Myocardial Infarction

Association of Rapid Care Process Implementation on Reperfusion Times Across Multiple ST-Segment–Elevation Myocardial Infarction Networks

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for the STEMI Systems Accelerator Project

Background—The Mission: Lifeline STEMI Systems Accelerator program, implemented in 16 US metropolitan regions, resulted in more patients receiving timely reperfusion. We assessed whether implementing key care processes was associated with system performance improvement.

Methods and Results—Hospitals (n=167 with 23,498 ST-segment–elevation myocardial infarction patients) were surveyed before (March 2012) and after (July 2014) program intervention. Data were merged with patient-level clinical data over the same period. For reperfusion, hospitals were grouped by whether a specific process of care was implemented, preexisting, or never implemented. Uptake of 4 key care processes increased after intervention: prehospital catheterization laboratory activation (62%–91%; P<0.001), single call transfer protocol from an outside facility (45%–70%; P<0.001), and emergency department bypass for emergency medical services direct presenters (48%–59%; P=0.002) and transfers (56%–79%; P=0.001). There were significant differences in median first medical contact-to-device times among groups implementing prehospital activation (88 minutes implementers versus 89 minutes preexisting versus 98 minutes nonimplementers; P<0.001 for comparisons). Similarly, patients treated at hospitals implementing single call transfer protocols had shorter median first medical contact-to-device times (112 versus 128 versus 152 minutes; P<0.001). Emergency department bypass was also associated with shorter median first medical contact-to-device times for emergency medical services direct presenters (84 versus 88 versus 94 minutes; P<0.001) and transfers (123 versus 127 versus 167 minutes; P<0.001).

Conclusions—The Accelerator program increased uptake of key care processes, which were associated with improved system performance. These findings support efforts to implement regional ST-segment–elevation myocardial infarction networks focused on prehospital catheterization laboratory activation, single call transfer protocols, and emergency department bypass. (Circ Cardiovasc Interv. 2017;10:e004061. DOI: 10.1161/CIRCINTERVENTIONS.116.004061.)

Key Words: percutaneous coronary intervention ■ quality improvement ■ reperfusion times ■ ST-segment–elevation myocardial infarction ■ systems of care

Primary percutaneous coronary intervention (PCI) is the preferred method of revascularization for acute STEMI. For patients undergoing primary PCI, clinical guidelines recommend a first medical contact (FMC)-to-device time of <90 minutes for patients presenting to a PCI-capable hospital and <120 minutes for patients presenting to a non-PCI-capable hospital. However, ≥30% to 50% of patients are not reperfused within those timeframes. This cannot be completely explained by inadequate access because 90% of Americans live within 60 minutes of PCI-capable hospitals, and this figure continues to grow at a rate exceeding that of the US

See Editorial by White


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WHAT IS KNOWN

- Few studies have compared the impact of multiple ST-segment-elevation myocardial infarction (STEMI) patient flow care processes on reperfusion times.
- No prior studies have determined the specific impact on system performance of rapidly implementing care processes across multiple heterogeneous STEMI systems at a national level.

WHAT THE STUDY ADDS

- Through the American Heart Association STEMI Systems Accelerator Project, the first effort to regionalize STEMI care nationally, we found that hospitals implementing key care processes (preactivation, single call transfer, emergency department bypass for both direct emergency medical service presenters and transfers) had shorter reperfusion times compared with hospitals that did not implement these processes.
- Our results support efforts to continue to optimize STEMI systems, with a focus on these key care processes.

population.6-8 The challenges in meeting target reperfusion times are often because of system issues that hinder coordination between emergency medical service (EMS) providers and hospitals and competition among hospitals and integrated physician groups.10

The American Heart Association Mission: Lifeline STEMI Systems Accelerator program was developed and implemented in 16 US metropolitan regions to organize leadership, develop common protocols, and initiate ongoing data collection and timely review to improve the proportion of patients receiving timely coronary intervention.10 This program significantly but modestly increased the overall proportion of patients meeting guideline goals for FMC-to-device times both for patients presenting directly to a PCI-capable hospital and those transferred from non-PCI-capable hospitals.10a

Few studies have compared the impact of multiple STEMI patient flow care processes on reperfusion times.11-14 To our knowledge, no prior studies have determined the specific impact on systems performance of rapidly implementing care processes across multiple heterogeneous STEMI systems as part of a large-scale, national effort. Therefore, the goal of the current study was to (1) determine the uptake of recommended care processes and protocols across hospitals using a pre- and postimplementation survey as part of a large-scale national effort to regionalize STEMI care and (2) determine whether hospitals implementing one of 4 specific key care processes had shorter reperfusion times versus those that did not.

Methods

The STEMI Accelerator intervention was organized and executed between March 2012 and July 2014 in 171 hospitals and 23,809 patients, as previously described.10,14 Each region identified a baseline quarter as the preintervention period, with the remaining quarters considered the postintervention period. Project initiation was conducted on a rolling basis over 6 months, and each region specified a quarter (quarters 3 or 4, 2012; or quarter 1, 2013) as the baseline from which to assess subsequent temporal trends in outcomes. The following 16 of 21 regions that applied for participation in the project met enrollment criteria by the baseline data collection quarter and were included: Atlanta, GA; Columbus, OH; Denver, CO; Hartford, CT; Houston, TX; Kern County, CA; Louisville, KY; New York City, NY; Northern New Jersey; Oklahoma City, OK; Philadelphia, PA; Pittsburgh, PA; St. Louis, MO; San Antonio, TX; Tampa, FL; and Wilkes-Barre/Scranton, PA. All hospitals within participating regions were enrolled in the National Cardiovascular Data Registry ACTION Registry-GWTG program (Acute Coronary Treatment and Intervention Outcomes Network Registry-Get With The Guidelines), described in more detail below.15 Each region developed common protocols for STEMI care based on guideline recommendations. A detailed description of the protocol has been published previously.10 All patients with ongoing ischemic symptoms lasting for >10 minutes but <12 hours and who had ECG-diagnosed ST-segment-elevation or left bundle-branch block were included. In cases where the first ECG did not have diagnostic ST-segment-elevation, FMC-to-device time was reset to the time of the first diagnostic ECG.

Reperfusion and Outcomes Data

The ACTION Registry-GWTG15 is a voluntary quality improvement registry in the United States that includes consecutive patients admitted to participating hospitals with STEMI or non-STEMI. This program is sponsored by the American College of Cardiology and the American Heart Association. Definitions for data elements of the registry are available at https://www.ncdr.com/webncdr/action/home/datacollection. The National Cardiovascular Data Registry data quality program includes data abstraction training, data quality thresholds for inclusion, site data quality feedback reports, independent auditing, and data validation. An audit of the data has demonstrated chart review agreement in >93% of patients.16 At participating sites, this registry was either approved by an institutional review board or considered quality assurance data and was, therefore, not subject to institutional review board approval based on individual site determinations. The Duke Clinical Research Institute serves as the data coordinating center to analyze deidentified data for research purposes.

Pre- and Postimplementation Survey

American Heart Association Mission: Lifeline coordinators at each participating hospital were contacted via mail or phone to answer a series of questions related to STEMI processes of care and other hospital procedures (Supplement S1 in the Data Supplement). Respondents answered each question at 2 different time points: (1) prior to implementation of STEMI regionalization (preintervention, quarter 1: region-dependent, but typically between July to September or October to December 2012) and (2) after implementation of STEMI regionalization (postintervention, after quarter 7: July to September 2014).

For the purpose of analyzing the relationship between the uptake of 4 key STEMI care processes and reperfusion times, hospitals were stratified according to pre- and postintervention survey responses: (1) hospitals that did not have the care process in place at baseline, but subsequently implemented the existing care process postintervention; (2) hospitals that had an existing care process in place at baseline; and (3) hospitals that did not have the care process in place at baseline and did not implement postintervention. The 4 care processes evaluated were the following:

- Prehospital cardiac catheterization laboratory activation for patients presenting directly via EMS to a PCI-capable hospital.
- Single call primary PCI transfer protocol for patients presenting to a non-PCI-capable hospital.
Emergency department (ED) bypass for patients presenting directly via EMS to a PCI-capable hospital (bypass was defined as <5 minutes in the ED).

ED bypass for patients transferred from a non-PCI-capable hospital to a PCI-capable hospital (with bypass again defined as <5 minutes in the ED).

Out of 171 STEMI Accelerator PCI-capable hospitals in 16 regions, 167 (97%) hospitals completed and returned the care processes survey. No outcomes data were revealed or known to the investigators until all the survey data were collected. Patient-level data, including reperfusion times, were linked to specific hospitals using American Hospital Association numbers. The overall study flow chart is shown in Figure 1.

Statistical Analysis

Descriptive statistics for continuous and categorical variables were described as medians (interquartile ranges) and numbers (percentages), respectively. Patient characteristics and process measures were compared by use of the Wilcoxon rank-sum test for 2-group comparisons (the Kruskal–Wallis test was used for comparisons of >2 groups) and Pearson’s χ² or Fisher’s exact tests as appropriate. A multivariable logistic regression model was used to estimate the adjusted odds ratio and 95% confidence interval for in-hospital mortality outcome based on variables found to be predictive of in-hospital mortality in the ACTION Registry-GWTG risk score: age, baseline creatinine, systolic blood pressure, initial troponin, heart failure on presentation, cardiogenic shock on presentation, heart rate, and a history of peripheral artery disease. In addition to the above variables, out-of-hospital cardiac arrest, a strong predictor of in-hospital mortality in ACTION-Registry GWTG hospitals, was also included in the model. FMC-to-device time data were presented and summarized graphically using mountain plots, which represent a folded-empirical distribution function curve of the data at the 50th percentile (median).

All statistical tests were conducted at the 0.05 significance level. Statistical analyses were performed with SAS version 9.2 or higher (SAS Institute Inc, Cary, NC). The project was reviewed by the Duke University Institutional Review Board and classified as exempt.

Results

Pre- and Postimplementation Survey

In the 167 hospitals surveyed, uptake of each of the 4 key processes increased after intervention (Figure 2): prehospital activation (62%–91%; P<0.001), single call transfer protocol (45%–70%; P<0.001), and ED bypass for direct presenters (48%–59%; P=0.002) and transfer patients (56%–79%; P=0.001). Uptake of most other care processes also increased after intervention (Supplement S2 in the Data Supplement).

Patient Characteristics and Presentation

Between 2012 quarter 3 and 2014 quarter 1 (7 quarters), 23,809 patients presented with acute STEMI, including 18,267 patients who presented directly to a PCI-capable hospital and 5,542 who were transferred from hospitals without PCI capability. Among those presenting to PCI-capable hospitals, 64% (n=11,765) were transported by EMS providers, while 36% (n=6,502) arrived by self-transport. For the current analysis, overall patient clinical characteristics did not change between quarter 1 and quarter 7 (Table 1), with some exceptions. Compared with quarter 1, patients in quarter 7 were more likely to be male (72.2% versus 70.0%; P=0.044), insured through Medicaid (11.0% versus 9.2%; P=0.03), and considered a reperfusion candidate (96.6% versus 93.9%; P<0.0001), but these patients were less likely to have prior heart failure (2.7% versus 3.5%; P=0.025).

Reperfusion Times for Key STEMI Care Processes

There were significant differences in median FMC-to-device times among patients treated at hospitals that implemented preactivation for EMS transport to a PCI-capable hospital compared with nonimplementers (88 minutes for implementers versus 98 minutes for preexisting versus 98 minutes for
nonimplementers; \(P < 0.001\) for group comparisons; Figure 3A). Similarly, patients treated at hospitals implementing single call transfer protocols at non-PCI-capable hospitals had shorter median FMC-to-device times (112 versus 128 versus 152 minutes; \(P < 0.001\)). ED bypass was also associated with shorter FMC-to-device times for both direct presenters (84 versus 88 versus 94 minutes; \(P < 0.001\)) and transfers (123 versus 127 versus 167 minutes; \(P < 0.001\); Figure 3B).

In-Hospital Mortality
After adjustment for 9 variables associated with increased in-hospital mortality (ACTION Risk Score+cardiac arrest), we found no statistically significant difference in mortality between hospitals for any of the 4 key care processes of preactivation, single call transfer protocol, or ED bypass for both direct presenters and transfers (Table 2). However, hospitals that implemented all 4 care processes by the end of the STEMI Accelerator program (or had them preexisting) had numerically lower in-hospital mortality (6.0%) compared with those implementing only 1 (6.2%), 2 (6.3%), or 3 (7.3%) processes (Supplemental S3 in the Data Supplement).

Discussion
The overall goal of this study was to determine the impact of rapidly implementing care processes across multiple heterogeneous STEMI systems as part of a large scale, national effort. We found that after implementation of the STEMI Accelerator program, there was a significant uptake in several care processes. Importantly, we found that hospitals implementing the key care processes of prehospital activation of a cardiac catheterization laboratory, single call transfer protocol from an non-PCI-capable facility, or ED bypass for both direct EMS presenters or transfers had shorter median reperfusion times compared with hospitals that did not implement these processes and comparable reperfusion times compared with hospitals that had the process in place at baseline.

Our work extends that of prior observational studies, which found associations between STEMI care processes and improved reperfusion times, including preactivation of the cardiac catheterization laboratory,\(^5\) interfacility transfer for primary PCI,\(^5\) and ED bypass.\(^3,4\) Some smaller studies have compared the impact of STEMI patient flow care process intervention on outcomes, such as reperfusion times and infarct size.\(^11\) However, to our knowledge, this is the first study to demonstrate the specific impact on systems performance of rapidly implementing care processes across multiple heterogeneous STEMI systems on such a large-scale basis, involving nearly one quarter of all STEMI patients in the United States during this study time period. Furthermore, by merging hospital-level care process data with patient-level data on reperfusion times, we are able to demonstrate that efforts at implementation were associated with modest reductions in reperfusion times using the most contemporary, guideline-recommended reperfusion metric, FMC-to-device time.

This study has several important implications. First, we show that STEMI systems may be rapidly implemented with data collection, feedback, multidisciplinary team engagement, and importantly, adopting specific key care processes. Second, times to reperfusion in systems implementing processes were comparable to those with preexisting processes. This provides a critical and positive message for regions who have not yet adopted formalized reperfusion protocols, demonstrating that system performance can improve in a timely fashion. As a corollary, our data also demonstrate that hospitals that do not implement key STEMI care processes continue to have the longest reperfusion times. Further, the overall program costs are relatively modest at \$1.9 million for the additional resources to implement regionalization across all study regions. This translates into a cost per patient of \$80 (\$1900000/23809 STEMI patients in Accelerator). We think that this additional expense is fairly modest on a per-patient basis compared with the total cost of a single hospitalization for STEMI patients, recently reported to range from \$23000 to \$28000 based on Nationwide Inpatient Sample data.\(^21\) Overall, these data support efforts to optimize STEMI systems, with ongoing focus on the key processes to reduce FMC-to-device times.
There are some limitations. The survey results were reported by representatives in regions, whereby all hospitals were participating in the ACTION Registry-GWTG and, thus, may be at risk for both reporting and selection bias. However, this strategy to assess care process implementation was independent of reperfusion time reporting, which was captured by the ACTION Registry-GWTG; therefore, the findings that care process implementation was associated with shorter reperfusion times are likely robust. We also focused on 4 key care processes and others not studied or yet to be analyzed may be important to reduce reperfusion times. However, these care processes were specifically chosen to be important determinants of system performance and highly modifiable at a hospital and regional level; we now extend these findings to a national level. We have limited power to evaluate subgroups based on individual processes because of unmeasured or unmeasurable system factors, as well as a lack of power to reliably assess impact on mortality, which was neutral in this study. With relatively smaller sample sizes and observational data, it may be unrealistic to expect a significant change in overall mortality during a relatively short follow-up period, particularly when some systems of care were already functioning well at baseline. Finally, we are unable to adequately compare the relative benefit of each care process over another because hospitals may have used >1 care process at a time.

The neutral mortality results may also be related to secular trends demonstrating increasing mortality risk in contemporary STEMI populations, which could then offset gains in patients with shorter reperfusion times (survivor-cohort effect). We found numeric (but not statistically significant) increases in both shock (7.5%–8.4%) and cardiac arrest (7.3%–8.1%) at presentation between quarters 1 and 7, suggestive of a temporal increase in risk among STEMI patients within our study (Table 1). While we were unable to demonstrate a mortality benefit associated with shorter reperfusion times at the population level, the benefit of shorter reperfusion times to decrease mortality at the individual patient level is still clear. As discussed earlier, our study may be underpowered to show a mortality benefit in our population or longer follow-up may be required to demonstrate the impact of mortality benefits at the national level.

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### Table 1. Patient Characteristics for All STEMI Patients: Quarter 1 Versus Quarter 7

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Quarter 1 (N=3477)</th>
<th>Quarter 7 (N=3311)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age, y</td>
<td>61.0 (52.0–70.0)</td>
<td>60.0 (52.0–70.0)</td>
<td>0.72</td>
</tr>
<tr>
<td>Male sex</td>
<td>2433 (70.0%)</td>
<td>2391 (72.2%)</td>
<td>0.044</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td>0.22</td>
</tr>
<tr>
<td>White</td>
<td>2913 (83.8%)</td>
<td>2724 (82.3%)</td>
<td></td>
</tr>
<tr>
<td>Black</td>
<td>375 (10.8%)</td>
<td>381 (11.5%)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>189 (5.4%)</td>
<td>206 (6.2%)</td>
<td></td>
</tr>
<tr>
<td>Latino ethnicity</td>
<td>358 (10.3%)</td>
<td>323 (9.8%)</td>
<td>0.47</td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private/HMO</td>
<td>1912 (55.0%)</td>
<td>1860 (56.2%)</td>
<td>0.64</td>
</tr>
<tr>
<td>Medicaid</td>
<td>321 (9.2%)</td>
<td>363 (11.0%)</td>
<td>0.03</td>
</tr>
<tr>
<td>None</td>
<td>565 (16.2%)</td>
<td>505 (15.3%)</td>
<td>0.27</td>
</tr>
<tr>
<td>Other</td>
<td>707 (20.3%)</td>
<td>632 (19.1%)</td>
<td>0.20</td>
</tr>
<tr>
<td>Prior myocardial infarction</td>
<td>376 (10.8%)</td>
<td>416 (12.6%)</td>
<td>0.11</td>
</tr>
<tr>
<td>Prior heart failure</td>
<td>123 (3.5%)</td>
<td>90 (2.7%)</td>
<td>0.02</td>
</tr>
<tr>
<td>Prior PCI</td>
<td>443 (12.7%)</td>
<td>441 (13.3%)</td>
<td>1.00</td>
</tr>
<tr>
<td>Prior coronary bypass surgery</td>
<td>132 (3.8%)</td>
<td>121 (3.7%)</td>
<td>0.52</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>919 (26.4%)</td>
<td>876 (26.5%)</td>
<td>0.98</td>
</tr>
<tr>
<td>Median symptom onset to FMC (minutes)</td>
<td>69.0 (31.0–172.0)</td>
<td>68.5 (31.5–167.5)</td>
<td>0.58</td>
</tr>
<tr>
<td>Shock on presentation</td>
<td>262 (7.5%)</td>
<td>278 (8.4%)</td>
<td>0.19</td>
</tr>
<tr>
<td>Heart failure on presentation</td>
<td>253 (7.3%)</td>
<td>267 (8.1%)</td>
<td>0.25</td>
</tr>
<tr>
<td>Reperfusion candidate</td>
<td>3264 (93.9%)</td>
<td>3200 (96.6%)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Median heart rate on presentation, bpm</td>
<td>80.0 (66.0–93.0)</td>
<td>80.0 (66.0–93.0)</td>
<td>0.21</td>
</tr>
<tr>
<td>Median systolic blood pressure, mm Hg</td>
<td>140.0 (119.0–160.0)</td>
<td>140.0 (120.0–163.0)</td>
<td>0.37</td>
</tr>
<tr>
<td>STEMI first diagnosed</td>
<td></td>
<td></td>
<td>0.81</td>
</tr>
<tr>
<td>First ECG</td>
<td>3403 (97.9%)</td>
<td>3233 (97.6%)</td>
<td></td>
</tr>
<tr>
<td>Subsequent</td>
<td>46 (1.3%)</td>
<td>50 (1.5%)</td>
<td></td>
</tr>
<tr>
<td>Procedures during hospitalization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI</td>
<td>3096 (89.0%)</td>
<td>2982 (90.1%)</td>
<td>0.18</td>
</tr>
<tr>
<td>Coronary bypass surgery</td>
<td>142 (4.1%)</td>
<td>137 (4.1%)</td>
<td>0.95</td>
</tr>
<tr>
<td>Complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-hospital death</td>
<td>195 (5.6%)</td>
<td>198 (6.0%)</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Data presented as n (%) or median (interquartile range). ECG indicates electrocardiogram; FMC, first medical contact-to-device time; HMO, health maintenance organization; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

(Continued)
implementing such care processes. We did find a numerically lower in-hospital mortality among hospitals that had implemented all 4 care processes by the end of the Accelerator program, compared with those that had implemented 1 to 3 processes (Supplement S3 in the Data Supplement). However, a dose–response trend was not observed between number of processes and mortality; therefore, these results should be interpreted with caution.

In conclusion, this study found that the rapid uptake of several care processes occurred during STEMI Accelerator implementation across multiple STEMI systems within the United States. The implementation of key care processes (preactivation, single call transfer, ED bypass for both direct EMS presenters and transfers) was associated with improved reperfusion times. Efforts to optimize STEMI systems should continue and with a focus of these key care processes.
Table 2. Comparison of Adjusted In-Hospital Mortality for Key Care Processes

<table>
<thead>
<tr>
<th>Process</th>
<th>Preexisting vs did not implement</th>
<th>Implemented vs did not implement</th>
<th>Preexisting vs did not implement</th>
<th>Implemented vs did not implement</th>
<th>Preexisting vs did not implement</th>
<th>Implemented vs did not implement</th>
<th>OR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single call transfer</td>
<td>0.76 (0.47–1.21)</td>
<td>1.67 (0.99–1.81)</td>
<td>1.26 (0.91–1.76)</td>
<td>1.40 (0.59–3.29)</td>
<td>0.90 (0.71–1.13)</td>
<td>1.26 (0.54–2.92)</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>ED bypass: directs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>Preexisting vs did not implement</td>
<td>0.87 (0.66–1.14)</td>
<td>1.07 (0.83–1.38)</td>
<td>0.93 (0.73–1.19)</td>
<td>1.26 (0.91–1.76)</td>
<td>0.85 (0.55–1.3)</td>
<td>1.09 (0.59–2.00)</td>
<td>0.52</td>
<td>0.59</td>
</tr>
<tr>
<td>ED bypass: transfers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.78</td>
<td>0.46</td>
</tr>
<tr>
<td>Preexisting vs did not implement</td>
<td>1.28 (0.63–2.60)</td>
<td></td>
<td>1.28 (0.63–2.60)</td>
<td></td>
<td></td>
<td></td>
<td>0.45</td>
<td></td>
</tr>
</tbody>
</table>

Cl indicates confidence interval; ED, emergency department; and OR, odds ratio.

Acknowledgments

We dedicate this article to the late Dr Lee Garvey, whose expertise, passion, and wisdom have been essential to this work. We thank Morgan deBlecourt for her editorial contributions, which were provided as part of her regular duties as an employee of the Duke Clinical Research Institute.

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Disclosures

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References


Association of Rapid Care Process Implementation on Reperfusion Times Across Multiple ST-Segment –Elevation Myocardial Infarction Networks


for the STEMI Systems Accelerator Project

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Supplement S1. Pre- and post-intervention hospital survey

1) Name
2) Hospital that you represent (Please include address)
3) Regional system
4) Do(es) the EMS agency(s) that support(s) your hospital have 12-lead ECG equipment?
   (1) Yes in all vehicles
   (2) Yes in >50%, but not all vehicles
   (3) Yes in some (<50%) vehicles
   (4) No
5) If yes, then do you have a system where ST-segment elevation on a pre-hospital ECG is used to activate the cardiac cath lab before the patient arrives at the hospital?
   (1) Yes
   (2) No
6) What are the ECG criteria to activate the cath lab? (Click all that apply)
   (1) Computer interpretation
   (2) Paramedic interpretation
   (3) ECG transmission
7) Do you require ECG transmission to the cath lab?
   (1) Yes
   (2) No
8) If the patient has a confirmed STEMI diagnosis in the field by EMS, do they have to be formally re-evaluated by an ED physician (>5 min check) prior to admission to the cath lab? (Does not apply to waiting in the ED for cath lab staff to arrive.)
   (1) Yes
   (2) No
9) Have you worked with EMS to develop destination plans for STEMI patients?
   (1) Yes
   (2) No
10) Have you worked with referral hospitals to develop reperfusion and transfer plans for STEMI patients?
    (1) Yes
    (2) No
11) Do you offer your referral (transfer non-PCI center) hospitals upon identification of a STEMI a single call activation of the entire cath lab team?
    (1) Yes
    (2) No
12) If the patient has a confirmed STEMI diagnosis at a non-PCI center with plan to transfer for primary PCI, do they bypass your ED and go straight to the cath lab when staff is available?
    (1) Yes
    (2) No
13) Does your hospital provide regular feedback on time to treatment to EMS providers?
    (1) Yes, within 48 hours
    (2) Yes within 7 days
    (3) Yes in >7 days
    (4) No
14) Does your hospital provide feedback on time-to-treatment to referral (transfer non-PCI center) hospital providers?
   (1) Yes, within 48 hours
   (2) Yes within 7 days
   (3) Yes in >7 days
   (4) No

15) Do you have a STEMI team (representing all disciplines) that routinely meets (at least monthly) to evaluate your STEMI performance and make improvement recommendations?
   (1) Yes
   (2) No

16) If yes, who attends your meetings? (Click all that apply)
   (1) EMS
   (2) ED physicians
   (3) Cardiologists
   (4) Front line staff
   (5) ED leadership
   (6) Cath lab leadership
   (7) Outcomes or quality representative

17) Does your hospital collect and review data on false activations (over activation of cath lab for patients that do not meet activation criteria)?
   (1) Yes
   (2) No

18) How many cardiology groups provide primary PCI at your hospital?
   (1) 1
   (2) 2–3
   (3) 4–5
   (4) >5

19) Is your cath lab open 24 hours/day, 7 days/week, 365 days/year for STEMI?
   (1) Yes
   (2) No

20) Is there a single interventional cardiologist on call for all STEMI patients on a given night/holiday?
   (1) Yes
   (2) No

21) If more than one group of cardiologists staffs your hospital, is there an automatic system in place for treating “unassigned” patients?
   (1) Yes
   (2) No

22) Does EMS have the ability to incorporate pre-hospital documentation of care into the ED’s/hospital’s medical record?
   (1) Yes
   (2) No

23) Do you currently participate in ACTION Registry-GWTG (started before July 1 2012)?
   (1) Yes
   (2) No
24) Do you have on-site surgical backup at your PCI center?
   (1) Yes
   (2) No

25) Has your hospital placed a peripheral ventricular support device (non-IABP, such as Impella, TandemHeart, ECMO) in the past year?
   (1) Yes
   (2) No

26) Does your hospital have a protocol in place to deliver therapeutic hypothermia to patients with cardiac arrest and coma?
   (1) Yes
   (2) No

27) If so, have you treated someone with therapeutic hypothermia in the past 6 months?
   (1) Yes
   (2) No

28) What is your expected time from call for activation to cath lab staffed and ready to receive patients during off hours?
   (1) <20 min
   (2) <30 min
   (3) >30 min

29) Do you have an interventional cardiologist in house 24 hours a day?
   (1) Yes
   (2) No

30) Do you have cath lab teams that routinely staff the lab as a group?
   (1) Yes
   (2) No

31) Do you have a cath lab team in-house 24 hours a day?
   (1) Yes
   (2) No
**Table S2. Pre- and post-implementation survey responses for 167 hospitals participating in the Accelerator program**

<table>
<thead>
<tr>
<th>STEMI Care Process</th>
<th>Pre-intervention N (%)</th>
<th>Post-intervention N (%)</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMS supporting hospital has pECG capability</td>
<td>80 (47.9)</td>
<td>105 (62.9)</td>
<td>0.0299</td>
</tr>
<tr>
<td>*Pre-hospital activation of cardiac cath lab</td>
<td>103 (61.7)</td>
<td>152 (91.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>pECG activation using computer interpretation</td>
<td>50 (29.9)</td>
<td>69 (41.3)</td>
<td>0.3495</td>
</tr>
<tr>
<td>Paramedic interpretation</td>
<td>90 (53.9)</td>
<td>128 (76.6)</td>
<td>0.0216</td>
</tr>
<tr>
<td>Transmission</td>
<td>101 (60.5)</td>
<td>104 (62.3)</td>
<td>0.0443</td>
</tr>
<tr>
<td>Require ECG transmission to the cath lab</td>
<td>16 (9.6)</td>
<td>21 (12.6)</td>
<td>0.6184</td>
</tr>
<tr>
<td>*ED bypass for direct presenters</td>
<td>69 (41.3)</td>
<td>87 (52.1)</td>
<td>0.0016</td>
</tr>
<tr>
<td>Worked with EMS to develop destination plans</td>
<td>83 (49.7)</td>
<td>137 (82.0)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Worked with referral hospitals to develop plans for STEMI patients</td>
<td>81 (48.5)</td>
<td>127 (76.0)</td>
<td>0.0001</td>
</tr>
<tr>
<td>*Single call inter-facility transfer protocol</td>
<td>75 (44.9)</td>
<td>116 (69.5)</td>
<td>0.0007</td>
</tr>
<tr>
<td>*ED bypass for transfers-in</td>
<td>94 (56.3)</td>
<td>132 (79.0)</td>
<td>0.0012</td>
</tr>
<tr>
<td>Provides regular feedback on time-to-treatment to EMS providers</td>
<td>38 (22.8)</td>
<td>63 (37.7)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Provides regular feedback on time-to-treatment to referral to hospital providers</td>
<td>27 (16.2)</td>
<td>48 (28.7)</td>
<td>0.0003</td>
</tr>
<tr>
<td>STEMI team routinely meets to evaluate STEMI performance</td>
<td>113 (67.7)</td>
<td>153 (91.6)</td>
<td>0.0007</td>
</tr>
<tr>
<td>Collects and reviews data on false activations</td>
<td>77 (46.1)</td>
<td>112 (67.1)</td>
<td>0.0138</td>
</tr>
<tr>
<td>How many cardiology groups provide primary PCI</td>
<td>33 (19.8)</td>
<td>53 (31.7)</td>
<td>0.1395</td>
</tr>
<tr>
<td>Cath lab open 24 hours/day, 7 days/week for STEMI</td>
<td>131 (78.4)</td>
<td>151 (90.4)</td>
<td>0.8991</td>
</tr>
</tbody>
</table>

* Key STEMI care process used for reperfusion data. ED, emergency department; EMS, emergency medical services; PCI, percutaneous coronary intervention; pECG, pre-hospital electrocardiogram; STEMI, ST-segment elevation myocardial infarction.
**Supplement S3. In-hospital mortality according to number of pre-existing or implemented care processes**

<table>
<thead>
<tr>
<th># of care processes pre-existing or implemented</th>
<th># of hospitals</th>
<th>In-hospital mortality (n=patients died/total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>0% (0/23)</td>
</tr>
<tr>
<td>1</td>
<td>47</td>
<td>6.2% (367/5967)</td>
</tr>
<tr>
<td>2</td>
<td>58</td>
<td>6.3% (514/8224)</td>
</tr>
<tr>
<td>3</td>
<td>38</td>
<td>7.3% (422/5730)</td>
</tr>
<tr>
<td>4</td>
<td>23</td>
<td>6.0% (143/2381)</td>
</tr>
</tbody>
</table>
多维ST段抬高型心肌梗死的网络建立与快速治疗流程
在缩短再灌注时间中的实施


背景：目前已在美国16个大都会区内实施的STEMI生命线系统提速项目任务,使更多的患者得到了及时的再灌注治疗。我们假设实施关键性治疗措施与此系统的改善密切相关。

方法和结果：在此项目开展前（2012年3月）和开始后（2014年7月），将多所医院（167所医院，23,498位ST段抬高型心肌梗死患者）纳入此项研究。在此期间主要收集患者层面的临床数据。对再灌注治疗策略来说,医院依据开展特殊治疗措施的不同，被分为新开展组、已开展组，和未开展组。总结数据得出有4项关键性治疗措施:院前导管室激活（62%~91%, P < 0.001）,来自院外机构人员的单独呼叫转运方案（45%~70%, P < 0.001）,以及为急诊医疗服务直接提供急诊绿色通道（56%~79%, P = 0.001）。在这几组中,实行院前导管室激活后,中位首次医疗接触至器械接触时间出现明显差异（新开展组88分钟、已开展组89分钟、未开展组98分钟, 三组对照P < 0.001）。同样,院外医疗人员单独呼叫转运方案也具有较短的中位首次医疗接触至器械接触时间（112 vs. 128 vs. 152分钟, P < 0.001）。急诊绿色通道也与较短的中位首次医疗接触至器械接触时间相关,包括急诊医疗服务绿色通道（84 vs. 88 vs. 94分钟, P < 0.001）和转运绿色通道（123 vs. 127 vs. 167分钟, P < 0.001）。

结论：通过此系统提速项目,我们总结出几项与系统效果改进密切相关的关键性治疗措施。这些发现表明实施区域性ST段抬高型心肌梗死网络建设应着眼于院前导管室激活、单独呼叫转运方案,以及急诊绿色通道。

性别差异对经皮冠状动脉介入术并植入药物涂层支架治疗后高血小板反应性患者的临床影响:ADAPT-DES研究（评估药物涂层支架植入术后双联抗血小板治疗效果）


背景：性别差异对经皮冠状动脉介入术并植入药物涂层支架治疗患者的临床结局以及对氯吡格雷反应性影响的研究已经被报道；然而,性别是否对氯吡格雷治疗高血小板反应性(high platelet reactivity, HPR)患者的临床风险存在差异,目前尚未知晓。

方法和结果：根据性别以及是否存在氯吡格雷治疗高血小板反应性(定义为:P2Y12反应性单位即PRU > 208)进行分组,比较ADAPT-DES研究中纳入的8448例患者的临床终点事件的差异。临床终点事件定义为:确诊/可疑的支架内血栓(stent thrombosis, ST)、临床相关出血、全因死亡、心肌梗死以及主要不良心脏事件(包括死亡、心肌梗死和靶血管重建)。

结果显示:与男性患者(2491/6285, 39.6%)相比, HPR多见于女性患者(1118/2163, 51.7%)。与术后无HPR患者相比,存在HPR患者1年内ST发生率增加约1倍(女性: 0.7% vs. 1.4%; HR, 2.02; 95% CI, 0.82~4.95; P = 0.12; 男性:1.2% vs. 0.5%; HR, 2.42; 95% CI, 1.36~4.30; P = 0.002; 交互作用 = 0.73)。在女性患者中,术后存在HPR可降低约1倍的临床相关出血风险(5.3% vs. 9.8%; HR, 0.54; 95% CI, 0.40~0.74; P < 0.001);然而,在男性患者中,HPR与临床相关出血风险无关(5.7% vs. 5.9%; HR, 0.96; 95% CI, 0.78~1.18; P = 0.70; 交互作用 = 0.003)。在校正后的倾向模型中,HPR是男性患者发生ST和心肌梗死的独立预测因素;在女性患者中,HPR与ST和心肌梗死无显著相关性，但是并未发现性别的交互作用。相反，仅在女性患者中发现HPR是降低临床相关出血的独立预测因素(女性:校正HR, 0.58; 95% CI, 0.41~0.82; P = 0.002; 男性:校正HR, 0.83; 95% CI, 0.65~1.04; P = 0.11; 交互作用 = 0.01)。

结论：虽然在男性和女性患者中,HPR可引起相似的ST发生风险，但是仅在女性患者中,HPR可降低临床相关出血发生风险。

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（张瑞岩 审校）

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