates and times to individual hospitals, benchmarked to state performance. The AR-G registry at PCI hospitals represented the majority of STEMI patients in the state eligible for reperfusion during the study period, as 95% of patients treated at non-PCI hospitals were transferred to PCI hospitals prior to discharge.

Once leadership and data systems were established, we organized all 21 PCI hospitals in the state with on-site surgery to serve as regional primary PCI centers (10 in the initial RACE intervention, 11 additional for the state-wide intervention). These hospitals agreed to collect and share ARG data, fund or co-fund a hospital STEMI system coordinator, accept all STEMI patients regardless of bed availability on a 24 hour 7 day per week basis, allow for catheterization laboratory activation by a single call from emergency physicians or trained paramedics without the need for cardiology consultation, have the catheterization laboratory available within 30 minutes including the presence of an interventional cardiologists at the start of the procedure, establish a single treatment regimen agreed upon by all physicians, and provide immediate and regular feedback to the emergency physicians and paramedics who initiated the procedure. The 98 non-PCI centers (55 in the initial RACE intervention, 43 additional for the state-wide intervention) designated themselves according to their reperfusion strategy for patients presenting with STEMI: routine transfer for primary PCI, routine fibrinolytic therapy, or a mixed strategy that consisted of transfer for primary PCI when transportation was readily
available (Figure 1).

Supported by the primary PCI facilities, system coordinators and their leadership approached every hospital and EMS within their referral region to establish a single plan to rapidly diagnose and reperfuse patients with an acute STEMI according to national time standards and guidelines. Emergency departments were encouraged to ascertain whether patients had potential symptoms prior to registration, designate an area and personnel to perform ECG within 10 minutes of arrival, and choose a reperfusion plan according to local consensus and resources that involved either primary PCI or fibrinolysis. Hospitals that selected fibrinolysis also developed plans for rapid primary PCI for patients with contraindications. For hospitals served by more than one primary PCI center, all PCI centers were represented in planning meetings. Under the guidance of the North Carolina Office of EMS, emergency medical systems were encouraged to obtain an ECG for every patient with potential STEMI symptoms, interpret the ECG and communicate the findings of a possible STEMI to receiving hospitals, divert to PCI centers if first medical contact to device could reliably be achieved within 90 minutes or patients were ineligible for fibrinolysis, and provide a standard method for the EMS time data to be available to receiving hospital personnel.

The final step of our intervention involved multiple levels of communication between hospitals and EMS regarding system performance, immediately after PCI, within 24 hours of a myocardial infarction admission, and in regularly scheduled hospital, EMS, regional, and state meetings. During these meetings, we shared best practices, reviewed treatment intervals (derived from symptom onset, first medical contact, door time, ECG time, departure time, catheterization lab time, device time, needle time), outcomes (deaths, complications, hospital and angiography findings) and opportunities for system improvement. Additional description of our intervention

**Statistical Analysis**

Descriptive statistics for continuous and categorical variables were described as median (interquartile range) and number (percentage), respectively. Patient characteristics and process measures were compared using Wilcoxon rank-sum test for 2 groups comparison (Kruskal-Wallis test for more than 2 groups comparison) and chi-square tests as appropriate. The Cochran-Armitage test for trend was used to assess changes in rates over time. To consider whether changes in treatment time varied by hospital, mixed-effects model analyses were conducted with PCI hospitals as a random effect. Performance data were compared in three month intervals from July 2008 through December 2009 stratified according to treatment and presentation to PCI hospital (fibrinolysis or primary PCI; presentation to PCI hospital by transfer, self, or EMS).

For the PCI hospitals, the objectives of the RACE intervention were to reduce door-to-device times for directly presenting patients and first medical contact to device for EMS transported patients. For non-PCI hospitals, the objectives of RACE were to reduce the door-in to door-out times and first door to device times for patients who were transferred to undergo PCI elsewhere and door-to-needle times for those receiving fibrinolysis. For both hospital settings, we also aimed to increase the rate of reperfusion among eligible patients. In cases where the first ECG did not have diagnostic ST elevation, door or first medical contact time was reset to the first diagnostic ECG. All tests were conducted at the 0.05 significance level. All patients with ischemic symptoms lasting greater than 10 minutes within 24 hours prior to arrival and an ECG with diagnostic ST segment elevation were included in the analyses. Statistical analyses were
carried out using SAS version 9.2 (SAS Institute INC, Cary, NC).

Results

Between July 2008 and December 2009, 6,841 patients presented with acute ST elevation myocardial infarction including 3,907 patients who presented directly (57%) and 2,933 patients who were transferred to PCI hospitals (43%). (Table 1) The median age of the cohort was 59 years (interquartile range 51-69), 30% of patients were women, and 15% were either black or of Latino ethnicity. Nineteen percent of patients had no insurance and 7% were covered by Medicaid. Median duration of chest pain from onset to ECG was 91 minutes, 20% of patients had prior myocardial infarction or PCI, and shock was present on admission for 9% of patients. By medical record review, 86% of patients were felt to be reperfusion candidates and STEMI was apparent on the initial ECG for 89% of patients.

Means of transport to the first facility was by EMS for 55% of patients and walk-in for 43% of patients. Over the course of the study, there was an increase in the percentage of patients presenting by EMS to PCI hospitals, from 70 to 75% (P=0.04). The inverse pattern and trend were seen at non-PCI hospitals, where EMS presentation fell from 35 to 30% (P= 0.10). During the final quarter of data collection, pre-hospital ECGs were identified for 88% of patients presenting to PCI centers via EMS and for 32% of patients presenting to non-PCI centers (P<0.0001). (Figure 2)

Treatment rates and times

Among the 5,888 eligible patients, the rate of patients not receiving reperfusion fell from 5.4% to 4.0% (P=0.04) largely attributable to a 4% absolute decline in eligible untreated patients at non-PCI hospitals (P<0.01) (Figure 3). During the same period, primary PCI as reperfusion mode
increased from 52% to 66% in non-PCI hospitals with a corresponding decrease in fibrinolysis from 41% to 31% of eligible patients. For patients presenting directly to PCI hospitals, primary PCI remained stable at 95%, with only 17 patients being treated with fibrinolysis during the study period. These patients either received fibrinolysis pre-hospital or when a significant delay to catheterization laboratory availability was anticipated due to simultaneously presenting patients.

Corresponding with guideline goals, treatment times of interest included door to device for patients undergoing primary PCI, first medical contact to device for patients presenting to PCI hospitals by EMS, first hospital door to device for patients transferred between hospitals, and door to needle for patients treated with fibrinolysis. Over the study period, median door to device times for patients presenting directly to PCI hospitals fell modestly from 64 to 59 minutes (P<0.001) with improvements in both self presenting patients from 79 to 73 minutes (P=0.01) and EMS transported patients from 58 to 55 minutes (P=0.06) (Figure 4). The proportion of directly presenting patients who underwent PCI within 90 minutes increased from 83% to 89%

For patients transported directly to PCI hospitals by EMS, pre-hospital ECG rates increased from 67% to 88% during the intervention. This improvement was accompanied by a decline in median time from first medical contact to device from 103 to 91 minutes (P<0.0001), with 50% of patients being treated within 90 minutes by the last quarter. The transport component of this time interval remained stable at a median of 35 minutes (interquartile range 25, 49) from first medical contact to hospital door. The percentage of patients receiving device activation within 90 minutes of first medical contact increased from 36% to 50% (P=0.0002). Patients transported by EMS were most likely to reach door to device goals, with 91% undergoing device activation within 90 minutes of hospital arrival and 52% being treated with 60
minutes by the end of the study.

Treatment times for patients transferred between hospitals for primary PCI significantly improved (Figure 5). The median time from first hospital door to device activation for 1,175 patients transferred from hospitals that adopted a “transfer for PCI” strategy (52 hospitals) fell from 117 minutes to 103 minutes (P=0.0008) with 39% patients being treated within the 90 minute goal by the end of the intervention. A time interval of focus for these transferred patients involved first hospital “door in door out” time, improving from 44 to 39 minutes. The 474 patients transferred from hospitals with a “mixed” strategy of transfer and fibrinolysis (15 hospitals) had substantially longer treatment time with first door to device falling from 195 minutes to 138 minutes by the end of the study (P=0.002). Treatment time varied substantially by transfer distance expressed as drive times according to standard mapping software [http://www.mapquest.com access October 21, 2010] Median first door to device time for hospitals within 30 minutes was 94 minutes, 134 minutes for hospitals between 31 and 45 minutes drive time, and 192 minutes for hospitals exceeding 45 minutes drive time. Mixed strategy hospitals had a 21 minute longer median drive time compared to transfer for PCI strategy hospitals. Among the 903 patients treated with fibrinolysis prior to transfer, door to needle did not significantly improve with median times of 35 minutes and 27 minutes in the first and last quarters of the study (P=0.27) with 48% being treated within 30 minutes during the entire study period. When treatment time analyses were stratified according to patients treated at the initial RACE intervention hospitals or hospitals added for the full state intervention, the findings were similar for both subgroups of patients. When treatment times were further considered in mixed-effects models with PCI hospital as a random effect, the models were significant, indicating that some hospitals had significantly greater improvement than others.
(P<0.01).

Outcomes

Patients treated within times suggested by guidelines had a mortality of 2.2% compared to 5.7% for patients whose treatment time exceeded guideline recommendations (P=0.001). Overall in-hospital mortality was 5.7% (95% confidence interval 5.2 – 6.3%) during the study period including 5.9% during the first half of the intervention and 5.5% during the second half (P=NS). Other clinical outcomes, bleeding, stroke, hemorrhagic stroke, congestive heart failure, and shock did not significantly vary over the study period.

Discussion

The RACE system is the largest state-wide ST elevation myocardial infarction system ever implemented in the United States. Our intervention demonstrates that systematic barriers in timely reperfusion can be overcome with a broadly organized voluntary effort to fill leadership gaps in the health care. These gaps primarily exist between competing institutions and between health care entities that function in separate and distinct systems. By building consensus among all primary PCI hospitals in the state, we were able to convince the majority of emergency departments and EMS systems to adopt uniform and coordinated processes for rapid diagnosis and treatment. This universal approach allowed us to establish and embed a standard of care independent of health care setting or geographic location of the patient. By the end of our intervention, our protocols were adopted by state regulation for all EMS agencies, and all PCI hospitals voluntarily agreed to continue sharing data and support regional care.


The findings identify some remarkable changes in patterns of care and improvements in
performance measures. Notable achievements of the RACE system include a historically low rate of eligible but untreated of 4.0% and exceptionally fast coronary intervention for patients presenting directly to PCI facilities with 89% being treated within 90 minutes and 52% treated within 60 minutes. These results achieved across all 21 PCI hospitals in the state are comparable to those achieved by 10 select systems that reported on EMS transported patients alone by Rokos and colleagues of 86% within 90 minutes and 50% within 60 minutes.3

At the same time, this work highlights areas that need further consideration in formulating STEMI treatment guidelines and building systems of care. Two particular areas of interest include EMS transported patients and patient transferred between hospitals for primary PCI. In 2007, the American College of Cardiology / American Heart Association STEMI guidelines first directed device activation to occur within 90 minutes of “first medical contact” rather than hospital door for patients initially treated by emergency personnel, defined as the time that the EMS crew arrives at the “scene” of the patient.14 By adding scene time and transport time to the 90 minute goal, this guideline effectively raised the bar on primary PCI and made hospitals and emergency medical services jointly accountable for patient treatment. This work describes the first broad application of this new standard with 50% of patients treated within 90 minutes of first medical contact (or EMS arrival on scene) by the end of our study. Time from scene arrival to hospital door consumed a median of 36 minutes of the 90 minute goal including 15 minute scene time and 21 minute transport time. Our findings indicate that incremental improvements in all processes of care will allow a majority of EMS transported patients to meet this goal. These improvements should include universal adoption of catheterization laboratory activation by paramedics as a standard of care (median time savings 17 minutes). The 28 minute median hospital door to laboratory arrival time for EMS transported
patients also indicates potential for a further improvement in hospital processes such as pre-registration of patients, proceeding directly to the catheterization laboratory when available, and cross training laboratory, emergency department, and intensive care unit personnel to cover emergent STEMI patients.

To our knowledge the 39% of patients undergoing primary PCI within 90 minutes of first hospital door in “transfer strategy” hospitals represents the highest rate reported in a multicenter study. For comparison, 15% of patients requiring hospital transfer in Massachusetts State were treated within 90 minutes in 2008, the latest year data are available, and the AR-G registry reported 24% of patients transferred for PCI in the fourth quarter of 2009 had device times within 90 minutes of first door.\(^\text{14}\) The AR-G registry involved a select group of approximately 220 hospitals that were submitting data and this national benchmark likely reflects above average performance. The treatment times in RACE for transferred patients also compare favorably to selected single center or single region reports from Abbot Northwestern of 32%, Mayo Clinic of 12%, and Springfield, Illinois Stat Heart of 12%.\(^\text{1,2,5}\) With national guidelines for inter-hospital transfer continuing to call for device activation within 90 minutes of first medical contact as a “systems goal,” our inability to reach this goal in a majority of patients despite focused efforts raises questions regarding the feasibility of achieving this benchmark on a broad scale.\(^\text{15}\) First door to device time varied as a function of inter-hospital drive time, from 93 minutes for hospitals within 30 minutes, 117 minutes for 31 to 45 minute drive times, and 121 minutes for hospitals beyond 45 minutes drive time. Patients transported by air were not treated faster, with median first door to device times of 125 minutes for hospitals in the 31 to 45 drive time range, and 138 minutes for hospitals beyond 45 minute drive times. Thus, treatment by the 90 minute goal for hospitals located beyond the 30 minute drive time appears less likely to occur for the
majority of patients using current processes. Our work supports the extension of the standard to 120 minutes in order to have relevance for the majority of patients undergoing hospital transfer for primary PCI.16

**Mortality**

While there are trends toward lower STEMI mortality in North Carolina since the initiation of our regional system, our study lacked adequate sample size to reliably identify mortality differences. Pathological, imaging, and clinical data support a strong relationship between earlier treatment, less myocardial necrosis and lower mortality, and we believe the significant time improvements in coronary reperfusion resulting from our intervention represent an important improvement of myocardial infarction care in North Carolina.17-19 Observations from our RACE data also support timely treatment according to a 2.2% mortality for those receiving reperfusion according to overall guideline time goals compare to a 5.7% mortality for those treated beyond recommended time intervals (P<0.001).

**Limitations**

This study relied on the voluntary submission of data to the AR-G registry, a system that lacks any mechanism for auditing. Thus, it is possible that some of the observed improvements in performance and outcome may have been due to self reporting. The extent to which our data elements overlapped with door to device and needle measures in CMS Hospital Compare, a subset of our data were subject to random audit, providing some impetus for accurate reporting.20 Our study design did not allow us to determine whether changes in care were directly attributable to the RACE interventions or whether they occurred independently of the project. During the corresponding time period from Q3 2008 to Q4 2009, the 220 hospitals submitting data to AR-G had improved median door to device times for directly presenting patients from 66 to 62 minutes
compared to 64 to 59 minutes in our study, and 120 to 113 minutes for transferred patients compared to 152 to 118 minutes in RACE. Thus, the improvements in our system were of a similar magnitude to those seen for all AR-G hospitals for directly presenting patients, and appear to be substantially larger for transferred patients. As hospitals participating in AR-G represent a select group focused on improving treatment times among the 1200 to 1400 hospitals in the United States that perform primary PCI, we believe that the improvements in North Carolina, particularly among transferred patients, likely reflect the effect of our system.

Conclusions

A uniform and comprehensive approach to organizing STEMI care across an entire state on a voluntary basis resulted in marked improvements in timely coronary artery reperfusion. Patients presenting directly to PCI hospitals received the fastest treatment, while those requiring inter-hospital transfer showed the greatest improvements in treatment time. By extending our organization to an entire state, rapid diagnosis and treatment of STEMI has become an embedded standard of care independent of health care setting or geographic location.

Funding Sources: Unrestricted grants from Phillips, Sanofi Aventis, Medtronic Foundation. Phillips, Sanofi Aventis, and the Medtronic Foundation had no role in the design and conduct of the study, analysis and interpretation of the data, or in the preparation, review, or approval of the manuscript

Conflict of Interest Disclosures: Jollis received research grants from Phillips, Sanofi Aventis, Medtronic Foundation and The Medicines Company. He also acted as a consultant for United Healthcare and Blue Cross Blue Shield North Carolina. Granger received research grants from Astellas, Medtronic Foundation, Astra Zeneca, Merck, Boehringer Ingelheim, Bristol-Myers Squibb, The Medicines Company, GlaxoSmithKline, and Sanofi Aventis. He also acted as a consultant for Boehringer Ingelheim, Sanofi Aventis, Astra Zeneca, Bristol-Myers Squibb, GlaxoSmithKline, Roche, Novarti, and The Medicines Company. Applegate acted as a consultant for Abbott, St. Jude, and Terumo Medical Corporation. Wilson acted as a consultant for Boston Scientific. Garvey acted as a consultant for Abbott Vascular.
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**Table 1.** Patient characteristics, procedures, and outcomes according to direct or transfer presentation to percutaneous coronary intervention hospital.

<table>
<thead>
<tr>
<th></th>
<th>All 6841</th>
<th>Direct 3907</th>
<th>Transfer 2933</th>
<th>P value</th>
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<tbody>
<tr>
<td>Age (yrs) Median (IQR)</td>
<td>59 (51, 69)</td>
<td>60 (51, 70)</td>
<td>59 (51, 69)</td>
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</tr>
<tr>
<td>Female (%)</td>
<td>29.6</td>
<td>30.0</td>
<td>29.1</td>
<td>0.36</td>
</tr>
<tr>
<td>Race (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>83.9</td>
<td>84.3</td>
<td>83.4</td>
<td>0.03</td>
</tr>
<tr>
<td>Black</td>
<td>13.6</td>
<td>13.6</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>2.5</td>
<td>2.1</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Latino ethnicity (%)</td>
<td>1.6</td>
<td>1.5</td>
<td>1.7</td>
<td>0.56</td>
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<tr>
<td>Insurance (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private / HMO</td>
<td>47.7</td>
<td>49.7</td>
<td>44.9</td>
<td>0.002</td>
</tr>
<tr>
<td>Medicaid</td>
<td>7.2</td>
<td>7.0</td>
<td>7.5</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>19.1</td>
<td>18.2</td>
<td>20.2</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>26.1</td>
<td>25.2</td>
<td>27.4</td>
<td></td>
</tr>
<tr>
<td>Prior myocardial infarction (%)</td>
<td>20.1</td>
<td>21.8</td>
<td>17.8</td>
<td>&lt;0.0001</td>
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<tr>
<td>Prior heart failure (%)</td>
<td>4.7</td>
<td>5.3</td>
<td>4.0</td>
<td>0.03</td>
</tr>
<tr>
<td>Prior PCI (%)</td>
<td>19.6</td>
<td>21.4</td>
<td>17.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Prior coronary bypass surgery (%)</td>
<td>6.5</td>
<td>7.5</td>
<td>5.2</td>
<td>0.0002</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>22.4</td>
<td>21.8</td>
<td>23.2</td>
<td>0.16</td>
</tr>
<tr>
<td>Chest pain duration in minutes, median (IQR)</td>
<td>91 (49, 190)</td>
<td>83 (42, 181)</td>
<td>100 (58, 205)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Means of transport to first facility (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self / family</td>
<td>43.4</td>
<td>26.5</td>
<td>65.9</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Ambulance</td>
<td>55.2</td>
<td>71.3</td>
<td>33.7</td>
<td></td>
</tr>
<tr>
<td>Other (Air/ICU)</td>
<td>1.4</td>
<td>2.2</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Shock on presentation (%)</td>
<td>9.2</td>
<td>9.6</td>
<td>8.6</td>
<td>0.18</td>
</tr>
<tr>
<td>Heart failure on presentation (%)</td>
<td>8.1</td>
<td>7.9</td>
<td>8.3</td>
<td>0.51</td>
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<td>Reperfusion candidate</td>
<td>86.2</td>
<td>86.6</td>
<td>85.8</td>
<td>0.38</td>
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<tr>
<td>STEMI first diagnosed (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1st ECG</td>
<td>88.6</td>
<td>89.3</td>
<td>87.5</td>
<td>0.03</td>
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<tr>
<td>Subsequent ECG</td>
<td>11.4</td>
<td>10.7</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td>Procedures during hospitalization (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI</td>
<td>85.6</td>
<td>87.1</td>
<td>83.5</td>
<td>&lt;0.0001</td>
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<td>Coronary bypass surgery</td>
<td>6.7</td>
<td>6.4</td>
<td>7.0</td>
<td>0.38</td>
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<tr>
<td>Complications (%)</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>In-hospital death</td>
<td>5.7</td>
<td>5.8</td>
<td>5.5</td>
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<tr>
<td>Stroke</td>
<td>1.1</td>
<td>0.8</td>
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<td>Hemorrhagic stroke</td>
<td>0.2</td>
<td>0.1</td>
<td>0.3</td>
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<td>Cardiogenic shock</td>
<td>6.1</td>
<td>6.2</td>
<td>5.9</td>
<td>0.72</td>
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<tr>
<td>Congestive heart failure</td>
<td>6.1</td>
<td>5.4</td>
<td>6.9</td>
<td>0.02</td>
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<tr>
<td>Major bleeding</td>
<td>5.7</td>
<td>5.4</td>
<td>6.2</td>
<td>0.16</td>
</tr>
<tr>
<td>Re-infarction</td>
<td>0.8</td>
<td>0.7</td>
<td>0.9</td>
<td>0.34</td>
</tr>
</tbody>
</table>

IQR = Inter-quartile range (25th, 75%).
Figure Legends:

**Figure 1.** North Carolina hospitals according to reperfusion strategy.

**Figure 2.** Pre-hospital ECG for patients presenting directly to PCI hospitals by EMS.

**Figure 3.** Reperfusion treatment by quarter, all eligible patients. P=0.04 for trend.

**Figure 4.** Hospital door to device times for patients presenting directly to PCI hospitals by arrival mode and quarter, median times. For trend, walk in P=0.01, EMS transported P=0.06.

**Figure 5.** Reperfusion times for patients presenting to hospitals without PCI facilities by quarter, median times. Door to needle times for patients treated with fibrinolysis. First hospital door to device time for patients transferred for PCI. For transferred patients, treatment times are presented according to hospital reperfusion strategy. For lytic P=0.27, transfer strategy P=0.0008, mixed strategy P=0.002.
Supplemental Material

RACE Investigators

State Project Leader
Lisa Monk, RN, MSN

Central Organizing Committee
Christopher B. Granger, MD
James G. Jollis, MD
Mayme Lou Roettig, RN, MSN

EMS Regional Coordinators
Claire Corbett, MMS, NREMT-P
Scott Starnes, NREMT-P

Nurse System Coordinators
Tracey Blevins, RN, BSN, MBA
Harriet Buss, RN, BSN, MSHA
Joanne Cary, BS, RN, CN,
Frank Castelblanco, RN, ADN, BA
Bridget Harding, RN, MSN
Cheryl Henderson, RN, BSN
Michelle Keasling, RN, MSN
Robyn Keller, RN, BSN
Jan Matthews, RN,
Jeannie Moore, RN, BSN
Linda Newton, RN, MSN
Heather Norman, MHA, RN, BSN
Gloria Paul, RN, MSN
Mary Printz, RN, MSN, FNC
Susan Rouse, RN, BSN
Betsy Russell, RN
Stephanie Starling, BSN, RN, MHA
Jennifer Sarafin, RN, MSN
Amanda Thompson, RN, BSN, MHA
April Traxler, RN, BSN
Annette Winkler, RN, MSN

Other Systems Coordinators
Keith Pendergrass, RRT, RCP
Cathy Rabb, RRT, RCP
David Reich RCIS, BS
Charles H. Wilson, MD

Interventional Cardiology Leaders
Akinyele O. Aluko, MD
Robert J. Applegate, MD
Joseph D. Babb, MD
Christopher C. Barber, MD
Bruce R. Brodie, MD
Brian P. Hearon, MD
R. Lee Jobe, MD
Kevin R. Kruse, MD
Michael R. Komada, MD
William T. Maddox, MD
Robert B. Preli, MD
Steven C. Rohrbeck, MD
John R. Sinden, MD
Patrick J. Simpson, MD
George A. Stouffer, III, MD
Thomas D. Stuckey, MD
Mark A. Thompson, MD
F. Scott Valeri, MD
John A. Williams, III, MD
B. Hadley Wilson, MD

Emergency Medicine Leaders
Robert L. Beaton, MD
Joshua N. Cochrane, MD
Sidney M. Fletcher, MD
J. Lee Garvey, MD
Penny Jo Hamilton-Gaertner, MD
Matthew R. Harmody, MD
James W. Hoekstra, MD
Paul E. Horton, MD
Jonathan D. Kelly, MD
Scott T. Miekley, MD
R. Darrell Nelson, MD
Brad A. Watling, MD
Randall N. Willard, MD

Emergency Medical Service Leaders

David Cuddeback, NREMT-P
Greg Mears, MD
J. Brent Myers, MD
Drexdal R. Pratt
Dwayne R. Young, BS, REMTP