Field Triage Reduces Treatment Delay and Improves Long-Term Clinical Outcome in Patients With Acute ST-Segment Elevation Myocardial Infarction Treated With Primary Percutaneous Coronary Intervention

Sune H. Pedersen, MD,* Soren Galatius, MD, DMSc,* Peter R. Hansen, MD, PhD, DMSc,* Rasmus Mogelvang, MD, PhD,† Steen Z. Abildstrom, MD, PhD,‡ Rikke Sørensen, MD,* Ulla Davidsen, MD,* Anders Galloë, MD, PhD,* Ulrik Abildgaard, MD, DMSc,* Allan Iversen, MD,* Jan Bech, MD, PhD,* Jan K. Madsen, MD, DMSc,* Jan S. Jensen, MD, PhD, DMSc*

Copenhagen, Holbaek, and Glostrup, Denmark

We evaluated the independent impact of field triage on treatment delay and long-term clinical outcome in a large contemporary, consecutive population of ST-segment elevation myocardial infarction (STEMI) patients undergoing primary percutaneous coronary intervention (pPCI).

Reduction of treatment delay is crucial for patients with STEMI.

From January 2005 to July 2008, 1,437 STEMI patients were treated with pPCI at a single high-volume invasive center. We present the 1-year outcome in this observational registry study.

A total of 616 patients were admitted by field triage and 821 by emergency departments. Baseline and angiographic variables were similar in the 2 populations. Patients admitted by field triage had a significantly shorter median door-to-balloon time compared with patients admitted by emergency department triage (83 min, interquartile range 67 to 100 min vs. 103 min, interquartile range 80 to 135 min; p < 0.001). Door-to-balloon times of less than the recommended 90 min were achieved in 61% of field triage patients, but only in 36% of non-field-triage patients (p < 0.001). After adjustment for relevant baseline variables, patients admitted by field triage had a reduced risk of reaching the combined end point of all-cause mortality or nonfatal myocardial infarction (hazard ratio: 0.67; 95% confidence interval: 0.46 to 0.97; p = 0.035).

This study shows that field triage of STEMI patients to pPCI significantly reduces treatment delay and improves outcome. These results emphasize the value of field triage as an important tool in the quest to improve clinical outcomes in STEMI patients undergoing pPCI. (J Am Coll Cardiol 2009;54:2296–302) © 2009 by the American College of Cardiology Foundation

The prognosis for patients surviving an ST-segment elevation myocardial infarction (STEMI) is improved when time to reperfusion of the occluded artery is reduced (1). Hence, it is essential that the door-to-balloon time is limited when primary percutaneous coronary intervention (pPCI) is used as the reperfusion strategy (2). Field triage has the potential to reduce delays, but inadequate information is available to clearly define its role in STEMI care. It is now generally accepted that when suitable local and regional emergency services and hospital capabilities are available, transfer of STEMI patients for pPCI is feasible and superior to on-site fibrinolysis (3–6). However, this treatment guideline relies on the premise that pPCI is performed promptly and in high-volume invasive centers (7–9). The benchmark door-to-balloon time (time from first medical contact to first pPCI balloon inflation) is currently a maximum of 90 min (6,10). This standard is based on results from randomized clinical trials, but it has proven difficult to achieve this goal in routine practice, and data from a recent large U.S. registry indicated that <5% of patients had door-to-balloon times <90 min (11). Consequently, a number of regional STEMI programs have been implemented to reduce treatment delay.
Field Triage in Primary PCI Improves Outcome

Pedersen et al. JACC Vol. 54, No. 24, 2009
December 8, 2009:2296–302

One initiative that seems particularly effective in reducing treatment delay is field triage. In this setting, a 12-lead electrocardiogram (ECG) is obtained immediately by the ambulance crew and then transmitted for evaluation by an experienced physician at the invasive center. When a STEMI is suspected, the patient is then field-triaged directly to the regional invasive center, thereby bypassing the local emergency department (ED) (in some programs the ECG is evaluated in the ambulance by specially trained paramedics [12]). A number of studies have shown that this approach is feasible and significantly reduces the door-to-balloon time, and in earlier observational studies of small-sized populations, field triage of STEMI cases for pPCI has generally been associated with more favorable short- to medium-term clinical outcomes compared with outcomes of patients triaged in the ED (12–22). However, no study has evaluated the independent impact of field triage on long-term outcomes in a large contemporary STEMI population undergoing pPCI. Consequently, we examined the independent impact of field triage on treatment delay and long-term outcomes in consecutive STEMI patients routinely admitted to a high-volume percutaneous coronary intervention (PCI) center from 2005 to 2008.

Methods

Study population. Routine treatment with pPCI for STEMI, including interhospital transportation, was introduced and implemented in Denmark in 2002 after the presentation of the DANAMI-2 (Danish Trial in Acute Myocardial Infarction–2) trial at the American College of Cardiology meeting in 2002 (3). From January 2005 to July 2008, we identified 1,437 consecutive STEMI patients admitted to our invasive center at Gentofte University Hospital (Denmark) either by “field triage” or “nonfield triage,” who were treated with pPCI. Field triage was gradually implemented in the region, starting in 2003. When field triage was introduced in our region, we scheduled the present study in order to evaluate the effect of the new strategy. Outcomes—treatment delay, mortality, and nonfatal myocardial infarction (MI)—were pre-specified. All patients were part of a regional plan including only 1 high-volume PCI center. No alternatives existed. STEMI was defined as presence of chest pain for >30 min and <12 h, cumulative persistent ST-segment elevation >4 mm in at least 2 contiguous pre-cordial ECG leads, or elevation >2 mm in at least 2 or more contiguous inferior ECG leads. Gentofte University Hospital serves a population of 1.2 million citizens (i.e., more than 20% of the total Danish population), and is the invasive hub for 10 non-pPCI centers, serving a predominantly urban population. On-site cardiac surgery is present, and >1,500 PCI procedures are performed annually (approximately 500 pPCI), with each individual PCI operator performing approximately 300 PCI and 100 pPCI per year.

Baseline and procedural data. The baseline data were prospectively collected from all patients and entered in a dedicated registry. Hypertension was defined as use of blood pressure-lowering drugs. Diabetes was defined as use of glucose-lowering drugs, fasting plasma glucose concentration ≥7 mmol/l, or nonfasting plasma glucose concentration ≥11.1 mmol/l. Multivessel disease was defined as 2 or 3-vessel disease and complex lesions as type C lesions. Data regarding medication at admission and during follow-up were extracted from The Danish Registry of Medical Product Statistics. This registry holds information about all prescription claims from Danish pharmacies and is highly validated. Prescription claims within 180 days before the pPCI date and 180 days after the pPCI date were recorded.

Triage for pPCI. Triage was determined by the way the patients “approached” the system.

1. Field-triage group: patients dialing 112 (equivalent to 911) from their homes or outside of hospital facilities would be field triaged if the ambulance was equipped with the sufficient technique. If a STEMI was suspected by the ambulance crew, a 12-lead ECG was recorded and immediately transmitted to the hand-held device (mobile phone with fax modem) carried by the on-call senior resident-level cardiologist at the invasive center using Lifenet (Medtronics, Minneapolis, Minnesota). After immediate evaluation of the ECG, the physician phoned the ambulance, and in case of suspected STEMI, the crew was instructed to drive directly to the catheterization laboratory of the invasive center, bypassing the local and invasive center EDs.

2. Nonfield-triage group: these patients were triaged for pPCI either: 1) after being admitted to noninvasive hospitals by ambulances not equipped with ECG transmission facilities or because they showed up there by themselves (“walk-ins”), in which case they were promptly transported to the catheterization laboratory of the invasive center by ambulance; or 2) after direct admittance to the invasive center ED, as walk-ins, or because they were transported to the ED by ambulances that were not yet equipped with ECG transmission facilities. Also, patients already admitted to a hospital due to other diseases than STEMI were in the nonfield triage group.

pPCI procedure. The catheterization laboratory staff was activated from their homes (<30 min away) by the invasive center on-call cardiologist who had performed the triage for pPCI. pPCI was performed according to contemporary interventional guidelines using pre-treatment with 10,000 IU of unfractionated heparin, 300 to 500 mg acetylsalicylic acid, and 300 to 600 mg clopidogrel. Glycoprotein IIb/IIIa inhibitors were used at the discretion of the operator.

Abbreviations and Acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>electrocardiogram</td>
</tr>
<tr>
<td>ED</td>
<td>emergency department</td>
</tr>
<tr>
<td>IQR</td>
<td>interquartile range</td>
</tr>
<tr>
<td>MI</td>
<td>myocardial infarction</td>
</tr>
<tr>
<td>PCI</td>
<td>percutaneous coronary intervention</td>
</tr>
<tr>
<td>pPCI</td>
<td>primary percutaneous coronary intervention</td>
</tr>
<tr>
<td>STEMI</td>
<td>ST-segment elevation myocardial infarction</td>
</tr>
</tbody>
</table>
Subsequent medical treatment included anti-ischemic, lipid-lowering, and antithrombotic drugs according to current treatment guidelines.

**Treatment delay variables.** The symptom-to-balloon time was defined as the time from onset of symptoms to first balloon inflation. The door-to-balloon time was defined as the time from first medical contact (i.e., admittance to ED for the nonfield-triage group, and ECG transmission for the field-triage group, respectively) to first balloon inflation.

**Follow-up and study end points.** Follow-up was 99.7% complete (5 patients were lost to follow-up due to emigration). The study end points were door-to-balloon time and all-cause mortality, nonfatal MI, and the combined end point of all-cause mortality or nonfatal MI at 1 year of follow-up.

Follow-up data on mortality were collected from the National Person Identification Registry, while follow-up data on re-MI were collected from the highly validated Danish National Board of Health’s National Patient Registry, using International Classification of Diseases-10 codes (23). If an event was registered, it was subsequently validated by cross checking with hospital source data. Nonfatal MI was defined as recurrent chest pain combined with significant increases in creatine kinase MB levels occurring at least 5 days after the index pPCI.

**Statistics.** Baseline characteristics were compared by the chi-square test, and continuous Gaussian distributed variables with the Student unpaired *t* test. Time variables had a non-Gaussian distribution and were compared using the Mann-Whitney test. We tested associations between the variable “field triage” and other baseline variables using univariate logistic regression. First order interactions between “field triage” and other baseline variables were assessed in these models. Association between time variables (door-to-balloon and symptom-to-balloon time) and other variables were tested using univariate linear regression. Linearity, variance homogeneity, and the assumption of normality were tested with plots of residuals for these variables were tested using univariate linear regression. In order to maintain a robust model, only 1 variable per each 10 events was entered in the multivariable Cox analyses of each end point. In these analyses, the effect of “field triage” was assessed adjusted for the pre-specified variable “inclusion year.” In addition, variables with the lowest *p* value on univariate analysis were included, until the maximum allowed number of variables was reached. In all of the statistical tests, *p* values ≤0.05 were considered of statistical significance. SPSS for Windows version 17.0 was used (SPSS Inc., Chicago, Illinois).

The study was approved by the local scientific ethical committee and The Danish Data Protection Agency, and complies with the second Declaration of Helsinki.
Results

Patient population and baseline characteristics. A total of 616 patients were admitted by field triage while 821 were admitted via EDs (85% from referral hospital and 15% from the hospital holding the invasive center). The median distance from noninvasive referral hospitals to the invasive center was 10 miles (interquartile range [IQR] 5 to 25 miles), and approximately 97% of the population had <60 min of overall transportation time to the center. Only minor differences were found in baseline and angiographic variables between the 2 populations. No significant difference in angiographic characteristics was found, apart from the use of drug-eluting stents, which were higher in the nonfield-triage group (Table 1). No significant associations or interactions between the variable “field triage” and other baseline variables were found. In general, the 2 groups were treated with the same medication at admission and during follow-up. In particular, no difference in the proportion of patients treated with clopidogrel was found (Table 2).

Treatment delays. Patients admitted by field triage had significantly shorter treatment delays compared with nonfield-triaged patients. In particular, median door-to-balloon time was shorter for field-triaged patients (83 min, IQR 67 to 100 min vs. 103 min, IQR 80 to 135 min; p < 0.001). The median door-to-balloon time for the entire population was 94 min (IQR 75 to 123 min), and door-to-balloon times of <90 min were achieved in 61% of field-triaged patients, but only in 36% of nonfield-triaged patients (p < 0.001) (Fig. 1). Nonfield-triaged patients admitted directly to the ED at the invasive institution had significantly shorter median door-to-balloon time compared with patients referred from other hospitals (81 min, IQR 55 to 106 min vs. 105 min, IQR 80 to 140 min). Other than “field triage,” none of the baseline variables in Table 1 were significantly associated to treatment delay. With regard to outcome, we found a significant association between increased treatment delay (symptom-to-balloon time) and impaired prognosis (Fig. 2).

Long-term prognosis. Figure 3 displays Kaplan-Meier plots stratified by “field triage.” In this univariate analysis, field-triaged patients had a significantly reduced risk of reaching the combined end point (all-cause mortality or nonfatal MI) compared with nonfield-triaged patients (log-rank p = 0.05). After adjustment for relevant baseline variables, patients admitted by field triage continued to show a reduced risk of reaching the combined end point.
Discussion

In the current study, we aimed to evaluate the independent impact of field triage on treatment delay and long-term clinical outcomes in STEMI patients treated with pPCI in a real-life scenario. The study demonstrates that field triage significantly reduces treatment delay and improves outcome, even after adjustment for relevant baseline variables. These findings clearly suggest that when suitable emergency services and hospital capabilities are available, field triage of STEMI patients for pPCI at regional high-volume invasive centers is an effective treatment organization. The superiority of pPCI over fibrinolytic therapy in STEMI patients has been shown in numerous randomized clinical trials (3–6,24,25). However, a number of reports have indicated that this superiority is time-dependent, and depends on pPCI being performed in high-volume centers by experienced interventional cardiologists (7–9). Fibrinolytic therapy can be initiated almost instantly after the STEMI diagnosis, while transfer to pPCI obviously increases treatment delay. Accordingly, studies have suggested that the survival advantage of pPCI is lost when the incremental PCI-related delay between the 2 strategies (door-to-balloon minus door-to-needle time) exceeds 60 to 120 min (26–28). It has therefore also been argued that since the incremental delay between pPCI and on-site fibrinolyses exceeds the crucial point of 60 to 120 min in most real-life STEMI patients, fibrinolyses should be considered in these cases (27,29). However, it is important to consider that the local transportation time to invasive centers in most countries with pPCI facilities is surprisingly short (e.g., 80% of the adult U.S. population have <60 min of transportation time...
to an invasive PCI center while 95% have <90 min of transportation time) (30). These data indicate that implementation of effective regional programs with field triage could provide timely access to pPCI for most STEMI patients and eventually improve clinical outcomes. In the present study, the overwhelming majority of patients had <60 min of overall transportation time to the invasive center, and in this setting (as in other parts of Denmark) it was deemed feasible to quickly implement a reperfusion strategy of pPCI for STEMI patients including field triage. We found that the median door-to-balloon time was reduced 20 min (19%) by field triage as compared with nonfield triage. Furthermore, almost two-thirds of patients referred by field triage had door-to-balloon times <90 min. These results are in concordance with other studies, which have found similar reductions in treatment delay after field triage (13,15–19,21). Not surprisingly, we also found a significant association between increased treatment delay (symptom-to-balloon time) and impaired prognosis.

The impact of field triage on clinical outcomes has only been investigated in a limited number of studies. These studies indicate that field triage improves outcome, but the conclusions are primarily generated from relatively small-sized populations and are based on either nonsignificant results or short-term follow-up data (12–14,16–19,22). Furthermore, outcomes have generally not been adjusted for potential confounders. The latter is obviously important in observational registry studies addressing a complex issue. In our study of 1,437 STEMI patients, we evaluated the independent predictive value of “field triage” using a multivariable Cox regression analysis and found that field triage significantly reduced the relative risk of all-cause mortality or nonfatal MI by 33%. This result supports the conclusion reached by van’t Hof et al. (12), who evaluated 467 STEMI patients referred for pPCI by field triage or by ED triage from 2001 to 2002. They presented an adjusted odds ratio of 0.3 (p = 0.03) in favor of field triage for reaching a combined end point of death or re-MI at 1 year of follow-up. Furthermore, our results support the nonsignificant results described in a study by Diercks et al. (22), where a trend toward improved adjusted in-hospital mortality for field-triaged STEMI patients was found (odds ratio: 0.80, p = 0.06).

**Study limitations.** Despite our efforts to reduce bias, the risk of unknown confounders exists in a nonrandomized trial. One could suspect that additional positive effects of field triage other than reduction of treatment delay exist (e.g., earlier administration of antithrombotic treatment and extensive care delivered by more extensively trained paramedics). We believe, however, that these are “built-in” effects of field triage and consequently we did not adjust for these variables. Furthermore, the fraction of field-triaged patients increased slightly throughout the study period. However, no changes in treatment guidelines were implemented at our institution after 2005: most important, all patients treated with a stent (both drug-eluting and bare-metal stents) were given clopidogrel for 12 months. Moreover, we included a time variable (“inclusion year”) into the multivariable analysis. In the present population, the prevalence of the baseline variables diabetes, previous MI, and previous PCI were relatively low in our population. Identification of the variables “previous MI” and “previous PCI” was done in highly validated registries and later confirmed by hospital source data. The lower fraction of diabetes could—to some extent—be explained by a lower background prevalence of diabetes in Denmark compared with the U.S. Care should be taken if the results are to be extrapolated to populations with very different incidences of potential risk factors. Finally, our geographical and organizational conditions may not necessarily apply to other countries and regions, and our findings should not be extrapolated to settings without high-volume PCI centers.
Field Triage in Primary PCI Improves Outcome

Conclusions

We found that field triage of STEMI patients for pPCI significantly reduces treatment delay and ensures that two-thirds of patients achieve door-to-balloon times of <90 min. Furthermore, we found that field triage significantly improves clinical outcome, even after adjustment for relevant baseline variables. Our results emphasize the value of field triage as an important tool in the quest to improve clinical outcomes in STEMI patients undergoing pPCI.

Reprint requests and correspondence: Dr. Sune H. Pedersen, Department of Cardiology P, Gentofte University Hospital, Niels Andersens Vej 65, DK-2900, Copenhagen, Denmark. E-mail: sunped01@geh.regionh.dk.

REFERENCES


Key Words: field triage • STEMI • primary PCI • myocardial infarction • door-to-balloon time.