Pre-Hospital Electrocardiography by Emergency Medical Personnel
Effects on Scene and Transport Times for Chest Pain and ST-Segment Elevation Myocardial Infarction Patients

Mitul Patel, MD,* James V. Dunford, MD,†§ Steve Aguilar, MD,† Edward Castillo, Ptd, MPH,† Ekta Patel, BE,‡ Roger Fisher, BS,§ Ginger Ochs, RN,§ Ehtisham Mahmud, MD
San Diego, California

Objectives
This study sought to measure the impact of pre-hospital (PH) electrocardiography (ECG) on scene-to-hospital time for patients with chest pain of cardiac origin and those with ST-segment elevation myocardial infarction (STEMI).

Background
Pre-hospital ECG decreases door-to-balloon (D2B) time for STEMI patients. However, obtaining a PH ECG might prolong scene time. We investigated the impact of obtaining a PH ECG on both scene and transport times for patients with chest pain suspected of cardiac origin.

Methods
City of San Diego Emergency Medical System runsheets of patients with chest pain from January 2003 to April 2008 were analyzed. The scene times and transport times were compared before (from January 2003 to December 2005) and after (from January 2006 to April 2008) implementation of the PH ECG. Among patients with a PH ECG, median scene times and transport times were compared in patients with and without STEMI.

Results
There were 21,742 patients evaluated for chest pain during the study period. Implementation of PH ECG resulted in minimal increases in median scene time (19 min, 10 s vs. 19 min, 28 s, p = 0.002) and transport time (13 min, 16 s vs. 13 min, 28 s, p = 0.007). However, compared with chest pain patients, in STEMI patients (n = 303), shorter median scene time (17 min, 51 s vs. 19 min, 31 s, p < 0.001), transport time (12 min, 34 s vs. 13 min, 31 s, p = 0.006), and scene-to-hospital time was observed (30 min, 45 s vs. 33 min, 29 s, p < 0.001).

Conclusions
Obtaining a PH ECG for patients with chest pain minimally prolongs scene and transport times. Further, for STEMI patients, both scene times and transport times are actually reduced leading to a potential reduction in total ischemic time. (J Am Coll Cardiol 2012;60:806–11) © 2012 by the American College of Cardiology Foundation

Coronary heart disease remains the leading cause of mortality in the United States (1). A number of pharmacological options, advancements in interventional techniques, and improved systems of care have led to significantly improved outcomes for patients with acute myocardial infarction (2). Timely administration of a thrombolytic agent or angioplasty of the infarct-related artery significantly improves outcomes for patients presenting with an ST-segment elevation myocardial infarction (STEMI) (3–6). In addition, sophisticated pre-hospital (PH) emergency medical services (EMS) systems have evolved to optimize the transport of patients suspected of myocardial infarction to not only the closest, but also the most appropriately equipped treatment facilities (7). Prior studies have highlighted the important role paramedics have played in the PH identification of STEMI with early identification leading to lower door-to-drug (D2D) time, door-to-balloon (D2B) time, and mortality (8–10). In fact, the most recent American College of Cardiology/American Heart Association guidelines suggested a Class 1 recommendation for each community to develop a process for PH identification of STEMI. These same guidelines also emphasize that the benchmark for D2B time should be “as soon as possible” rather than 90 min (11). In patients treated with percutaneous coronary intervention for STEMI, each 30 min of delay translates into a 7.5%
increase in the relative risk of 1-year mortality (12). In addition, when considering in-hospital mortality, a review of the National Cardiovascular Data Registry in 2005 to 2006 showed that for STEMI patients, longer D2B times were associated with a higher adjusted risk of mortality in a continuous nonlinear fashion (30 min = 3.0%, 60 min = 3.5%, 90 min = 4.3%, 120 min = 5.6%, 150 min = 7.0%, 180 min = 8.4%; p < 0.001) (13).

Along these lines, multiple studies evaluating the use of a PH 12-lead electrocardiogram (ECG) have demonstrated the benefits of its implementation for decreasing overall D2D time and D2B time in patients with STEMI (10,14–24). In particular, 2 large, multicenter studies have demonstrated clinically relevant time savings, resulting in a 10-min decrease in D2D time and 15- to 20-min decreases in D2B time (16,17). Additionally, the successful achievement of D2B time ≤ 90 min was shown in 86% of STEMI cases when a PH ECG was used for cardiac triage in 10 STEMI receiving center networks across the United States (25).

Currently, approximately 90% of EMS systems serving the 200 largest cities in the United States have PH 12-lead ECG capability (26). However, though the PH ECG helps in reducing the D2B time, some have suggested it may increase total ischemic time by prolonging the time obtaining an ECG at the scene and thus offsetting the reduction in D2B time (16,27–30).

We undertook this study to measure the impact of obtaining a PH ECG on both the scene and transport times for out-of-hospital patients with chest pain suspected of cardiac origin. In addition, we sought to measure the impact of obtaining a PH ECG on scene and transport times for patients diagnosed with a STEMI.

Methods

This study analyzes a subset of patients managed by the San Diego Medical Services (SDMS), a public-private partnership between the San Diego Fire-Rescue Department and the Rural/Metro Corporation of San Diego. SDMS is the exclusive provider of paramedic services to the City of San Diego, the nation’s eighth largest city, with a population of 1.3 million residing in a 342-square-mile land area. SDMS deploys 450 paramedics on 60 advanced life support first responder vehicles (fire engines and trucks) and 26 ambulances. Fire first responder units are deployed with 3 emergency medical technicians and 1 paramedic, and typically begin assessment (including PH ECG acquisition) and stabilization before ambulance arrival.

The study protocol was approved by the Institutional Review Board of the University of California, San Diego. We retrospectively analyzed the City of San Diego computer-aided dispatch system and emergency medical system runsheets of patients with chest pain between January 2003 and December 2005 (period of time before the implementation of the PH ECG) and compared the data to the time period between January 2006 and April 2008 (after the implementation of the PH ECG). In this study, a STEMI was defined by the interpretation of the Marquette (General Electric, Waukesha, Wisconsin) software algorithm. The time from arrival of the first paramedic-staffed unit (fire first responder or ambulance) to departure of the ambulance was recorded as the scene time. The transport time was documented as the time from the scene to the time of arrival at the emergency department. The scene-to-hospital time was calculated as the time from arrival at the scene to the arrival at the emergency department (Fig. 1).

For the primary analysis, the median scene time, transport time, and scene-to-hospital time were compared before and after implementation of the PH ECG for the entire chest pain cohort. A secondary analysis was restricted to the 9,631 “after PH ECG implementation” cohort and the same time intervals were compared between patients
with STEMI versus no STEMI using a Mann–Whitney U test. Medians, interquartile ranges, and associated p values are presented. Data were analyzed with SPSS version 16.0 (SPSS, Inc., Chicago, Illinois).

Results

There were 21,742 patients (mean age 62 ± 17 years; 53% male) evaluated by EMS activation for chest pain potentially of cardiac origin between January 2003 and April 2008 in the City of San Diego. Baseline demographic data are presented in Table 1. In total, 12,111 of these cases were before the implementation of the PH ECG (between January 2003 and December 2005; 35 months) and 9,631 were after (between January 2006 and April 2008; 27 months). Of the 12,111 cases before the institution of PH ECGs, all except 7 patients were transported and, of the 9,631 cases with PH ECGs, all except 18 patients were transported (Table 1). After institution of the PH ECG, 303 patients (3.1%) were diagnosed with a STEMI in the field (Table 2).

Implementation of the PH ECG resulted in minimal increases in median scene time (19 min, 10 s vs. 19 min, 28 s, p = 0.002) and transport time (13 min, 16 s vs. 13 min, 28 s, p = 0.007) in the study cohort (Fig. 2). However, compared with chest pain patients, when PH ECG suggested a STEMI (n = 303), significantly shorter median scene time (17 min, 51 s vs. 19 min, 31 s, p < 0.001) and transport time (12 min, 34 s vs. 13 min, 31 s, p = 0.006) were observed (Fig. 3). This shortened the median scene-to-hospital time by 2 min, 44 s (30 min, 45 s vs. 33 min, 29 s, p < 0.001) for the study cohort with a PH ECG diagnosis of STEMI (Table 2, Fig. 3).

Discussion

This study demonstrates that the reduction in door-to-reperfusion time with PH ECG is not at the expense of delays in obtaining the PH 12-lead ECG at the scene by EMS. Implementing a PH ECG adds trivial delay to the total time EMS personnel spend on patients with chest pain. These findings support the use of PH ECG for all EMS response patients experiencing chest pain. In particular, the clinically insignificant 18-s prolongation in scene time in our cohort is in contrast to previous reports demonstrating an average increase of 1.2 to 5.2 min in the on-scene time interval (21,27–29,32). This difference may be a reflection of our EMS system design, which deploys paramedics on both fire first responders and ambulances and thereby increases the efficiency of rapid patient assessment. Importantly, utilization of PH ECG did not result in delay of care for chest pain patients or specifically STEMI patients.

Before the PH ECG, it has been posited that STEMI/acute coronary syndrome patients transported by EMS could expect delay from time of symptom onset to reperfusion therapy. Potential delay has been divided into 4 time

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Scene, Transport, and Scene-to-Hospital Times Before and After PH ECG Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Period</td>
<td>n</td>
</tr>
<tr>
<td>Scene time (min:s)</td>
<td></td>
</tr>
<tr>
<td>Before PH ECG</td>
<td>12,111</td>
</tr>
<tr>
<td>After PH ECG</td>
<td>9,631</td>
</tr>
<tr>
<td>Transport time (min:s)</td>
<td></td>
</tr>
<tr>
<td>Before PH ECG</td>
<td>12,104</td>
</tr>
<tr>
<td>After PH ECG</td>
<td>9,613</td>
</tr>
<tr>
<td>Scene-to-hospital time (min:s)</td>
<td></td>
</tr>
<tr>
<td>Before PH ECG</td>
<td>12,098</td>
</tr>
<tr>
<td>After PH ECG</td>
<td>9,611</td>
</tr>
</tbody>
</table>

ECG = electrocardiogram; PH = pre-hospital.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Scene, Transport, and Scene-to-Hospital Times in STEMI Versus No STEMI Diagnosis After PH ECG Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis</td>
<td>n</td>
</tr>
<tr>
<td>Scene time (min:s)</td>
<td></td>
</tr>
<tr>
<td>No STEMI</td>
<td>9,328</td>
</tr>
<tr>
<td>STEMI</td>
<td>303</td>
</tr>
<tr>
<td>Transport time (min:s)</td>
<td></td>
</tr>
<tr>
<td>No STEMI</td>
<td>9,311</td>
</tr>
<tr>
<td>STEMI</td>
<td>302</td>
</tr>
<tr>
<td>Scene-to-hospital time (min:s)</td>
<td></td>
</tr>
<tr>
<td>No STEMI</td>
<td>9,309</td>
</tr>
<tr>
<td>STEMI</td>
<td>302</td>
</tr>
</tbody>
</table>

STEMI = ST-segment elevation myocardial infarction; other abbreviations as in Table 1.
intervals: 1) symptom onset to EMS arrival; 2) EMS arrival to hospital arrival; 3) hospital arrival to ECG; and 4) ECG to reperfusion. With a PH ECG, the third interval can be eliminated and fourth time interval is shortened with advanced notification of the hospital, activation of the catheterization laboratory en route, and/or bypass of the emergency department to the catheterization laboratory (24,33–38). In this study, we address the second interval and demonstrate that EMS personnel have improved their workflow to insure that PH ECG does not adversely prolong both scene and transport times for patients who are evaluated for chest pain of potential cardiac origin. In fact, when the diagnosis of STEMI is made in the field, the EMS arrival-to-hospital time is lower than for other chest pain patients thereby potentially reducing total ischemic time.

These findings suggest that previous reports of reduced ischemic time with PH ECG may have been underestimated, as the reduction in the D2D and D2B time intervals do not take into account the additional reduction in PH scene and transport times (10,14–17,19–23,31). For patients presenting with a STEMI in the City of San Diego, obtaining a PH ECG led to significantly lower median scene time, transport time, and overall scene-to-hospital time compared with chest pain patients without STEMI. The decrease of 1 min 40 s in the median scene time and 57 s in median transport time resulted in an overall reduction of 2 m in 44 s of pre-hospital ischemic time. These findings reflect additional reduction in total ischemic time when considering the reductions in D2B time achieved by field activation of the cardiac catheterization laboratory.

Although it is clear in this study that patients identified by PH ECG with STEMI actually received expedited care, how EMS personnel achieved this efficiency is unknown. It is possible that once identified, obvious and suspected STEMI patients were treated with greater urgency resulting in expedited transport to the closest STEMI center. It is also possible that these patients might appear to be in greater extremis on the basis of a clinical evaluation and would have reduced scene and transport times independent of the ECG findings. Cities or counties that have instituted a PH ECG protocol and/or have developed appropriate STEMI triage networks have shown significant improvements in both D2B times and first medical contact to balloon times in smaller patient populations (25,39). The city and county of San Diego also established a PH ECG identification of STEMI with preferential transport to a percutaneous coronary intervention–capable hospital in January 2007. This has the potential to confound the findings of this study.

This study assumed that all patients with the chief complaint of “chest pain of suspected cardiac origin” received a 12-lead ECG because it was the protocol during the study period, and extensive paramedic training focused...
on this chief complaint as the primary criteria to perform an ECG. However, only PH ECGs that demonstrated a software interpretation of an acute STEMI were mandatorily saved and uploaded for review and storage. Nevertheless, this large population-based study supports the notion that obtaining a PH ECG does not prolong ischemic time in the setting of a STEMI, and might actually reduce it. We acknowledge that ideally a comparison of the various time intervals in the STEMI subgroup pre- and post-implementation of the PH ECG would further strengthen the presented data. However, before the implementation of the PH ECG in our community, specific identification of STEMI patients was not available.

Conclusions

Obtaining a PH ECG by emergency medical personnel for patients with chest pain suspected of cardiac origin adds trivial time at the scene and during transport to the hospital. Compared with all chest pain patients, for patients with a STEMI on a PH ECG, both of these time intervals are actually shorter and complement the benefits of previously established reductions in D2B times with a PH ECG.

Acknowledgements

The authors would like to thank San Diego Medical Services (the paramedic provider for the city) whose international award-winning electronic health record, Tapchart, allowed for ease in data acquisition.

Reprint requests and correspondence: Dr. Ehtisham Mahmud, UC San Diego Sulpizio Cardiovascular Center, 9434 Medical Center Drive #7784, La Jolla, California 92037. E-mail: emahmud@ucsd.edu.

REFERENCES


Key Words: electrocardiography • ischemia • myocardial infarction • reperfusion.