Impact of a Rural Regional Myocardial Infarction System of Care in Wyoming

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Background—Primary percutaneous coronary intervention (PCI) is the preferred reperfusion strategy for patients presenting with ST-segment elevation myocardial infarction; however, to be effective, PCI must be performed in a timely manner. Rural regions are at a severe disadvantage, given the relatively sparse number of PCI hospitals and long transport times.

Methods and Results—We developed a standardized treatment and transfer protocol for ST-segment elevation myocardial infarction in the rural state of Wyoming. The study design compared the time-to-treatment outcomes during the pre- and postintervention periods. Details of the program, changes in reperfusion strategies over time, and outcome improvements in treatment times were reported. From January 1, 2013, to December 31, 2014, 889 patients were treated in 11 PCI-capable hospitals (4 in Wyoming, 7 in adjoining states). Given the large geographic distance in the state (median of 47 miles between patient and PCI center), 52% of all patients were transfers, and 36% were administered fibrinolysis at the referral facility. Following the intervention, there was a significant shift toward greater use of primary PCI as the dominant reperfusion strategy (from 47% to 60%, $P=0.002$), and the median total ischemic time from symptom onset to arterial reperfusion was decreased by 92 minutes ($P<0.001$). There was a similar significant reduction in median time from receiving center door to balloon of 11 minutes less than the baseline time ($P<0.01$).

Conclusions—Rural systems of care for ST-segment elevation myocardial infarction require increased levels of cooperation between emergency medical services agencies and hospitals. This study confirms that total ischemic times can be reduced through a coordinated rural statewide initiative. (*J Am Heart Assoc*. 2016;5:e003392 doi: 10.1161/JAHA.116.003392)

Key Words: outcomes research • primary percutaneous coronary intervention • quality of care • ST-segment elevation myocardial infarction • systems of care

P rimary percutaneous coronary intervention (PCI) is the preferred reperfusion strategy for patients presenting with ST-segment elevation myocardial infarction (STEMI).[1,2] This is somewhat more straightforward when patients present directly at the nearest PCI-capable facility, but in regions that are sparsely populated and that have low density of PCI-capable hospitals, there is often a prolonged transfer interval that negatively affects timely intervention.[3–5] Although an estimated 39% of all US hospitals have interventional cardiology capabilities, there is a large geographic imbalance, and rural states like Wyoming are among the states with the lowest interventional capability, even when adjusting for population.[6]

Regional myocardial infarction systems of care have been shown to improve outcomes[7–11]; however, there is a lack of documented findings from rural or "frontier" states, namely, those with low population density and large geographic transfer distances. Wyoming is characterized by long transport times and predominantly volunteer emergency medical services (EMS). In addition, there are issues related to excessive elevation, mountainous terrain, climate, poor telecommunications coverage in the more rural parts of the state, and lack of technology-enabled EMS vehicles. Based on a need to address these challenges, the Mission: Lifeline Wyoming program was initiated in 2012. The primary focus of

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An accompanying Data S1 is available at http://jaha.ahajournals.org/content/5/5/e003392/DC1/embed/inline-supplementary-material-1.pdf

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this initiative was to reduce total ischemic time from symptom onset to arterial reperfusion (SOAR) and to improve outcomes in the cardiac care of patients with STEMI.

Methods

Wyoming is the 10th largest state in geographic size but is the least populated state, with only 585 000 citizens. An American Heart Association–sponsored STEMI initiative was organized in 2012 in Wyoming. The initiative was funded in part through a $5.9 million grant from the Leona M. and Harry B. Helmsley Charitable Trust. Table 1 shows the list of volunteer multidisciplinary stakeholder committee members that represented the diverse needs of the regional system of care (Table 1).

Quality-of-care outcomes were established in the first few months and created a primary focus on time-to-treatment metrics including (1) total ischemic time (defined as the difference in minutes of SOAR), (2) time from receiving center door to balloon, and (3) time from door to needle (D2N) for the 22 participating community referral hospitals. In addition, given long transport times, there was a special focus on increasing the utilization and sophistication of EMS (as opposed to using a self- or patient-owned vehicle). The Wyoming Department of Health was engaged and provided deidentified EMS data for the analyses. As an observational study, patients were provided standard of care, and informed consent was not required. The study was approved by the University of Texas Health Science Center institutional review board.

Study Setting

This study took place in Wyoming with participation from hospitals bordering the state. During the 36-month initiative, Mission: Lifeline Wyoming deployed 30 educational programs on STEMI identification that trained 555 EMS and hospital personnel. Protocol subcommittees met ≈25 times to review and approve clinical protocols, especially transfer protocols from STEMI referral facilities, and to provide education across the provider community. The program consisted of development of standardized protocols, training, technology and communication, and outcomes measurement and evaluation. More than 165 12-lead ECG devices with transmission capability were acquired and placed into service for the 56 agencies involved, representing 81% of all agencies in the state. Nearly 200 automated external defibrillators were placed into service throughout the state in law enforcement and first-responder vehicles. Quarterly in-person collaboration meetings were held at rotating locations within the state of Wyoming or by webinar or teleconference during times of inclement weather.

Standardized Protocol and Intervention

Given the high percentage of transfer patients presenting with STEMI, the focus of the initiative was on achieving collaboration and agreement for EMS transport and transfers from referral facilities to PCI-capable centers. Although there are often disagreements about the proper utilization and administration of fibrinolysis,[12] given the long transport times and distances, this was considered an important component of treatment from community referral hospitals. In addition, the protocol emphasized (1) rapid patient ECG device acquisition (with a door-to-ECG goal of <10 minutes), both before hospital arrival and at the initial community or PCI-capable hospital, and transmission of ECG results to the PCI-capable facility for early catheterization laboratory activation; (2) early notification from the referral hospital to the PCI center; (3) consideration of fastest dispatch transportation, including air if available; and (4) both antiplatelet and anticoagulant medications, based on the treating cardiologist's input. The final approved emergency room diagnostic and treatment protocol is provided in Data S1.

Data and Statistical Analyses

We assessed the impact of this initiative using abstracted data from all 11 participating PCI-capable facilities, 4 within Wyoming (Cheyenne Regional Medical Center, Wyoming Medical Center, Sheridan Memorial, and Campbell County Health) and 7 in the adjoining border states of Idaho, Utah, Colorado, South Dakota, and Montana. The data source consisted of deidentified extracts from each facility's National Cardiovascular Data Registry submissions. We analyzed all STEMI patients presenting during 2013–2014. Figure shows a map of the region.

We defined data collected during the first 2 quarters of the program as our "preintervention period," during which the

Table 1. Mission: Lifeline Wyoming Stakeholder Committee

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|---|
| Four Wyoming physician cochair leaders |
| Nursing, administrative, and physician representatives from 11 percutaneous coronary intervention–capable hospitals and 25 ST-segment elevation myocardial infarction–referring facilities |
| Chiefs and managers or their designees from 56 emergency medical services agencies |
| Data abstractors |
| Wyoming Department of Health, Emergency Medical Services Division |
| Wyoming Hospital Association |
| American Heart Association staff |
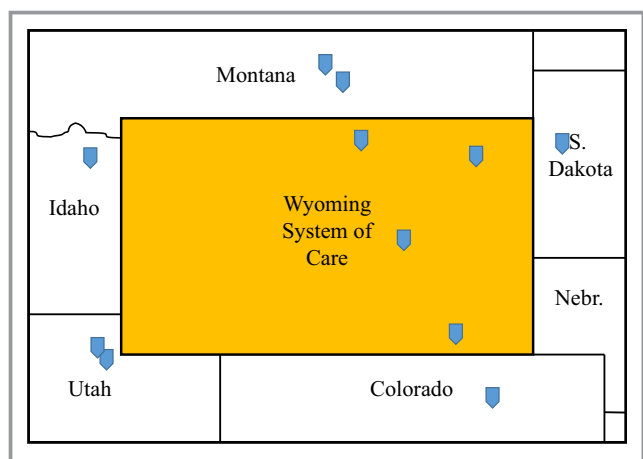
Figure. Wyoming-area facilities capable of percutaneous coronary intervention. Nebr. indicates Nebraska.

program teams and schedules were being trained; we used the subsequent 3 quarters as our baseline while the intervention was being implemented and then established our postgroup as the final 3 quarters of the initiative.

Our primary outcome metric was SOAR (total ischemic time) in minutes. Although symptom recognition is somewhat subjective, this parameter reflects the most comprehensive measure of the responsiveness of the total system of care.[13,14] We compared differences in median values across times for SOAR, receiving center door to balloon, and D2N. In addition, we collected information on the reperfusion strategies received by these patients and categorized the strategies as follows: not eligible for reperfusion, primary PCI, fibrinolysis only, or a combination of PCI plus fibrinolysis. We also collected data on the distance in miles between patient residence and the PCI-capable facility, whether the patient was transferred from a facility, length of stay in the PCI-capable hospital, and arrival mode (self- or patient-owned vehicle versus EMS). Demographic data and ZIP code of the patient residence were also collected.

Descriptive statistics for continuous variables were presented as median with interquartile range (IQR), and categorical variables were presented as frequency with percentage. We used the preintervention group as a reference when independently comparing the characteristics and time outcomes of the baseline and postintervention groups. We used the Mann–Whitney *U* test to compare the distributions of time variables (SOAR, receiving center door to balloon, D2N, and SOAR partial time components) and the chi-square test for nominal and ordinal variables. In the subgroup of pre- and postintervention patients who received primary PCI and PCI with fibrinolysis, we determined the factors associated with SOAR time. To evaluate these factors, we performed univariate analysis with the Mann–Whitney *U* test to analyze

categorical variables and linear regression for continuous variables. Because the SOAR time variable was not normally distributed, it had to be transformed into a log scale for analysis. In a second step, in the same group of patients, we determined the independent predictors of SOAR time by constructing a multivariate linear regression model and including the covariates with $P \leq 0.10$ in the univariate analyses. A 2-tailed $P < 0.05$ was considered statistically significant for all tests. All analyses were conducted in IBM SPSS Statistics software (version 23; IBM Corp).

Results

A total of 889 unique STEMI patients were included in this study. The median total SOAR time was 257 minutes (IQR 137–548 minutes), and the median time from receiving center door to balloon measured from arrival at the PCI-capable facility was 56 minutes (IQR 37–83 minutes) throughout the entire program. The median SOAR time for women was 286 minutes (IQR 145–696 minutes) compared with only 246 minutes (IQR 133–525 minutes) for men; however, the median difference was not significant ($P = 0.06$).

The median distance between patient home and PCI-capable facility was 47 miles (IQR 11.2–117 miles), calculated using ZIP code geocoding. In comparing the median distance in miles traveled from patient home to a PCI-capable facility, we observed a significant difference between the pre- and postintervention groups of 85 versus 30 miles, respectively ($P = 0.02$). Patient characteristics are summarized in Table 2.

When comparing the pre- and postintervention groups, there were significant findings. Total SOAR time decreased from a median of 307 minutes (IQR 162–769 minutes) to 215 minutes (IQR 130–434 minutes), a statistically significant decline of 92 minutes, or 30% from preintervention SOAR time ($P < 0.001$). Median time from receiving center door to balloon had a significant decrease of 11 minutes, from 53 to 42 minutes ($P < 0.01$). Median D2N time increased from 30 to 36 minutes; however, the difference was not significant ($P = 0.23$) (Table 3).

To further explore the differences in individual time segments within SOAR, we decomposed total ischemic time into the following time segments: symptom onset to first medical contact, first medical contact to arrival at a PCI-capable facility, onset to arrival, and arrival to hospital ECG. There were statistically significant reductions in the categories of first medical contact to arrival at a PCI-capable facility ($P = 0.007$), onset to arrival ($P = 0.02$), and arrival to hospital ECG ($P < 0.001$) between the pre- and postintervention groups, providing insight into the overall reduction in SOAR (Table 4). There was also a significant change in the distance (in miles) driven between patients' homes and the destination

Table 2. Characteristics of Patients With ST-Segment Elevation Myocardial Infarction Included in the Study According to Time of Intervention

Characteristics	All	Preintervention	Baseline	Postintervention
Total patients, n (%)	889 (100)	206 (23.2)	123 (13.8)	560 (63)
Age, y, mean, median (interquartile range)	65, 64 (57–73)	64, 64 (56–64)	66, 65 (58–73)	65, 65 (56–73)
Female sex, n (%)	223 (25.1)	41 (19.9)	31 (25.2)	151 (27)
Length of stay, days, mean, median (interquartile range)	3.8, 2 (2–4)	4, 2 (0–0)	3.9, 2 (1–1)	3.7, 2 (2–2)
Distance, miles, mean, median (interquartile range)	97.3, 47 (11.2–117)	81.5, 85 (20.1–115)	83.2, 93.6 (20.3–118)	105.7, 30 (9.7–117.8)*

The preintervention group is the reference for comparison of baseline and postintervention groups. The Mann–Whitney *U* test was used to determine differences in distributions of continuous variables, and the chi-square test was used to evaluate differences by sex. *P*<0.05 was considered statistically significant for all tests.
*P=0.02.

hospital between the pre- and postintervention groups that could influence the change in time-to-treatment outcomes.

Regardless of perfusion strategy, 490 patients (55%) received primary PCI only, 52 patients (6%) received fibrinolysis only, 263 (30%) received a combination of full-dose fibrinolysis plus PCI, and 84 patients (9%) were considered not eligible for primary reperfusion and received neither (Table 5). In accordance with published national clinical practice guidelines,[2] implemented protocols emphasized primary PCI reperfusion if transport could be accomplished rapidly. During the program, we observed a significant shift toward greater primary PCI utilization, from 47% during the preintervention period toward 60% during the postintervention period (P=0.002), and lower but not significant utilization of fibrinolysis alone, from 8% to 4%. A total of 36% of patients (n=315) received fibrinolysis, with 98% of those patients receiving full-dose tenecteplase administered at the referral hospital. Consequently, D2N time increased from a median of 30 minutes (IQR 21–49.5 minutes) to a median of 36 minutes (IQR 22–54 minutes; P=0.23) from the pre- versus postintervention assessment, and the percentage of eligible patients receiving fibrinolysis decreased from 45% to 30% (P<0.001).

To determine the independent predictors associated with SOAR times in the subgroup of pre-and postintervention patients who received primary PCI only or combination PCI plus fibrinolysis, we performed univariate analysis, and in a second step, we constructed a multivariate linear regression model including variables with P≤0.10 in the univariate analysis. Univariate analyses of factors associated with total SOAR time in the subgroup of patients indicated that transfer from another facility (P<0.001), mode of arrival at the PCI-capable facility (P<0.001), reperfusion strategy (P<0.001), and study group (P<0.001) were significantly associated with SOAR time (data not shown). To determine the relative impact of relevant factors over SOAR time in the study subgroup, we constructed a multivariate regression model including transfer from another facility, mode of arrival, reperfusion strategy (primary PCI only versus combination PCI plus fibrinolysis), and study group. In addition, we included 2 covariates that were relevant when comparing the study groups: distance (P=0.02) and sex (P=0.06). The factors independently associated with prolonged SOAR time were transfer from another facility (P<0.001), self-transportation mode of arrival at the hospital (P<0.001), allocation in the preintervention group (P=0.02), and female sex (P=0.04). The variance of SOAR times explained by this model was 25% (Table 6).

The choice of reperfusion strategy also had a significant impact on ischemic times. The median total ischemic time

Table 3. Pre- and Postintervention Temporal Outcomes Comparison

Variable	All	Preintervention	Baseline	Postintervention
Total patients, n (%)	703 (100)	169 (24)	101 (14.4)	433 (61.6)
Total ischemic time, symptom onset to arterial reperfusion, median (interquartile range)	257 (137–548)	307 (162–769)	291 (158–848)	215 (130–434)*
Door to balloon, median (interquartile range)	56 (37–83)	53 (32–110)	58 (40–177)	42 (17–69)†
Door to needle, median (interquartile range)	35 (22–55)	30 (21–49.5)	29 (21–50)	36 (22–54)

The preintervention group is the reference for comparison of baseline and postintervention groups. Data were missing for 37 patients in the preintervention group, 22 in the baseline group, and 127 in the postintervention group on the variables compared. The Mann–Whitney *U* test was used to analyze these data, and *P*<0.05 was considered statistically significant for all tests.
*P<0.001.
†P<0.01.

Table 4. Comparison of Partial Time Components by Time of Intervention in Participants Eligible for Reperfusion Strategy

Partial Time Components of Symptom Onset to Arterial Reperfusion, min	All	Preintervention	Baseline	Postintervention
Onset to first medical contact, median (interquartile range)	45 (21–105)	47 (21–104)	47 (20–142)	45 (21–95)
First medical contact to arrival at a percutaneous coronary intervention–capable facility, median (interquartile range)	36 (24–158)	128 (24–186)	118 (27–225)	33 (23–124)*
Onset to arrival, median (interquartile range)	179 (77–323)	223 (110–337)	192 (87–281)	160 (71–319)†
Arrival to hospital ECG, median (interquartile range)	50 (8–152)	112 (11–175)	98 (9–173)	31 (7–133)‡

The preintervention group is the reference for comparison of baseline and postintervention groups. Times from onset to first medical contact and from first medical contact to arrival included only patients who arrived using EMS. All patients had total time from symptom onset to arterial reperfusion reported. The Mann–Whitney U test was used to analyze these data. $P<0.05$ was considered statistically significant for all tests.
*$P=0.007$.
†$P=0.02$.
‡$P<0.001$.

was only 167 minutes (IQR 112–405 minutes) for patients with primary PCI and 375 minutes (IQR 279–825 minutes) for patients with the combination of fibrinolysis and PCI. Primary PCI had the lowest overall total ischemic time for the reperfusion strategies. Transferred patients and female patients exhibited significantly longer ischemic times, and regression confirmed that the postintervention group had significantly lower times.

Discussion

Based on the importance of regional coordination of EMS and hospitals, the 2009 American College of Cardiology and American Heart Association STEMI guidelines added a class 1 recommendation that each community develop a system of care.[2] The Mission: Lifeline Wyoming initiative is one of the largest rural systems in terms of geographic size, covering 7 states. Our results provide an opportunity to understand how to improve coordination in a large rural frontier state.

Differences in the relative frequency of transfers, excessive driving distance between patients and PCI, and mostly volunteer EMS agencies make rural systems of care complex.

Our results indicate that SOAR time can be positively affected by a statewide set of protocols, procedures, training, and technology. The routine collaboration and feedback from this partnership of >250 persons showed significant improvement in SOAR time by 92 minutes. In this rural population, however, even the postintervention group had much longer ischemic times than the recommended guideline of 120 to 180 minutes. Rural populations with low density of PCI-capable facilities provide an opportunity to establish more reasonable metrics, given long transport distances, challenging terrain, and unpredictable weather conditions. EMS utilization and reperfusion strategy (primary PCI only) were also significantly associated with SOAR times. D2N times, however, did not have similar significant improvement during the study.

The length of time that the system components have worked together is a factor for achieving and maintaining

Table 5. Referral Patterns, Arrival, and Reperfusion Strategies Used During the Study

Variable	All, n (%)	Preintervention, n (%)	Baseline, n (%)	Postintervention, n (%)
Total patients	889 (100)	206 (23)	123 (14)	560 (63)
Transfer from referral facility	548 (52)	120 (58)	77 (63)	261 (47)*
Mode of arrival				
Self	547 (61)	122 (59)	79 (64)	346 (62)
Emergency medical services	342 (39)	84 (41)	44 (36)	214 (38)
Reperfusion strategies				
Primary percutaneous coronary intervention only	490 (55)	97 (47)	60 (49)	333 (60)†
Combination percutaneous coronary intervention plus fibrinolysis	263 (30)	76 (37)	44 (36)	143 (26)†
Fibrinolysis only	52 (6)	16 (8)	12 (10)	24 (4)
Not eligible for reperfusion	84 (9)	17 (8)	7 (6)	60 (11)

The preintervention group is the reference for comparison of baseline and postintervention groups. $P<0.05$ was considered statistically significant for all tests.
*$P=0.004$.
†$P=0.002$.

Table 6. Multivariate Analyses of Associated Factors With SOAR Times for Patients Allocated to the Pre- and Postintervention Groups

Covariates	Unstandardized Coefficient β	SE	P Value
Constant	5.413	0.191	<0.001
Transfer from other facility	0.702	0.098	<0.001
Self-transport mode of arrival to hospital	−0.262	0.070	<0.001
Reperfusion strategy	0.103	0.102	0.31
Intervention group	−0.085	0.038	0.02
Distance, miles	0.000	0.000	0.05
Sex	0.165	0.080	0.04

R^2=0.25, n=602.

significant system improvements. We believe that system development takes time to overcome challenges and to fully assimilate the protocols into a cohesive system of care. Although the results of this study showed significant improvement, it will be important to continue monitoring the rural impact of the collaboration in years to come.

Reperfusion strategy also indicated significant differences in total ischemic times. More than half of the patients were treated solely with primary PCI, but 30% were treated with a combination of PCI and fibrinolysis. It is interesting to note the significant differences in temporal outcomes for the various reperfusion strategies. Although we observed longer treatment times with the combination of PCI and fibrinolysis compared with primary PCI (375 versus 167 minutes, respectively), there are several potential reasons for this difference that we did not examine for this study. It could be that these patients lived farther away or traveled greater distances and thus received the combination to salvage as much myocardium as possible. As described by Borgia et al, routine early coronary intervention after fibrinolysis is associated with a decrease in mortality and reinfarction without an increase in bleeding.[15] Consequently, we can conclude from this observational analysis only that there were differences in treatment times and that further research is needed to better understand why and how. Our future research will incorporate other explanatory variables to determine whether mortality and other outcomes were associated with the choice of reperfusion strategy.

Interestingly, sex was identified as an independent determinant of SOAR time. Women exhibited considerably prolonged SOAR times compared with their male counterparts when controlling for other relevant variables. Although differences in median SOAR times by sex were not significant in univariate analyses (277 versus 235 minutes, P=0.22), the differences observed by sex in the multivariate model could be driven by the lower number of women (25.1%) participating in the study compared with men (74.9%). Nevertheless, other important research questions remain to be answered, regardless of differences by sex. Our findings raise questions about why these differences exist: Are women less likely to be taken seriously at presentation? Is their diagnosis delayed for other reasons? Do they have less social support to be able to access the care system in a timely manner? Because only limited research exists on symptom presentation,[16] clinical characteristics, and mortality differences between sexes in coronary intervention, these issues must be explored thoroughly to improve outcomes of care.

Limitations

This study has several limitations. It was designed as a comprehensive observational study with effects measured on a pre- versus postintervention basis. The lack of randomization in the design is an inherent issue with regional systems of care. In addition, we chose to focus on total ischemic times, which are limited, at least partially, based on patient recollection of when symptoms began. We believe that this issue should not discourage researchers from focusing on this important time segment, so we sought to systematically document and measure this aspect as best we could.

Conclusions

This study showed that formal coordinated STEMI programs can be associated with improvements in treatment times, even in rural regions. The program's plans and structure may provide insight for developing other rural systems of care. The use of coordinated transfer and treatment interventions can be expected to positively affect rural treatment times despite potential barriers that are geographical, technological, communication, financial, organizational, and even political. Crossing state lines (in this case, 5 additional states) proved the importance of physician leadership in a system of care to enhance collaboration across multiple stakeholder groups. In addition, partially based on findings from the study, postprogrammatic efforts to increase public awareness of cardiac symptomatology and to promote earlier presentation and EMS utilization are potentially fruitful initiatives for improving rural cardiac care.

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Disclosures

None.

References

1. Antman EM, Anbe DT, Armstrong PW, Bates ER, Green LA, Hand M, Hochman JS, Krumholz HM, Kushner FG, Lamas GA, Mullany CJ, Ornato JP, Pearle DL, Sloan MA, Smith SC Jr, Alpert JS, Anderson JL, Faxon DP, Fuster V, Gibbons RJ, Gregoratos G, Halperin JL, Hiratzka LF, Hunt SA, Jacobs AK. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction. *Circulation*. 2004;110:e82–e292.

2. Kushner FG, Hand HM, Smith SC Jr, King SB III, Anderson JL, Antman EM, Bailey SR, Bates ER, Blankenship JC, Casey DE Jr, Green LA, Hochman JS, Jacobs AK, Krumholz HM, Morrison DA, Ornato JP, Pearle DL, Peterson ED, Sloan MA, Whitlow PL, Williams DO; American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. 2009 focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2009;120:2271–2306.

3. Henry TD, Gibson CM, Pinto DS. Moving toward improved care for the patient with ST-elevation myocardial infarction. *Circ Cardiovasc Qual Outcomes*. 2010;3:441–443.

4. Langabeer J, Prasad S, Seo M, Smith D, Segrest W, Owan T, Gerard D, Eisenhauer M. The effect of interhospital transfers, emergency medical services, and distance on ischemic time in a rural ST-elevation myocardial infarction system of care. *Am J Emerg Med*. 2015;33:913–916.

5. Danchin N. Systems of care for ST-segment elevation myocardial infarction: impact of different models on clinical outcomes. *JACC Cardiovasc Interv*. 2009;2:901–908.

6. Langabeer J, Henry T, Kereiakes D, DelliFraine J, Emert J, Wang Z, Stuart L, King R, Segrest W, Moyer P, Jollis J. Growth in percutaneous coronary intervention capacity relative to population and disease prevalence. *J Am Heart Assoc*. 2013;2:e000370 doi: 10.1161/JAHA.113.000370.

7. Jollis JG, Roettig M, Aluko A, Anstrom K, Applegate RJ, Babb JD, Berger P, Bohle DJ, Fletcher S, Garvey L, Hathaway WR, Hoekstra JW, Kelly RV, Maddox W, Shiber J, Valeri S, Watling BA, Wilson BH, Granger C; for the Reperfusion of Acute Myocardial Infarction in North Carolina Emergency Departments (RACE) Investigators. Implementation of a statewide system for coronary reperfusion for ST-segment elevation myocardial infarction. *JAMA*. 2007;298:2371–2380.

8. Henry TD, Sharkey SW, Burke MN, Chavez IJ, Graham KJ, Henry CR, Lips DL, Madison JD, Menssen KM, Mooney MR, Newell MC, Pedersen WR, Poulose AK, Traverse JH, Unger BT, Wang YL, Larson DM. A regional system to provide timely access to percutaneous coronary intervention for ST-elevation myocardial infarction. *Circulation*. 2007;116:721–728.

9. Jacobs AK, Antman EM, Faxon D, Gregory T, Solis P. Development of systems of care for ST-elevation myocardial infarction patients: executive summary. *Circulation*. 2007;116:217–230.

10. Jollis J, Granger C, Henry TD, Antman EM, Berger P, Moyer P, Pratt F, Rokos I, Acuna AR, Roettig M, Jacobs AK. Systems of care for ST-segment-elevation myocardial infarction: a report from the American Heart Association's Mission: Lifeline. *Circ Cardiovasc Qual Outcomes*. 2012;5:423–428.

11. Bagai A, Al-Khalidi HR, Sherwood MW, Munoz D, Roettig M, Jollis J, Granger C. Regional systems of care demonstration project: Mission: Lifeline STEMI Systems Accelerator: design and methodology. *Am Heart J*. 2014;167:15–21.e3.

12. Denktas A, Athar H, Henry TD, Larson D, Simons M, Chan R, Niles NW, Thiele H, Schuler G, Ahn C, Sdringola S, Anderson HV, McKay RG, Smalling RW. Reduced-dose fibrinolytic acceleration of ST-segment elevation myocardial infarction treatment coupled with urgent percutaneous coronary intervention compared to primary percutaneous coronary intervention alone results of the AMICO (Alliance for Myocardial Infarction Care Optimization) Registry. *JACC Cardiovasc Interv*. 2008;1:504–510.

13. DelliFraine J, Langabeer J, Segrest W, Fowler R, King R, Moyer P, Henry TD, Koenig W, Warner J, Stuart L, Griffin R, Fathiamini S, Emert J, Roettig ML, Jollis J. Developing an ST-elevation myocardial infarction system of care in Dallas County. *Am Heart J*. 2013;165:926–931.

14. Denktas AE, Anderson HV, McCarthy J, Smalling RW. Total ischemic time: the correct focus of attention for optimal ST-segment elevation myocardial infarction care. *JACC Cardiovasc Interv*. 2011;4:599–604.

15. Borgia F, Goodman SG, Halvorsen S. Early routine percutaneous coronary intervention after fibrinolysis vs. standard therapy in ST-segment elevation myocardial infarction: a meta-analysis. *Eur Heart J*. 2010;31:2156–2169.

16. Jacobs AK. Coronary intervention in 2009: are women no different than men? *Circ Cardiovasc Interv*. 2009;2:69–78.

SUPPLEMENTAL MATERIAL

Data S1: Mission: Lifeline Wyoming ER Diagnostic and Treatment Protocol

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ER physician to activate transport as early as possible and notify receiving hospital.

A. To be completed by physician:

   Type of MI: _____;   **Heart rhythm:** _____;

   Most severe/recent chest pain / equivalent onset: ____ **hours ago;   Allergies:** _____;

   Patient already taking: Plavix Y/N;   Effient Y/N;   Brilinta Y/N;

   Coumadin Y/N;   Pradaxa Y/N;   Xarelto Y/N;   Eliquis Y/N

B. To be completed by RN:

   Estimated weight = _____ kg; **BP** = _____ / _____ mmHg; **HR** = _____ bpm; **O2 saturation** = _____ %;

   □ if SaO$_2$ <90% give **oxygen** 2 L NC;   □ x2 IV **lines** (prefer both on L upper extremity) and **NS** 75 ml/h;

   □ **Labs:** CBC, CMP, troponin, PT/INR;   □ **Defibrillator pads** (A/P placement);

C. Physician to check initial medications.   RN to write or circle dosage and time medications given, and to sign:

Medication (unless contraindicated. If not given write reason)	MD	Dose	Time	RN Signature
***ALL PATIENTS* must receive:**				
1. **Aspirin** (if given by EMS write "EMS")		4 baby Aspirin (81mg, 324mg total) chewed		
2. **Heparin** bolus: 60 Units/kg IV (**maximum 4,000Units**) **and** drip: 12 Units/kg/hour IV (**maximum 1,000 Units/hour**) ***NOTE: Please be aware that ground EMS Crew may not be able to transport heparin drip based on scope of practice***		Units Units/hour		
***THROMBOLYSIS*:**				
Exceptions: Primary PCI possible (see below), contraindication to thrombolysis, cardiogenic shock.				
1. **TNK** Absolute contraindication.: known structural cerebral vascular lesions, known malignant intracranial neoplasm, ischemic stroke within 3 months (and more than 3h ago) suspect aortic dissection, Active bleeding/bleeding diathesis, close head trauma within 3months; also revise relative contraindications.		<60 kg – 30 mg IV, 60-69 kg – 35mg IV, 70-79 kg – 40 mg IV, 80-89 kg – 45 mg IV, >90 kg – 50 mg IV		
2. **Plavix** **If age less than 75 years old**, give dose of		300 mg PO		
If age 75 or greater, give dose of		75 mg PO		
***PRIMARY PCI*:**				
If door to balloon ≤120 minutes (desired door in/door out less than 30 minutes with less than 60 minute transport to PCI). Consider thrombolysis if chest pain onset 2 hours ago.				
1. **Brilinta** If no history of intracranial hemorrhage or ongoing bleeding and no heart blocks **OR**		180 mg PO		
2. **Plavix** If Brilinta is unavailable or contraindicated		600 mg PO		
Additional medications if needed either for Thrombolysis or Primary PCI				
1. **Nitroglycerin** 0.4mg sublingual (may repeat x 2, every 5 min, if SBP > 100 mmHg and if drip has not been initiated) and consider a drip (start 10 mcg/min, increase gradually per need) Absolute contraindication: If BPs less than 100 mmHg (or BPs more than 30mmHg below baseline), if HR less than 50 bpm, if HR more than 100 bpm, RV infarction (need right precordial ECG for inferior MI), recent phosphodiesterase inhibitors ***NOTE: Please be aware that ground EMS Crew may not be able to transport nitroglycerin drip based on scope of practice*** Repeat sublingual dosing is acceptable per transfer protocol				
2. **Metoprolol** 5 mg IV (x3 doses, one dose every 10 min) (verify BP & HR before each dose) Absolute contraindication: BPs less than 120 mmHg, if HR less than 60, if HR more than 110, AV block (starting w PR more than 240ms), crackles, gallop - S3, reactive airway disease				
3. **Morphine** 2 mg IV per dosage in increments				
4. Other medications:				

Copy of this protocol, labs and timing sheet: □sent with patient; □faxed to PCI receiving physician

ER physician signature _____; date/time: _____

                                                                           Patient sticker

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