Rural Interhospital Transfer of ST-Elevation Myocardial Infarction Patients for Percutaneous Coronary Revascularization

The Stat Heart Program

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Background—In Europe, interhospital transfer of ST-elevation myocardial infarction (STEMI) patients for primary percutaneous coronary intervention (PCI) from non–PCI-capable (STEMI-referral) to PCI-capable (STEMI-accepting) facilities has been shown to be a superior reperfusion strategy compared with on-site fibrinolysis. The feasibility of such programs in the United States remains poorly defined.

Methods and Results—We describe an observational cohort of 230 consecutive presumed STEMI patients who underwent interhospital transfer between January 2005 and March 2007 among 6 STEMI-referral and 2 STEMI-accepting hospitals in rural central Illinois. A standard treatment protocol using rapid interhospital transfer for primary PCI or rescue PCI after full-dose intravenous fibrinolysis (in event of unanticipated transfer delays) was initiated by the STEMI-referral emergency department physician. Three time intervals were evaluated: STEMI-referral care (door 1 to departure), transport time (door 1 departure to STEMI-accepting hospital arrival [door 2]), and STEMI-accepting hospital care (door 2 to balloon). Primary PCI was performed in 165 STEMI-confirmed patients (87.7%), whereas fibrinolysis was required in 16 patients (8.5%), with 56% undergoing rescue PCI. The median door 1–to-departure time was 46 minutes (25th and 75th percentiles, 32 and 62 minutes); approximately two-thirds of this delay was attributable to the wait for transport arrival and departure. The transport and door 2–to-balloon times were 29 minutes (25th and 75th percentiles, 25 and 35 minutes) and 35 minutes (25th and 75th percentiles, 32 and 46 minutes), respectively. The door 1–to-balloon time was 117 minutes (25th and 75th percentiles, 98 and 137 minutes), with 12.2% and 58% of patients achieving a time of ≤90 and ≤120 minutes, respectively. No adverse clinical events occurred during interhospital transport.

Conclusion—In rural US communities, emergency department physician–initiated interhospital transfer of STEMI patients for primary or rescue PCI is feasible and was safely executed with achievement of timely reperfusion when performed within coordinated healthcare networks. (Circulation. 2008;117:1145-1152.)

Key Words: angioplasty □ myocardial infarction □ reperfusion

Current European and American practice management guidelines for ST-elevation myocardial infarction (STEMI) recommend mechanical revascularization as the preferred reperfusion treatment, provided that the procedure can be performed in a timely fashion by experienced operators in high-volume centers.1,2 Unfortunately, in the United States, ≈75% of STEMI patients present to medical centers incapable of performing primary percutaneous coronary intervention (PPCI).3 The 2004 American College of Cardiology/American Heart Association (ACC/AHA) STEMI practice guidelines4 and AHA Mission: Lifeline initiative5 address interhospital transfer of STEMI patients from non–PCI-capable (ie, STEMI-referral) to PCI-accessible (ie, STEMI-accepting) facilities as a potential strategy to enhance the generalizability of PPCI for the treatment of STEMI patients (ie, transfer PCI), provided that a door-to-balloon time of ≤90 minutes is achievable.
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In the United States, interhospital transfer PCI programs are increasingly being explored as a treatment strategy for STEMI patients. The feasibility and clinical applicability of such programs remain inconclusive, especially in rural US communities where logistic and environmental barriers may contribute to treatment delays. For this reason, exclusive reliance on interhospital transfer for PPCI as the sole treatment strategy may not be conducive to achieving timely reperfusion for all STEMI patients at all times.

The Stat Heart Program was initiated in January 2005 among 6 STEMI-referral hospitals and 2 STEMI-accepting hospitals in rural central Illinois. We sought to examine the feasibility of an interhospital-transfer, guideline-based STEMI reperfusion protocol. In Stat Heart, interhospital transfer for PPCI is designed as the preferred STEMI reperfusion treatment strategy. Full-dose intravenous fibrinolytic therapy with “backup” rescue PCI was used if unanticipated transfer delays were encountered. In this observational report, we describe the feasibility of this reperfusion strategy of interhospital transfer for primary or rescue PCI; elucidate specific components of the processes of care at the STEMI-referral hospital, interhospital transfer, and STEMI-accepting hospital; and report on the clinical outcomes among the first 230 consecutive patients who were treated within this rural STEMI reperfusion program.

Methods

Program Design/Treatment Protocols

The Stat Heart Program is a regional STEMI consortium of 6 rural STEMI-referral hospitals, 2 STEMI-accepting hospitals (online-only Data Supplement Appendix I), and a large cardiovascular specialty group (Prairie Cardiovascular Consultants) in central Illinois (Figure 1). The STEMI-referral centers are hospital affiliates with long-standing referral relationships with the 2 STEMI-accepting facilities. The bed capacity of the 6 STEMI-referral hospitals ranged from 25 to 146 beds. The 2 STEMI-accepting hospitals are teaching facilities with inpatient capacities of 563 and 731 beds, perform between 2500 and 3500 PCI procedures per year, and provide access to PPCI 24 hours a day, 7 days a week.

The 4-step triage algorithm (Figure 2) and 3 treatment protocols (online-only Data Supplement Appendix II) were developed to be guideline-based and to provide standardized treatment within the STEMI-referral emergency department (ED). The program design and treatment protocols were provided to the STEMI-referral facilities, requiring the approval of the local medical, nursing, ED, and administrative staffs before participation. Interinstitutional policies were developed to allow universal patient transfer regardless of insurance carrier, hospital volume, or time of day.

All patients with angina or angina-equivalent symptoms within 12 hours of symptom onset (Figure 2, step I) with ECG ST elevation ≥1 mV in ≥2 contiguous ECG leads or with presumably new left bundle-branch block were considered eligible for participation (Figure 2, step II). Once STEMI was clinically suspected, the ED physician initiated the Stat Heart process with a single call to a centralized operator via a dedicated phone line at the STEMI-accepting facility. Simultaneous notification of the accepting cardiologist, cardiac catheterization laboratory (CCL) personnel, coronary care unit staff, and admitting offices was provided via an alpha pager activated by the operator at the STEMI-accepting facility. All patients were transferred directly to the STEMI-accepting CCL, where the interventional cardiologist and CCL staff were required to be available within 20 minutes of the “activation” page.

Figure 1. Illinois county map displaying the location and distance between the 6 STEMI-referral and 2 Springfield STEMI-accepting facilities.

Specific treatment and triage were subsequently based on the patient’s baseline hemorrhagic risk (Figure 2, step III) and accessibility to rapid interhospital transport (Figure 2, step IV). For example, patients with contraindications to fibrinolytic or anticoagulant therapy received the contraindication protocol—defined treatment (online-only Data Supplement Appendix II) and were emergently transferred directly to the STEMI-accepting center CCL for PPCI. Patients without increased baseline hemorrhagic risk received the PCI protocol—defined treatment (online-only Data Supplement Appendix II) and were emergently transferred directly to the CCL for PPCI if transport was readily accessible. If rapid interhospital transport was not readily available (ie, expected transport arrival to STEMI-referral facility of ≥20 minutes), patients received full-dose intravenous fibrinolytic therapy (ie, fibrinolytic protocol; online-only Data Supplement Appendix II), were transferred directly to the CCL of the STEMI-accepting center via the “backup” mode of transportation, and were assessed for need for rescue PCI. Rescue PCI was recommended if <50% resolution of ST elevation in the lead with the greatest elevation persisted at the time of STEMI-accepting hospital presentation, regardless of the presence or absence of anginal symptoms.

The mode of interhospital transportation (ie, air or ground) was predetermined on the basis of the estimated transport time from the STEMI-referral to STEMI-accepting facilities. Helicopter transfer was preferred if the interhospital transport time was ≥40 minutes, regardless of the absolute transfer distance. Air transfer was used primarily among 4 of the 6 STEMI-referral hospitals. Backup ground or air transportation was used if the primary mode of transportation was unavailable. The choice of fibrinolytics and glycoprotein IIb/IIIa receptor inhibitors was left to the discretion of the treating community ED physician based on hospital formulary availability.

The process of care for each individual case was reviewed and real-time feedback was provided to the STEMI-referral institution within 48 hours. Quarterly meetings are held to review program policies and overall processes of care among the participating institutions. No prospective registry existed to identify nontransferred STEMI patients. Every effort to include all presumed STEMI patients who were willing to be treated and transferred was determined at each STEMI-referral hospital before its program participation.
Process Measures/Time Intervals

Individual time intervals encompassing 3 global components of the overall STEMI process of care delivered by the STEMI-referral hospital, transport service, and STEMI-accepting hospitals were prospectively collected.

**STEMI-Referral Hospital Process Measures**

Six time intervals were analyzed: symptom onset to door 1 (ie, symptom onset to STEMI-referral hospital ED presentation), door 1 to medical contact (ie, STEMI-referral hospital ED presentation to initial physician or nurse contact), door 1 to ECG (ie, STEMI-referral hospital ED presentation to acquisition of 12-lead ECG), door 1 to decision (ie, STEMI-referral hospital ED presentation to ED physician’s call to initiate transfer), door 1 to needle (ie, STEMI-referral hospital ED presentation to initiation of intravenous fibrinolytic; acquired only from fibrinolytic-treated patients), and door 1 to departure (ie, STEMI-referral hospital ED presentation to ED departure).

**Transport Process Measures**

Five transport time intervals were acquired: decision to transport arrival (ie, STEMI-referral hospital ED physician call to initiate interhospital transfer to transport arrival at the community hospital), arrival to departure (ie, transport arrival at STEMI-referral hospital to departure from hospital), decision to departure, transfer (ie, departure from STEMI-referral hospital to arrival at STEMI-accepting hospital), and door 1 to door 2 (ie, STEMI-referral hospital ED presentation to arrival at STEMI-accepting hospital).

**STEMI-Accepting Hospital Process Measures**

Five time intervals at the STEMI-accepting hospitals were analyzed: door 2 to CCL arrival (ie, transport arrival at STEMI-accepting hospital to CCL arrival), CCL arrival to coronary angiogram (ie, CCL arrival to first diagnostic coronary injection), coronary angiogram to balloon (ie, first coronary injection to balloon inflation), door 2 to reperfusion (ie, STEMI-accepting hospital arrival to infarct artery Thrombolysis in Myocardial Infarction [TIMI] grade 3 perfusion or balloon inflation, whichever occurred first), door 1–to-balloon time (ie, STEMI-referral hospital ED presentation to balloon inflation), and PCI-related delay (ie, median door 1–to-balloon time minus the median door-to-needle time; calculated only for facilities that required use of fibrinolytic therapy).

**Clinical Outcomes**

STEMI was confirmed by the presence of a high-grade lesion or complete obstruction of the infarct-related artery at the time of coronary angiography with concomitantly elevated creatine phosphokinase-MB or troponin values. All other patients were categorized as having an “alternative” diagnosis.

In-hospital and 30-day individual and cumulative rates of death, recurrent myocardial infarction, and stroke were assessed. Recurrent myocardial infarction was defined as recurrent anginal symptoms with recurrent ECG ST elevation >1 mm and creatine phosphokinase-MB elevation of >2 times the upper limit of normal (among those with values returned to baseline) or >2 above the previous baseline value (among those with persistent elevation). Stroke was defined as new neurological signs with new or presumably new computed tomography– or magnetic resonance imaging–confirmed central nervous system infarct. Hemorrhagic complications included any of the following: retroperitoneal bleed, vascular access site bleeding requiring intervention or blood product transfusion, gastrointestinal or genitourinary bleeding, intracranial bleed, or need for blood transfusion. PCI procedural success was defined as a residual postprocedural infarct artery stenosis of <10% with TIMI grade 3 flow.

**Data Analysis**

We attempted to achieve the predefined STEMI care between 30 to 40 minutes within each of the 3 global care components (ie, STEMI-referral hospital, transport, and STEMI-accepting hospital). Continuous variables are presented as mean±SD or as medians with interquartile percentiles. We used χ² testing to compare categorical variables. All probability values are 2 tailed; a value of P≤0.05 considered significant. The exact method for computation of 95% confidence intervals (CIs) of point estimates was used. All statistical analyses were performed with SAS software, version 9 (SAS Institute). The Stat Heart Program was approved by the Institutional Review Board of the 2 STEMI-accepting facilities.
The authors had full access to and take full responsibility for the integrity of the data. All authors have read and agree to the manuscript as written.

**Results**

Between January 1, 2005, and March 1, 2007, 230 patients with presumed STEMI were assessed at the 6 STEMI-referral hospitals. Of these patients, 188 (81.7%) had confirmed STEMI and 42 (18.3%) were defined as having alternative diagnoses (Figure 3). Among the STEMI subgroup, 164 (87.2%), 8 (4.3%), and 16 (8.5%) were treated with the PCI, contraindication, and fibrinolytic protocols, respectively. Of the STEMI-confirmed patients, 165 of 188 (87.8%) received either PPCI (n=156) or rescue PCI (n=9). Coronary bypass surgery was performed in 19 (10.1%) (emergent, n=4; elective, n=15) STEMI-confirmed patients, whereas 2 were treated medically and 2 received elective postlytic PCI. Three of the patients with alternative diagnoses received fibrinolytic therapy.

The patient population consisted largely of white men, approximately one third of whom had anterior infarction (Table 1). The mean age was 59±15 years (range, 19 to 92 years); 19% were >75 years of age. The median time from symptom onset to STEMI-referral hospital ED presentation was 60 minutes (interquartile percentiles, 46 and 158 minutes).

**STEMI-Referral Hospital Process of Care**

The overall time spent in the STEMI-referral hospital ED (ie, door 1 to door 1 departure) ranged between 32 and 65 minutes among the 6 STEMI-referral centers; 62% to 67% of the total time could be attributed directly to waiting for transport arrival and departure after STEMI diagnosis (Table 2). Among the 19 fibrinolytic-treated patients, the median door-to-needle time was 27 minutes (interquartile percentiles, 23 and 36 minutes), with minimal observed variance noted during the 3 years after program initiation.

**Transport Care**

Air transport was used in 151 patients (65.7%) and ground transport in 79 patients (34.3%). The median interhospital distance traveled by the 230 patients was 45 miles (interquartile percentiles, 39 and 46 miles; range, 28 to 88 miles). Interhospital transport of 45 miles was required among 54% and 32 miles among 25% of patients. The median interhospital transfer time was slightly longer with ground (31 minutes; interquartile percentiles, 28 and 41 minutes) compared with air (26 minutes; interquartile percentiles, 23 and 33 minutes; P=0.139) transport. Use of the predefined backup transportation was required in 24 patients (10.4%), largely because of weather-related issues (22 of 24, 92%). All transfers were performed without hemodynamic compromise or death. The overall door 1–to–door 2 times ranged between 61 and 95 minutes among the 6 STEMI-referral centers.

**STEMI-Accepting Hospital Care**

The overall door 2–to-balloon time was 35 minutes (interquartile percentiles, 31 and 42 minutes) and was 31 minutes (interquartile percentiles, 24 and 37 minutes) and 39 minutes (interquartile percentiles, 33 and 48 minutes) among the 2 STEMI-accepting hospitals, respectively.

Among STEMI-confirmed patients undergoing PCI, procedural success rate was 96.4% (159 of 165). Rescue PCI was performed in 9 of the 16 fibrinolytic-treated STEMI patients (56.3%) (median door 1–to-balloon time, 160 minutes; interquartile percentiles, 142 and 169 minutes), achieving a

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**Table 1. Baseline Demographics**

<table>
<thead>
<tr>
<th>Demographic</th>
<th>Total (n=230)</th>
<th>STEMI (n=188)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean±SD, y</td>
<td>59±15</td>
<td>59±15</td>
</tr>
<tr>
<td>Male, %</td>
<td>74</td>
<td>71</td>
</tr>
<tr>
<td>White, %</td>
<td>94</td>
<td>93</td>
</tr>
<tr>
<td>Anterior MI, %</td>
<td>34*</td>
<td>30</td>
</tr>
<tr>
<td>Diabetes mellitus, %</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>Hypertension, %</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>Prior MI, %</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Prior CABG, %</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Prior PCI, %</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>Killip class III/IV, %</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

*CABG indicates coronary artery bypass grafting.  
*Presumed MI.
procedural success rate of 89% (8 of 9 patients). Glycoprotein IIb/IIIa antagonist therapy was administered in 149 of 165 patients (90.3%; abciximab, n/H1100564; eptifibatide, n/H1100585). Preprocedural TIMI grade 2/3 flow was observed in 62 of 165 patients (37.6%). An average of 1.4 coronary stents was implanted in 156 of 165 patients (94.5%). Multivessel coronary artery disease was present in 15.2% of patients.

Quality Measures
Among the STEMI-confirmed patient group, the median door 1–to-reperfusion time and door 1–to-balloon times were 107 minutes (range, 64 to 297 minutes) and 117 minutes (range, 64 to 314 minutes), respectively (Table 2). The frequency distributions of these time intervals are illustrated in Figure 4. The proportions of STEMI-confirmed patients achieving a door 1–to-balloon time ≤90 minutes and ≤120 minutes were 12.2% and 58%, respectively. The door 1–to-balloon time was >150 and >180 minutes among 15% and 6% of the STEMI-confirmed patients, respectively. The door 1–to-balloon time varied among the 6 STEMI-referral hospitals (range, 100 to 140 minutes) and was independent of the interhospital transfer distance or mode of transport. Among the 4 STEMI-referral hospitals that required the use of intravenous fibrinolytic therapy, the PCI-related delay was 71, 71, 90, and 98 minutes. The median total ischemic time (ie, symptom onset to balloon) was 199 minutes (interquartile percentiles, 158 and 270 minutes).

Clinical Outcomes
Table 3 lists in-hospital and 30-day clinical outcomes. The median length of hospitalization was 3 days. Seven in-hospital deaths occurred among the 230 total patients (3.0%; 95% CI, 1.2 to 6.2). One of these deaths occurred among the 42 alternative-diagnosed patients (2.4%). Of the 6 STEMI-related deaths (3.2%; 95% CI, 1.2 to 6.8), 2 were related to cardiogenic shock. Among the STEMI-confirmed subgroup, hemorrhagic complications occurred in 2 fibrinolytic-treated (12.5%; 95% CI, 1.6 to 38.4) and 5 non–fibrinolytic-treated (2.9%; 95% CI, 1.0 to 6.7) patients. By 30 days, 2 additional

<table>
<thead>
<tr>
<th>Table 2. Time Intervals of Process of Care</th>
<th>Total (n=230)</th>
<th>STEMI PPCI (n=156)</th>
<th>STEMI PPCI and Rescue PCI (n=165)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Interval</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STEMI-referral hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door 1 to first contact*</td>
<td>3 (0, 8)</td>
<td>3 (0, 8)</td>
<td>3 (0, 8)</td>
</tr>
<tr>
<td>Door 1 to ECG</td>
<td>5 (2, 9)</td>
<td>4 (2, 7)</td>
<td>4 (2, 7)</td>
</tr>
<tr>
<td>Door 1 to decision</td>
<td>14 (6, 25)</td>
<td>11 (5, 20)</td>
<td>11 (5, 20)</td>
</tr>
<tr>
<td>Door 1 to departure</td>
<td>46 (32, 62)</td>
<td>45 (31, 60)</td>
<td>45 (32, 60)</td>
</tr>
<tr>
<td>Interhospital transport</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decision to transport arrival</td>
<td>15 (7, 29)</td>
<td>15 (8, 29)</td>
<td>17 (8, 30)</td>
</tr>
<tr>
<td>Arrival to departure</td>
<td>13 (8, 19)</td>
<td>13 (8, 19)</td>
<td>13 (8, 19)</td>
</tr>
<tr>
<td>Decision to departure</td>
<td>31 (21, 42)</td>
<td>31 (21, 43)</td>
<td>32 (21, 44)</td>
</tr>
<tr>
<td>Transfer</td>
<td>29 (25, 35)</td>
<td>28 (24, 33)</td>
<td>28 (24, 35)</td>
</tr>
<tr>
<td>Door 1 to door 2</td>
<td>78 (63, 94)</td>
<td>75 (61, 90)</td>
<td>75 (62, 93)</td>
</tr>
<tr>
<td>STEMI-accepting hospital</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door 2 to CCL</td>
<td>11 (7, 15)</td>
<td>11 (7, 15)</td>
<td>10 (7, 15)</td>
</tr>
<tr>
<td>CCL to coronary angiogram</td>
<td>14 (10, 18)</td>
<td>14 (10, 17)</td>
<td>14 (10, 17)</td>
</tr>
<tr>
<td>Coronary angiogram to balloon</td>
<td>NA</td>
<td>13 (9, 20)</td>
<td>14 (10, 21)</td>
</tr>
<tr>
<td>Door 2 to reperfusion†</td>
<td>NA</td>
<td>33 (26, 42)</td>
<td>32 (25, 42)</td>
</tr>
<tr>
<td>Door 2 to balloon</td>
<td>NA</td>
<td>35 (32, 46)</td>
<td>35 (31, 45)</td>
</tr>
<tr>
<td>Door 1 to balloon</td>
<td>NA</td>
<td>107 (95, 128)</td>
<td>107 (96, 129)</td>
</tr>
<tr>
<td>Door 1 to balloon</td>
<td>NA</td>
<td>115 (87, 132)</td>
<td>117 (88, 137)</td>
</tr>
</tbody>
</table>

Values are median minutes (25th, 75th percentiles). NA indicates not applicable.
*First medical contact after STEMI-referral ED presentation.
†Reperfusion is infarct artery TIMI grade 3 flow or balloon inflation, whichever occurs first.

Figure 4. A, Histogram of the frequency distribution of door-to-balloon time among STEMI patients undergoing primary percutaneous coronary revascularization. B, Histogram of the frequency distribution of door-to-reperfusion time among STEMI patients undergoing primary percutaneous coronary revascularization.
patients died (3.9%; 95% CI, 1.8 to 7.3); 1 STEMI-confirmed and 1 alternative-diagnosed patient. The cumulative inhospital and 30-day composite of death, reinfarction, and stroke occurred in 4.8% (95% CI, 0.6 to 16.2) and 5.9% (95% CI, 3.0 to 10.2) of the alternative-diagnosed and STEMI-confirmed patient subgroups, respectively. None of the fibrinolytic-treated patients experienced a nonhemorrhagic clinical event through 30 days.

Discussion

The nonuniformity of STEMI treatment strategies in the United States contributes to untimely reperfusion therapy and complicates the overall process of STEMI care. In the current program, the 4-step algorithm provided the STEMI-referral ED physician with standardized pharmacological or mechanical reperfusion options and empowered this physician to activate the process of care at the STEMI-accepting facility without prior cardiologist consultation, a strategy previously demonstrated to reduce reperfusion delays. Within the design of the protocol, several important observations were noted. First, despite the primary goal of using interhospital transfer for PPCI, full-dose fibrinolytic therapy was required in ~10% of this rural patient population. Inclement weather conditions and unanticipated helicopter unavailability contributed to the unexpected interhospital transfer delays, requiring use of an alternative reperfusion strategy. Unlike other transfer PCI programs that use controversial “facilitated” lytic PCI strategies to compensate for long interhospital transport distances, full-dose fibrinolytic therapy with “backup” rescue PCI was used in Stat Heart as an alternative, definitive reperfusion treatment based on previously described favorable clinical outcomes with this reperfusion strategy. The availability of a backup reperfusion option has important clinical implications for similar rural healthcare systems and confirms the concept that “one size does not fit all” in the management of STEMI.

Second, patients without STEMI (ie, alternative-diagnosed subgroup) accounted for 1 of every 6 to 7 patients transferred in this program. A “misdiagnosis” in this clinical scenario has been suggested to contribute to the performance of unnecessary procedures with resultant increased resource use and exposure to excess patient risk. Although 19 of the 42 alternative-diagnosed patients (45%) had a noncardiac chest pain syndrome, their 30-day mortality rate was observed to be similar (ie, 4.8%) to that of the STEMI-confirmed subgroup. The findings of high-risk clinical diagnoses, including nonSTEMI, pulmonary embolism, and aortic dissection, among the alternative-diagnosed patient subgroup most likely explain this 30-day mortality observation. Overall, this structured program was believed to help facilitate the expeditious care and to avoid the potential risks of universally using fibrinolytic therapy among this particular patient subgroup without confirmed STEMI.

Third, the Stat Heart program demonstrates the generalizability of initiating standardized STEMI care strategies in rural healthcare systems of varying complexity in accordance with national STEMI initiatives. The various strategies recommended by the ACC Door-to-Balloon (D2B) initiative, including using a single call from the STEMI-referral ED physician, avoiding delays associated with acquiring a cardiology consultation before transfer, requiring CCL staff to be available in the CCL within 20 minutes of initial page notification, and providing comprehensive and timely (ie, within 48 hours) process-of-care feedback to all participants, were used in this program. In accordance with the AHA Mission: Lifeline initiative, this program also pursued the active participation of key healthcare stakeholders to help ensure the success of the program. In Stat Heart, the cooperation of 2 competitive tertiary healthcare systems (ie, STEMI-accepting facilities) was required to initiate and sustain this structured, global STEMI care program throughout our healthcare network. In addition, the Stat Heart program included referral hospitals regardless of bed size and the presence or absence of locum tenens ED physicians. Thus, the maintenance of such programs requires the commitment of dedicated healthcare providers and continual review of processes to ensure the appropriateness of overall STEMI care.

Time delays associated with interhospital transfer PCI programs can be assessed within 3 specific components of process of care: STEMI-referral hospital care, transport care, and STEMI-accepting hospital care. Time delays of ≤30 minutes within each of these 3 global components (ie, the “30-30-30 rule”) have been recommended as a target to achieve optimal (ie, ≤90 minutes) reperfusion. In Stat Heart, this benchmark threshold was nearly achieved within both the transfer (ie, median delay, 29 minutes) and STEMI-accepting hospital (ie, median door 2–to-balloon time, 35 minutes) care components. However, the greatest delay was observed within the STEMI-referral facilities (ie, median door 1–to-departure time, 46 minutes), accounting for 40% of the overall door 1–to-balloon time. Thus, among the STEMI-confirmed population in Stat Heart, the overall median door 1–to-balloon time was 117 minutes, with 12% and 58% of patients achieving successful reperfusion ≤90 and ≤120
minutes, respectively. Although falling short of the benchmarks recently defined by the ACC/AHA initiatives, these observations compare favorably to recently published interhospital US\textsuperscript{4,5,14} and European\textsuperscript{15} transfer PCI studies and are superior to current US registry data. For example, in the Mayo Clinic STEMI Protocol,\textsuperscript{5} the median door 1–to-balloon time was 116 minutes (12\% ≤90 minutes) among 105 STEMI patients undergoing interhospital transfer for PCI. In the National Registry of Myocardial Infarction 3/4 analysis of 4278 STEMI patients undergoing interhospital transfer for primary PCI in the United States, the median door-to-balloon time was 180 minutes, with only 4.2\% and 16.2\% of patients achieving door-to-balloon times of <90 and ≤120 minutes, respectively. Importantly, among rural teaching hospitals similar to our Stat Heart centers, the median door-to-balloon time was 249 minutes, a 2-fold-longer delay than was observed in our current program.

The major “rate-limiting” delay occurred at the STEMI-referral facilities, largely resulting from awaiting transport arrival and “packaging” of the patient for transport. This transport-associated delay accounted for =62\% to 67\% of the total STEMI-referral facility care component and tended to be longer among the sites requiring air (median decision-to-door 1 departure time, 37 minutes; 25, 45 minutes) compared with those using ground transport (median decision-to-door 1 departure time, 24 minutes [interquartile percentiles, 17 and 31 minutes]; \textit{P}=0.09). In Stat Heart, 69\% of patients were transferred by helicopter, a factor contributing to the incremental transport-associated delay. Similar delays were encountered with interhospital air and ground transfer in the Air Primary Angioplasty in Myocardial Infarction study,\textsuperscript{14} in which the median call for transport-to-departure time was 38 minutes and accounted for >50\% of the time spent in the STEMI-referral facility. Preliminary Stat Heart data suggest that STEMI diagnosed before presentation to a rural STEMI-referral hospital ED with use of prehospital 12-lead ECG acquisition can reduce interhospital transport-associated delays to an STEMI-accepting facility by up to 20 minutes.\textsuperscript{17} This strategy similarly conforms with current ACC D2B alliance recommendations aimed at reducing door-to-balloon times.\textsuperscript{13} If confirmed and universally applied, this technology could contribute to the expansion of interhospital STEMI transfer programs in many rural US communities.

This report describes our initial efforts. Gradual reductions in treatment delays have been observed as the program has matured, with a 5-minute decrease in the median door 1–to-balloon time noted over the past year (ie, from 122 to 117 minutes). In addition, since the institution of this coordinated interhospital STEMI transfer, PCI-related delays also have been reduced. For example, the median door 1–to-balloon time and PCI-related delay were 227 and 200 minutes, respectively, among STEMI patients transferred from our 6 STEMI-referral hospitals in the 2 years (ie, 2003 to 2004) before the initiation of the current program.

Study Limitations

The relatively young age of the current cohort was unexpected and may partially explain our observed clinical outcomes. However, no discrimination of patient participation in Stat Heart was prespecified on the basis of age or other comorbid factors. This resulted in the inclusion of patients between 19 and 92 years of age and 2 “do not resuscitate” patients in the present study.

Although PPCI is the preferred reperfusion strategy among STEMI patients presenting to hospital >3 hours after symptom onset, the preferred reperfusion strategy for those presenting ≤3 hours is largely dependent on the availability of timely mechanical reperfusion. Findings of the Vienna STEMI Registry Group\textsuperscript{18} have reconfirmed prior observations of comparable in-hospital mortality rates among STEMI patients receiving PPCI compared with fibrinolytic-treated patients when treatment is initiated within 2 to 3 hours of symptom onset. Our observed door 1–to-balloon time of 115 to 117 minutes and PCI-related delay (71 to 98 minutes) exceed the current ACC/AHA guideline recommendations of ≥90 and ≤60 minutes, respectively. Because most patients in the present study presented within 3 hours of symptom onset, inclusion of a time-to-presentation decision node (ie, ≤3 or >3 hours) in our treatment algorithm, similar to that of the Mayo Clinic STEMI protocol,\textsuperscript{5} may enhance our present quality measurement outcomes.

Conclusion

In the current program, we demonstrate the feasibility and generalizability of initiating various reperfusion options on the basis of a standardized, port-of-entry triage and treatment STEMI algorithm. This program, which empowers community ED physicians with the capacity to initiate reperfusion therapy and begin interhospital transfer within a coordinated health facility network, can be executed safely in rural US communities, with the accomplishment of timely primary or rescue PCI.

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Disclosures

None.

References

When a door-to-balloon time of ≤90 minutes can be achieved, primary percutaneous coronary intervention (PPCI) is preferred over intravenous fibrinolytic therapy as a reperfusion strategy for ST-elevation myocardial infarction (STEMI). Unfortunately, only 25% of US hospitals have PPCI-capable facilities. Interhospital transfer of STEMI patients from non-PCI-capable (STEMI-referral) to PPCI-capable (STEMI-accepting) facilities has been suggested as a strategy (transfer PCI) to enhance the generalizability of PPCI. In rural US communities, unexpected impediments to interhospital transport may contribute to reperfusion delays, necessitating alternative “backup” treatment strategies (ie, full-dose intravenous fibrinolysis). We established a regional transfer PCI STEMI consortium (Stat Heart) in rural central Illinois consisting of 6 STEMI-referral hospitals, which were within 28 to 88 miles of our 2 STEMI-accepting facilities. We used a 4-step, guideline-based STEMI protocol that empowered the STEMI-referral emergency department physician to initiate treatment and to expedite interhospital transfer for primary or rescue PCI, if needed, after fibrinolysis. Among the first 230 Stat Heart patients, the median door-to-balloon time among those receiving PPCI was 117 minutes. Unexpected interhospital transport delays (usually resulting from inclement weather) required the use of intravenous fibrinolysis in 19 patients (8.3%; 9 requiring rescue PCI) with achievement of a median door-to-needle time of 27 minutes. In Stat Heart, we observed that universal reperfusion strategies for all STEMI patients at all times are not always feasible (ie, “one size does not fit all”) and demonstrated that interhospital transfer for timely primary and rescue PCI can be achieved safely in rural US communities when incorporated within coordinated healthcare networks.

CLINICAL PERSPECTIVE

When a door-to-balloon time of ≤90 minutes can be achieved, primary percutaneous coronary intervention (PPCI) is preferred over intravenous fibrinolytic therapy as a reperfusion strategy for ST-elevation myocardial infarction (STEMI). Unfortunately, only 25% of US hospitals have PPCI-capable facilities. Interhospital transfer of STEMI patients from non-PCI-capable (STEMI-referral) to PPCI-capable (STEMI-accepting) facilities has been suggested as a strategy (transfer PCI) to enhance the generalizability of PPCI. In rural US communities, unexpected impediments to interhospital transport may contribute to reperfusion delays, necessitating alternative “backup” treatment strategies (ie, full-dose intravenous fibrinolysis). We established a regional transfer PCI STEMI consortium (Stat Heart) in rural central Illinois consisting of 6 STEMI-referral hospitals, which were within 28 to 88 miles of our 2 STEMI-accepting facilities. We used a 4-step, guideline-based STEMI protocol that empowered the STEMI-referral emergency department physician to initiate treatment and to expedite interhospital transfer for primary or rescue PCI, if needed, after fibrinolysis. Among the first 230 Stat Heart patients, the median door-to-balloon time among those receiving PPCI was 117 minutes. Unexpected interhospital transport delays (usually resulting from inclement weather) required the use of intravenous fibrinolysis in 19 patients (8.3%; 9 requiring rescue PCI) with achievement of a median door-to-needle time of 27 minutes. In Stat Heart, we observed that universal reperfusion strategies for all STEMI patients at all times are not always feasible (ie, “one size does not fit all”) and demonstrated that interhospital transfer for timely primary and rescue PCI can be achieved safely in rural US communities when incorporated within coordinated healthcare networks.
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