# Emergency Department Bypass for ST-Segment–Elevation Myocardial Infarction Patients Identified With a Prehospital Electrocardiogram

## A Report From the American Heart Association Mission: Lifeline Program

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***Background***—For patients identified before hospital arrival with ST-segment–elevation myocardial infarction, bypassing the emergency department (ED) with direct transport to the catheterization laboratory may shorten reperfusion times.

***Methods and Results***—We studied 12 581 ST-segment–elevation myocardial infarction patients identified with a prehospital ECG treated at 371 primary percutaneous coronary intervention–capable US hospitals participating in the Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With The Guidelines, including those participating in the American Heart Association Mission: Lifeline program from 2008 to 2011. Reperfusion times with primary percutaneous coronary intervention and in-hospital mortality rates were compared between patients undergoing ED evaluation and those bypassing the ED. ED bypass occurred in 1316 patients (10.5%). These patients had a lower frequency of heart failure and shock on presentation and nonsystem reasons for delay in percutaneous coronary intervention. ED bypass occurred more frequently during working hours compared with off-hours (18.3% versus 4.3%); ED bypass rate varied significantly across hospitals (median, 3.3%; range, 0%–71%). First medical contact to device activation time was shorter (median, 68 minutes [interquartile range, 54–85 minutes] versus 88 minutes [interquartile range, 73–106 minutes]; $P<0.0001$) and achieved within 90 minutes more frequently (80.7% versus 53.7%; $P<0.0001$) with ED bypass. The unadjusted in-hospital mortality rate was lower among ED bypass patients (2.7% versus 4.1%; $P=0.01$), but the adjusted mortality risk was similar (adjusted odds ratio, 0.69; 95% confidence interval, 0.45–1.03; $P=0.07$).

***Conclusions***—Among ST-segment–elevation myocardial infarction patients identified with a prehospital ECG, the rate of ED bypass varied significantly across US hospitals, but ED bypass occurred infrequently and was mostly isolated to working hours. Because ED bypass was associated with shorter reperfusion times and numerically lower mortality rates, further exploration of and advocacy for the implementation of this process appear warranted. **(*Circulation*. 2013;128:352-359.)**

**Key Words:** emergency service, hospital ■ myocardial infarction ■ reperfusion

The American College of Cardiology Foundation/American Heart Association (ACCF/AHA) ST-segment–elevation myocardial infarction (STEMI) guidelines recommend that device activation should occur within 90 minutes of first medical contact (FMC) by emergency medical service (EMS) providers for STEMI patients transported to a hospital capable of performing primary percutaneous coronary intervention (PCI).[1] Several strategies are recommended to optimize and shorten reperfusion times, including the use of prehospital ECGs and direct transport to a PCI-capable hospital while bypassing a hospital without PCI capabilities.[1–4] Furthermore, expecting PCI-capable hospitals to have their catheterization laboratories ready within 20 to 30 minutes of activation for a primary PCI procedure has synergistic effects on both emergency department (ED) and catheterization laboratory processes and is associated with a shorter ED evaluation phase before transport to the catheterization laboratory.[5] Along this spectrum, the recently updated 2012 European Society of Cardiology STEMI guidelines state that in the optimal situation, STEMI patients diagnosed with a prehospital ECG should be directly transported to the catheterization laboratory of a PCI-capable hospital, thereby bypassing the ED.[6] This recommendation however, was not endorsed in the updated 2013 ACCF/AHA STEMI guidelines, likely reflecting the lack of feasibility, efficacy, and safety data for this practice in the United States.[1]

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Editorial see p 322
Clinical Perspective on p 359

We evaluated the contemporary use of ED bypass at hospitals participating in the National Cardiovascular Data Registry (NCDR) Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With The Guidelines (ACTION Registry–GWTG), including those participating in the AHA Mission: Lifeline program to delineate the uptake of this strategy in the United States, as well as its impact on reperfusion times for STEMI patients undergoing primary PCI. We also evaluated patient and hospital factors associated with ED bypass and investigated the association of ED bypass with in-hospital mortality rates.

## Methods

All patients admitted with STEMI from the ACTION Registry–GWTG from July 1, 2008, to March 31, 2011, were included in the initial study population because this time frame encompassed revisions to the data collection form designed to capture expanded data elements of prehospital treatments and evaluation. The ACTION Registry–GWTG serves as a hospital data collection and evaluation mechanism for the AHA's Mission: Lifeline program and has been described previously.[7] A diagnosis of STEMI was defined as persistent ST-segment elevation ≥1 mm in ≥2 contiguous ECG leads or an STEMI equivalent such as a new or presumed new left bundle-branch block or an isolated posterior MI. All participating institutions were required to comply with local regulatory and privacy guidelines and, if required, to secure institutional review board approval. Because data were used primarily at the local site for quality improvement, sites were granted a waiver of informed consent under the common rule. The Duke Clinical Research Institute serves as the data analysis center and has an agreement to analyze the aggregate de-identified data for research purposes.

### Analysis Population

For this analysis, we focused on patients with a prehospital ECG diagnosis of STEMI who were transported by EMS directly to a PCI-capable hospital for ultimate treatment with primary PCI. Therefore, among 83 461 STEMI patients enrolled in ACTION Registry–GWTG during the study period, we excluded patients who did not receive primary PCI (n=22 380), those who did not arrive directly at a PCI-capable hospital (n=17 297), those who did not receive a prehospital ECG (n=26 761), those who did not have ST-elevation or ST-elevation equivalents (left bundle-branch block or isolated posterior MI) on the first prehospital ECG (ie, were diagnosed as STEMI on a subsequent ECG performed after hospital arrival; n=1978), and those who did not arrive at a hospital by EMS (ie, self-transporters; n=923). Patients were further excluded because of the use of a short data collection form that did not include critical prehospital variables (n=1321), first evaluation at a location other than a catheterization laboratory or ED (n=46), missing information on location of first evaluation (n=10), missing information on time of FMC (n=85) or time of device activation (n=9), time interval from hospital arrival to PCI recorded as 0 minutes (n=1), time interval from hospital arrival to device activation >6 hours (n=49), and time interval from FMC to device activation (FMC-to-device) >6 hours (n=20). The final study population thus consisted of 12 581 patients with a prehospital STEMI diagnosis transported directly by EMS to 1 of 371 PCI-capable hospitals for primary PCI. Patients whose first evaluation was in the catheterization laboratory (ED bypass) were compared with patients whose first evaluation was in the ED (ED evaluation).

### Statistical Analysis

Descriptive statistics were summarized as medians with interquartile ranges for continuous variables and as percentages for categorical variables. Differences between groups were compared by use of Wilcoxon tests for continuous variables and Pearson $\chi^2$ tests for categorical variables.

### Temporal Trends in the Use of ED Bypass

Yearly temporal trends in the use of ED bypass were determined from July 1, 2008, to March 31, 2011. Because ED bypass cannot be performed without prehospital use of EMS or ECGs, temporal trends in the use of EMS transport and prehospital ECG use among patients transported by EMS were also determined. For each calendar year (2008, 2009, 2010, and 2011), we evaluated the proportion of STEMI patients arriving at a hospital by EMS transport from the overall STEMI population included in the database for the calendar year. Next, among STEMI patients arriving at a hospital by EMS transport, the proportion of patients with the first ECG performed before hospital arrival (versus after hospital arrival) was determined. Finally, among STEMI patients identified via prehospital ECG who arrived directly at a PCI-capable hospital by EMS, we determined the yearly proportion of patients bypassing the ED with the first evaluation occurring in the catheterization laboratory.

### Hospital Variability and Factors Associated With ED Bypass

We determined variability in the use of ED bypass across hospitals by determining the proportion of patients with ED bypass at each hospital. For this analysis, only hospitals with at least 25 patients in the study cohort were included (144 of 371 hospitals). Then, the impact of the time of presentation (hospital arrival time) on the decision for ED bypass was determined by comparing the proportion of ED bypass patients during working hours versus off-hours. Working hours were characterized as 7:01 AM to 6 PM from Mondays to Fridays. Off-hours were characterized as 6:01 PM to 7 AM from Mondays to Fridays, all times on Saturdays and Sundays, and the 24-hour period for all US national holidays. Hierarchical logistic regression with hospital as a random effect was then used to determine factors independently associated with ED bypass (versus ED evaluation). A hierarchical model was used to account for site confounding because hospitals have different practices regarding ED bypass. Patient factors tested in the model included demographics (age, sex, race, weight), medical history (diabetes mellitus, hypertension, dyslipidemia, current/recent smoking, peripheral artery disease, MI, PCI, coronary artery bypass grafting, heart failure, stroke), home medications, insurance status, and presentation features (heart rate, systolic blood pressure, heart failure, shock, time from FMC to hospital arrival, and time of presentation [working hours versus off-hours]). The hospital factors that were considered included region, teaching status, onsite coronary artery bypass grafting capability, number of hospital beds, and number of primary PCIs performed per year. Proportions of missing values were <0.6% across all variables. Missing categorical variables were imputed to the most frequent value; missing continuous variables were imputed to the median of the nonmissing values. Backward selection was used to identify significant variables at a critical level of 0.05. Model validation was not performed. Results are presented as odds ratios with 95% confidence intervals.

### Timing of Reperfusion Therapy

The FMC-to-device time and the proportion of patients with FMC-to-device time within 90 minutes were compared between the 2 groups. As defined by the ACTION Registry–GWTG data dictionary, time of device activation referred to the time the first intracoronary device was activated, regardless of the type of device used. If the lesion could not be crossed with a guidewire or a device could not be activated (and therefore none of the above apply), the time of device activation was defined as the time of guidewire introduction. The median time from ED arrival to catheterization laboratory arrival (time in the ED) was also determined for ED evaluation patients. As a sensitivity analysis, treatment time intervals were compared between the 2 groups after the exclusion of high-risk patients with heart failure or shock on presentation, as well as those with site-reported nonsystem reasons for delay in PCI (n=2630). Nonsystem reasons for delay in PCI were defined and categorized as difficult vascular access, cardiac arrest or intubation before PCI, patient delays in providing consent for the procedure, and difficulty crossing the culprit lesion during the PCI procedure.[8] Treatment time intervals were also compared between the 2 groups stratified by presentation during working hours versus off-hours.

### In-Hospital Clinical Outcomes

All-cause in-hospital mortality was compared between ED bypass and ED evaluation patients. Hierarchical logistic regression with hospital as a random effect was performed to compare in-hospital mortality between the 2 groups using a validated, published in-hospital mortality model from the ACTION Registry–GWTG.[9] In addition to those established variables, we included the time from FMC to hospital arrival and the day and time of presentation (expressed as working hours versus off-hours, as previously defined) as variables in the model for this analysis. Adjusted odds ratios are reported with 95% confidence intervals. This analysis was repeated after the exclusion of patients with heart failure or shock on presentation and patients with nonsystem reasons for delay in PCI because we expected that these patients would typically require ED evaluation owing to their high-risk features and likely need for urgent clinical evaluation and stabilization before transfer to the cardiac catheterization laboratory.[8] A value of $P<0.05$ was considered significant for all tests, and results need to be interpreted in the context of multiple testing, consistency, and plausibility. All statistical analyses were performed by the Duke Clinical Research Institute with SAS software (version 9.2; SAS Institute, Cary, NC).

## Results

### Temporal Trends in the Use of ED Bypass

During the entire time period of analysis, ED evaluation occurred in 11 265 patients (89.5%), whereas ED bypass occurred in 1316 patients (10.5%). The use of ED bypass increased from 8.5% in 2008 to 11.5% in 2011. Meanwhile, the proportion of the overall STEMI population transported by EMS remained unchanged at ≈50%, but the use of prehospital ECGs among EMS-transported patients increased from 47% to 55% during the same time period (Figure 1).

### Baseline Characteristics, Hospital Variation, and Factors Associated With ED Bypass

Demographic and clinical characteristics of the patients are presented in Table 1. ED bypass patients were less likely to have had a prior MI, heart failure, or cardiogenic shock on presentation. Nonsystem reasons for delays in PCI were more frequently documented among ED evaluation patients. ED bypass occurred more frequently during working hours compared with off-hours (18.3% versus 4.3%). Figure 2 displays the significant variability in ED bypass rates across hospitals, ranging from 0% to 71.0% (median, 3.3% [interquartile range, 0%–14.9%]). Presentation during working hours and the time from FMC to hospital arrival were the variables most strongly associated with ED bypass (Table 2).

### Reperfusion Times and Time Components

The time from FMC to hospital arrival was longer with ED bypass, but the median FMC-to-device time was 20 minutes shorter compared with ED evaluation (68 minutes [interquartile range, 54–85 minutes] versus 88 minutes [interquartile range, 73–106 minutes]; $P<0.0001$) and was more frequently achieved within 90 minutes (80.7% versus 53.7%; $P<0.0001$; Table 3 and Figure 3). Among ED evaluation patients, the median time in the ED was 30 minutes (25th and 75th percentiles, 20 and 42 minutes). After the exclusion of high-risk patients with heart failure or shock on presentation and those with documented nonsystem reasons for delay in PCI, the median FMC-to-device time remained shorter (67 minutes [interquartile range, 54–84 minutes] versus 86 minutes [interquartile range, 72–102 minutes]; $P<0.0001$) and was achieved within 90 minutes more frequently (82.2% versus 58.5%; $P<0.0001$) among ED bypass patients.

The proportion of patients with FMC-to-device time within 90 minutes was higher among ED bypass patients both during working hours (84.2% versus 68.9%; $P<0.0001$) and during off-hours (69.0% versus 43.5%; $P<0.0001$; Table 3). Among ED evaluation patients, the median time in the ED was greater during off-hours (36 minutes [interquartile range, 26–47 minutes]) compared with working hours (22 minutes [interquartile range, 14–31 minutes]).

### In-Hospital Clinical Outcomes

The unadjusted in-hospital mortality rate was lower among ED bypass patients (2.7% versus 4.1%; $P=0.01$); however, the adjusted risk of mortality was similar between the 2 groups (adjusted odds ratio, 0.69; 95% confidence interval, 0.45–1.03; $P=0.07$). After the exclusion of patients with heart failure or shock on presentation and those with documented nonsystem reasons for delay, the adjusted risk of mortality was similar (adjusted odds ratio, 0.66; 95% confidence interval, 0.33–1.31; $P=0.24$).

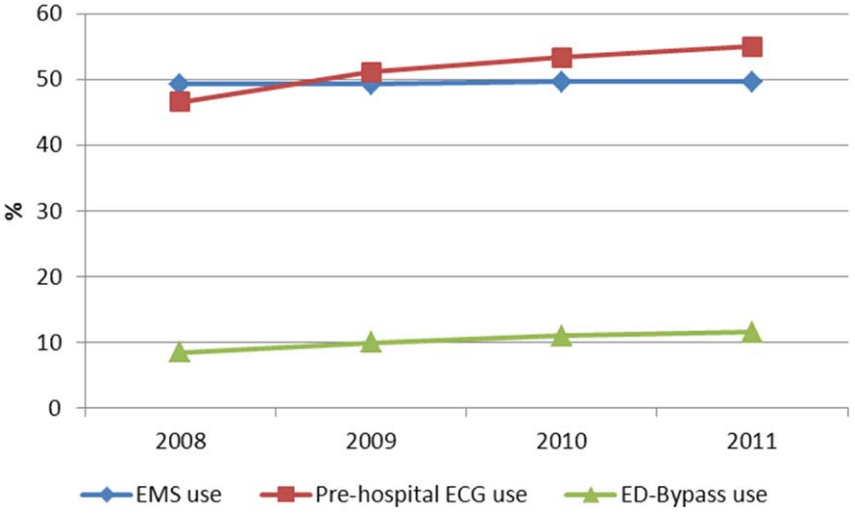


**Figure 1.** Temporal trends in use of emergency medical services (EMS), prehospital ECGs, and emergency department (ED) bypass. EMS use indicates the proportion of ST-segment–elevation myocardial infarction (STEMI) patients arriving at the hospital by EMS transport from the overall STEMI population. Prehospital ECG use indicates the proportion of patients with the first ECG performed before hospital arrival (vs after hospital arrival) among STEMI patients arriving at the hospital by EMS transport. ED bypass use indicates the proportion of patients bypassing the ED with the first evaluation occurring in the catheterization laboratory among STEMI patients identified via prehospital ECG transported directly to a percutaneous coronary intervention–capable hospital by EMS.

**Table 1. Demographic and Clinical Characteristics of the Study Population**

| | ED Evaluation (n=11 265) | ED Bypass (n=1316) | *P* Value |
|---|---|---|---|
| Demographics | | | |
| Age, y | 60 (52, 70) | 60 (52, 69) | 0.52 |
| Female sex, % | 28.7 | 27.1 | 0.23 |
| Race, % | | | 0.001 |
| White | 83.8 | 87.9 | |
| Black | 9.0 | 7.0 | |
| Other | 6.5 | 4.6 | |
| Weight, kg | 84 (73, 98) | 84 (73, 98) | 0.79 |
| Insurance, % | | | 0.004 |
| Private/HMO | 58.2 | 54.4 | |
| Medicare | 19.2 | 22.5 | |
| Military/VAHP | 1.8 | 2.3 | |
| Medicaid | 4.1 | 3.7 | |
| Self/none | 15.7 | 16.8 | |
| Medical history, % | | | |
| Diabetes mellitus | 20.3 | 19.9 | 0.75 |
| Hypertension | 61.9 | 58.0 | 0.006 |
| Dyslipidemia | 53.2 | 54.2 | 0.49 |
| Current/recent smoker | 46.9 | 44.8 | 0.13 |
| Currently on dialysis | 0.7 | 0.5 | 0.37 |
| Prior myocardial infarction | 20.3 | 16.2 | 0.001 |
| Prior heart failure | 4.0 | 3.1 | 0.11 |
| Prior PCI | 22.3 | 20.4 | 0.12 |
| Prior CABG | 5.4 | 5.2 | 0.69 |
| Prior stroke | 4.4 | 4.6 | 0.74 |
| Peripheral arterial disease | 4.8 | 4.8 | 0.95 |
| Atrial fibrillation or flutter | 3.7 | 2.9 | 0.14 |
| Presentation characteristics | | | |
| ECG findings, % | | | 0.002 |
| ST elevation | 98.6 | 99.6 | |
| Left bundle-branch block | 0.9 | 0.2 | |
| Isolated posterior MI | 0.5 | 0.1 | |
| Heart rate, bpm | 76 (62, 90) | 76 (62, 89) | 0.99 |
| Systolic blood pressure, mm Hg | 132 (112, 153) | 136 (116, 153) | 0.01 |
| Heart failure, % | 6.7 | 4.0 | 0.0002 |
| Cardiogenic shock, % | 9.4 | 6.9 | 0.003 |
| Nonsystem reasons for delay in PCI* % | 12.3 | 5.9 | <0.0001 |
| Creatinine, mg/dL | 1.0 (0.9, 1.2) | 1.0 (0.8, 1.1) | <0.0001 |
| Troponin ratio, baseline (×ULN) | 0.6 (0.1, 3.7) | 7.5 (0.7, 64.1) | <0.0001 |
| Peak cardiac marker values | | | |
| Troponin ratio, peak (×ULN) | 154 (36, 592) | 173 (41, 586) | 0.22 |
| CK-MB ratio, peak (×ULN) | 24 (9, 48) | 22 (8, 46) | 0.06 |
| Hospital characteristics | | | |
| Region, % | | | <0.0001 |
| West | 17.4 | 13.8 | |
| Northeast | 6.0 | 3.3 | |
| Midwest | 25.5 | 18.6 | |
| South | 51.1 | 64.3 | |
| CABG on site, % | 92.0 | 97.6 | <0.0001 |
| Academic status, % | 24.7 | 21.2 | 0.004 |
| Hospital beds, n | 411 (313, 621) | 501 (332, 730) | <0.0001 |

Data are presented as percentages or median (25th, 75th percentiles). CABG indicates coronary artery bypass grafting; CK-MB, creatine kinase-MB; ED, emergency department; HMO, health maintenance organization; LVEF, left ventricular ejection fraction; MI, myocardial infarction; PCI, percutaneous coronary intervention; ULN, upper limit of normal, and VAHP, Veteran's Affairs Health Plan.

*Nonsystem reasons for delay in PCI include difficult vascular access, cardiac arrest, need for intubation before PCI, patient delays in providing consent for the procedure, difficulty crossing the culprit lesion during the PCI procedure, and other.

## Discussion

We have demonstrated that in contemporary US practice, ED bypass for patients with STEMI identified with a prehospital ECG and transported by EMS to a PCI-capable hospital occurs infrequently, with most patients evaluated in the ED before transport to the catheterization laboratory for primary PCI. Nevertheless, we observed several novel findings: (1) substantial variability across hospitals in the use of ED bypass, (2) a very strong influence of presentation during working hours on the use of ED bypass, (3) a significant shortening of reperfusion times and improvement in the achievement of reperfusion quality benchmarks with ED bypass, and (4) no adverse impact of ED bypass on in-hospital mortality rates.

Unlike the recently updated ACCF/AHA STEMI guidelines,[1] the updated European Society of Cardiology STEMI guidelines[6] give a new but cautious recommendation (*Class IIa*; *Level of Evidence, B*) for ED bypass for STEMI patients identified with a prehospital ECG as a strategy to optimize timely reperfusion. Although ED bypass rates across European countries have not been reported publicly, anecdotal evidence and experience with conducting STEMI clinical trials in the prehospital setting suggest that ED bypass is performed more frequently at European hospitals. Some reasons for these differences may include the frequent staffing of ambulances with physicians in many European countries, integrated EMS networks within single nationalized healthcare systems, more robust information technology infrastructure to allow digital transmission of prehospital ECGs for physician overread, and concentration of primary PCI procedures at highly experienced regional centers with high annual primary PCI volumes. In contrast, the treatment paradigm for STEMI care is quite different in the United States, with multiple, separate EMS providers across healthcare systems, no physician staffing in ambulances, larger and more diverse geographic areas and terrain, lack of consistent information technology infrastructure

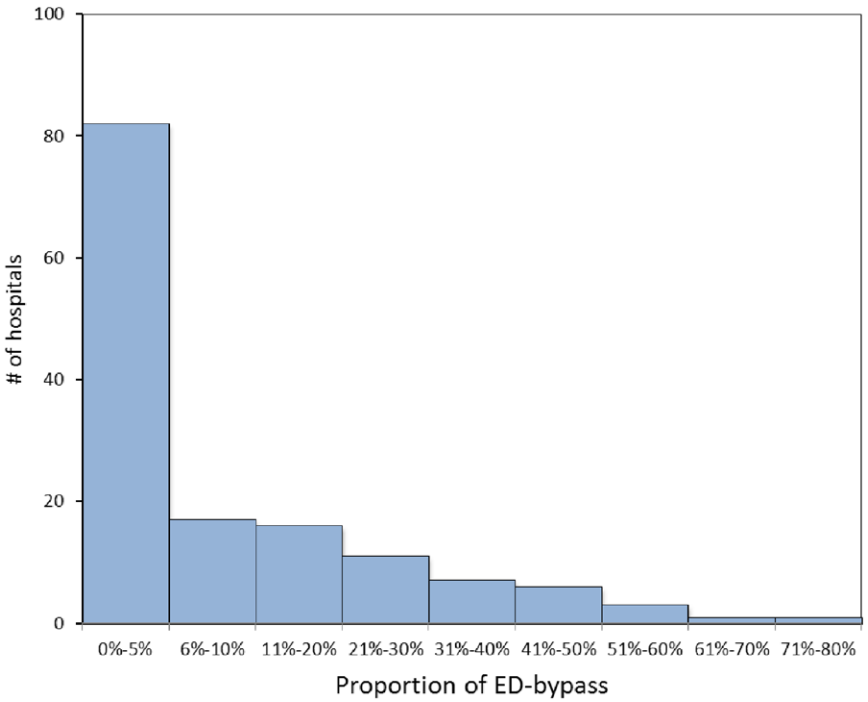


**Figure 2.** Distribution by hospital emergency department (ED) bypass rate. For this analysis, only hospitals with >25 patients were included (n=144).

to support the routine digital transmission of ECGs for physician overread to minimize false catheterization laboratory activations, and the dispersal of primary PCI services across a much larger number of hospitals on a per-capita basis compared with Europe.

Despite the differences in STEMI care and guidelines between the United States and Europe, recently published single-center experience indicates that ED bypass can be performed reliably and safely in the United States when there is a substantial institutional and physician commitment to adopt this process.[10] Although we observed significant variation in the use of ED bypass across hospitals in the United States, a small number of hospitals used ED bypass in >50% of their STEMI patients. Presentation during working hours appeared to most strongly influence the use of ED bypass, a finding that is likely explained by the proximity and availability of the primary PCI team when the hospital is first notified of the incoming STEMI patient by EMS. Most hospitals in the United States do not have primary PCI teams immediately available on site during off-hours and have inherent delays in the arrival of team members to the catheterization laboratory in this setting. Therefore, STEMI patients presenting during off-hours are usually triaged to wait in the ED until the catheterization laboratory team arrives and is ready to receive them.

**Table 2. Factors Significantly Associated With ED Bypass**

| Variable | $\chi^2$ | OR (95% CI) | *P* Value |
|---|---|---|---|
| Presentation during working hours | 626.3 | 7.58 (6.47–8.89) | <0.0001 |
| First medical contact to hospital arrival time (per 5-min increase) | 245.0 | 1.18 (1.16–1.20) | <0.0001 |
| Age | 18.5 | | <0.0001 |
| Age <65 y (per 5-y increase) | | 1.02 (0.98–1.08) | 0.34 |
| Age ≥65 y (per 5-y increase) | | 0.87 (0.82–0.93) | <0.0005 |
| On-site CABG capabilities | 10.6 | 3.91 (1.72–8.91) | 0.001 |
| Hypertension | 7.8 | 0.81 (0.70–0.94) | 0.005 |
| Cardiogenic shock at presentation | 4.6 | 0.76 (0.59–1.00) | 0.047 |

Model c index=0.92. The estimated variance of the hospital intercepts was 2.5 with an SE of 0.3 ($P$<0.0001), indicating that there was a significant hospital effect on ED bypass. Patient factors that were evaluated but found to not be significant included sex, race, weight, heart rate, smoking status, systolic blood pressure, heart failure at presentation, history of diabetes mellitus, peripheral artery disease, dyslipidemia, previous myocardial infarction, previous percutaneous coronary intervention, previous CABG, previous heart failure, previous stroke, home medications, and insurance status. Hospital factors that were evaluated but found not to be significant included region, teaching status, total number of beds, and number of primary percutaneous coronary intervention procedures per year. CABG indicates coronary artery bypass surgery; CI, confidence interval; ED, emergency department; and OR, odds ratio.

The factors shown to influence the use of ED bypass notwithstanding, our study demonstrated a median 20-minute-faster FMC-to-device time for patients undergoing primary PCI who bypass the ED. This was observed despite longer FMC-to-hospital-arrival duration among ED bypass patients, a finding likely explained by the increased likelihood of catheterization laboratory readiness to perform ED bypass for patients with longer prehospital transport times. Similar findings of shorter FMC-to-device times have also been observed with ED bypass in single-center studies.[10–13] As a result, our findings are consistent and noteworthy when considered in the context of the previously published relative impact of the implementation of the Door-to-Balloon Alliance recommendations on door-to-balloon times for patients with STEMI identified after hospital presentation (14-minute reduction)[14] and the impact of prehospital ECG performance on door-to-balloon times (14-minute reduction).[15] The median 20-minute reduction in FMC-to-device time with ED bypass demonstrated in this analysis provided further incremental reduction in reperfusion times, contributed to a substantial improvement

**Table 3. Reperfusion Time Intervals**

| | ED Evaluation | ED Bypass | *P* Value |
|---|---|---|---|
| Overall | | | |
| FMC to hospital arrival,* min | 30 (24, 39) | 39 (29, 53) | <0.0001 |
| ED arrival to catheterization laboratory arrival, min | 30 (20, 42) | … | … |
| Catheterization laboratory arrival to device activation, min | 24 (18, 31) | 23 (17, 30) | <0.0001 |
| FMC-to-device, min | 88 (73, 106) | 68 (54, 85) | <0.0001 |
| FMC-to-device ≤90 min, % | 53.7 | 80.7 | <0.0001 |
| Working hours | | | |
| FMC to hospital arrival,* min | 30 (23, 38) | 37 (28, 49) | <0.0001 |
| ED arrival to catheterization laboratory arrival, min | 22 (14, 31) | … | … |
| Catheterization laboratory arrival to device activation, min | 23 (18, 31) | 22 (17, 29) | 0.0002 |
| FMC-to-device, min | 78 (65, 95) | 65 (52, 81) | <0.0001 |
| FMC-to-device ≤90 min, % | 68.9 | 84.2 | <0.0001 |
| Off-hours | | | |
| FMC to hospital arrival,* min | 31 (24, 39) | 48 (34, 62) | <0.0001 |
| ED arrival to catheterization laboratory arrival, min | 36 (26, 47) | … | … |
| Catheterization laboratory arrival to device activation, min | 24 (18, 32) | 24 (17, 34) | 0.96 |
| FMC-to-device, min | 94 (80, 111) | 79 (65, 95) | <0.0001 |
| FMC-to-device ≤90 min, % | 43.5 | 69.0 | <0.0001 |

Time intervals reported as medians (25th, 75th percentiles). ED indicates emergency department; FMC, first medical contact; and FMC-to-device, FMC to device activation.

*Hospital arrival refers to ED arrival for patients evaluated in the ED and to catheterization laboratory arrival for patients bypassing the ED.

in the achievement of reperfusion quality benchmarks (FMC-to-device time ≤90 minutes), and may be associated with improvements in mortality. However, the impact of ED bypass on mortality can be accurately determined only in a sufficiently sized, randomized study that could be designed on the basis of the relative treatment effect of ED bypass identified in our study.[16,17]

Before ED bypass can be more widely adopted across the United States as a strategy to reduce reperfusion times for patients with STEMI identified on a prehospital ECG, certain factors require consideration and discussion. First, over the 4-year time period studied, only half of patients with STEMI presenting to US hospitals were transported by EMS with no temporal changes observed. Although it is encouraging to observe a modest increase in the use of prehospital ECGs among EMS-transported patients, only slightly more than 50% of EMS-transported patients had a prehospital ECG performed in 2011. Factors associated with the low use of EMS for STEMI patients in the US have been investigated, but creative approaches are needed to further increase the use of EMS services for patients with ischemic symptoms and the use of prehospital ECGs among EMS providers.[18] Second, given the concerns regarding false activation of the catheterization laboratory for suspected STEMI patients, highly trained paramedics and better infrastructure to support the transmission of prehospital ECGs are needed.[19,20] Third, reliable triage protocols are needed to guide EMS providers to accurately identify patients who should be triaged for initial ED evaluation and

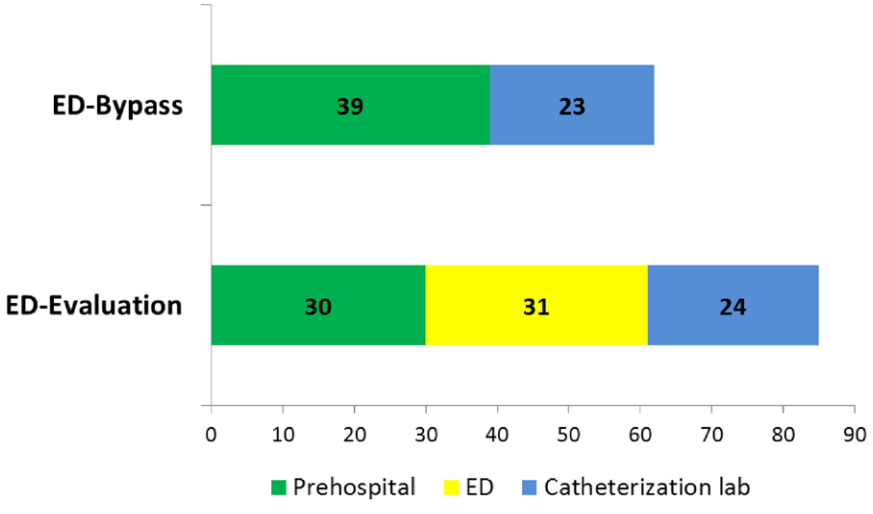


**Figure 3.** Time components of first medical contact to device activation (FMC-device). Median times are listed; the sum of components may not equal median FMC-to-device time. ED indicates emergency department.

stabilization such as those with prehospital cardiac arrest, cardiogenic shock, severe heart failure, or respiratory failure. Yet, despite concerns that ED bypass may be dangerous because of these factors, we observed no adverse impact of ED bypass on in-hospital mortality rates in this initial experience. This finding suggests that appropriate triage protocols for ED bypass are already being used by front-line clinicians and generally select more stable STEMI patients who arrive during working hours. Finally, the risk of performing ED bypass during off-hours when the primary PCI team may still be in transit to the hospital should not be overlooked but may be mitigated by developing overlapping in-house care team coverage for the time period of initial patient arrival.[21] Despite these challenges, the next phase for the implementation and optimization of STEMI systems of care across the United States should have a specific focus on ED bypass within the context of the aforementioned issues.

### Limitations

Several limitations merit consideration in the interpretation of our study. First, the data are nonrandomized and therefore are subject to unmeasured confounding and bias. Second, the decision to bypass the ED appears to be influenced by the time of day, treatment hospital, and patient stability; therefore, it is possible that part of the difference in reperfusion timing in favor of patients bypassing the ED may be related to these factors. It is reassuring, however, that reperfusion times were shorter among patients bypassing the ED during both working and off-hours, as well as after the exclusion of patients with nonsystem reasons for delay and heart failure or cardiogenic shock on presentation. Third, other factors that may influence both the decision to bypass the ED and timing of reperfusion include the capability of the EMS to preactivate the catheterization laboratory before arrival in the hospital, the distance from the scene to the hospital, and whether the catheterization laboratory was ready to receive the patient. Unfortunately, these factors were not documented and cannot be accounted for in this study. Finally, we were also not able to measure from this data set whether ED bypass was associated with a greater rate of missed alternative diagnoses or a greater rate of catheterization laboratory false-positive activation.

### Conclusions

The use of ED bypass before primary PCI for STEMI patients identified with a prehospital ECG was low in contemporary practice but varied substantially across US hospitals. Because we found ED bypass to be associated with a significant reduction in reperfusion times with no adverse impact on mortality rates, more widespread evaluation and implementation of this process are warranted in the United States.

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## Disclosures

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## CLINICAL PERSPECTIVE

Several strategies are recommended to optimize and shorten reperfusion times for patients with ST-segment–elevation myocardial infarction. These include the use of prehospital ECGs and direct transport to a percutaneous coronary intervention–capable hospital while bypassing a hospital without percutaneous coronary intervention capabilities. Along this spectrum, the European Society of Cardiology guidelines recommend that in the optimal situation, ST-segment–elevation myocardial infarction patients diagnosed with a prehospital ECG should be directly transported to the catheterization laboratory of the percutaneous coronary intervention–capable hospital, thereby bypassing the emergency department (ED). This strategy of bypassing the ED, however, was not endorsed in the updated 2013 American College of Cardiology Foundation/American Heart Association guidelines, likely reflecting the lack of feasibility, efficacy, and safety data for this practice in the United States. We evaluated hospitals participating in the National Cardiovascular Data Registry Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With The Guidelines, including those participating in the American Heart Association Mission: Lifeline program to determine the contemporary use of ED bypass in the United States and to investigate the association of this strategy with reperfusion times and in-hospital mortality. We found that among ST-segment–elevation myocardial infarction patients identified with a prehospital ECG, the rate of ED bypass varied significantly across US hospitals. Overall, ED bypass occurred infrequently in ≈11% of patients and was mostly isolated to working hours. Compared with evaluation in the ED before transport to the catheterization laboratory, bypassing the ED was associated with significantly faster reperfusion times with no adverse effect on in-hospital mortality. We believe that this strategy is feasible, safe, and efficacious and that it warrants widespread implementation in the United States.