Peer reviewed article

Prehospital emergency physician activation of interventional cardiology team reduces door-to-balloon time in ST-elevation myocardial infarction

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Summary

Question under study: To explore whether early activation of an interventional cardiology team, by prehospital emergency physicians, reduces door-to-balloon time (DTBT) in patients with ST-elevation myocardial infarction (STEMI) diagnosed with prehospital ECG.

Methods: Design: before-after comparison. Setting: emergency department (ED) of an urban teaching hospital with a catheterisation laboratory open continuously. Study subjects: patients with STEMI diagnosed in the prehospital setting or in the ED within 12 hours of symptoms. Intervention: a paging system or "STEMI alarm", activated by prehospital physicians, which simultaneously notified both the catherisation laboratory and cardiology teams before the patient's arrival to the ED. Outcome measures: DTBT and the proportion of patients with DTBT <90 minutes.

Results: A total of 196 patients were included; 77 before and 119 after implementation of the "STEMI alarm". Between the two periods, median DTBT decreased from 109 to 76 minutes (p <0.001) and the proportion of patients treated within 90 minutes increased from 36% to 66% (p <0.001). During intervention, the STEMI alarm was activated in 67 patients (56%). In these cases the median DTBT was 50 minutes, with 96% within 90 minutes. The alarm was inappropriately activated in 9 cases (11%).

Conclusions: Catheterisation laboratory activation by a prehospital emergency physician markedly reduces DTBT in STEMI patients.

Key words: STEMI; door-to-balloon time; prehospital emergency physician; direct admission to catheterisation laboratory

Introduction

The prognosis for patients with ST-elevation myocardial infarction (STEMI) depends upon reperfusion delay, whether treatment consists of thrombolysis [1–7] or percutaneous coronary intervention (PCI) [8–11]. Many trials have shown that PCI is superior to thrombolysis, in particular when initiated within 90 minutes of Emergency Department (ED) admission [12]. Therefore, provided that PCI is rapidly available, it has become a standard treatment in STEMI patients [13, 14].

In practice, the objective of achieving a reperfusion delay of under 90 minutes is not frequently met [9, 10, 15, 16]. To improve time to treatment, successful strategies have been developed, including door-to-balloon time (DTBT) performance feedback to emergency and cardiology teams, prehospital electrocardiograms linked to a specific protocol, and catheterisation laboratory activation by a single call from an emergency physician or by an Emergency Medical Service (EMS) paramedic at the prehospital scene [16–21].

In Switzerland, ED physicians are routinely dispatched together with the EMS team in case of suspected acute coronary syndrome (ACS). The goal of this study was to measure whether direct admission from ambulance to the catheterisation laboratory (bypassing the ED) via a prehospital physician-based alarm system reduced DTBT in patients with STEMI.

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Trial registration: reperfusion time in STEMI, clinical Trials.gov Identifier: NCT00497419

Methods

Study design

A before-after study design was used, comparing the effect of implementation of the prehospital alarm system on DTBT.

Study setting

The study was conducted at the Geneva University Hospital, an 800-bed primary and tertiary urban teaching hospital with 58 000 annual ED visits. This hospital, which serves as the main regional catheterisation referral centre, performs a high volume of coronarography and also has a primary PCI program available on a continuous basis. Thus, primary PCI is the preferred reperfusion therapy for STEMI.

As a general rule in Switzerland, prehospital evaluation of patients with suspected ACS is performed by EMS providers including an ED physician. The decision to dispatch a physician is made by the emergency call centres' dispatchers. In the field, ECG is routinely performed and interpreted by the prehospital ED physician for all patients with suspected ACS. Thus, patients with suspected STEMI are admitted to the ED either by their own means (self-presenters) or by ambulance.

At admission at the ED, all patients are first triaged by a triage nurse according to a validated triage protocol. Patients with suspected ACS are immediately installed in the ED and ECG is immediately performed by the ED nurse. The patient is then evaluated within 10 minutes by a senior ED physician. When STEMI is diagnosed by the ED physician, an in-hospital cardiology fellow is called to confirm the indication for urgent PCI. This procedure is in agreement with current AHA guidelines.

Intervention

If a diagnosis of STEMI is made in the field, the prehospital ED physician of the EMS team is empowered to simultaneously activate the catheterisation laboratory (CL) and cardiology team using a paging system (called "STEMI alarm" and hereinafter also referred to as "the intervention"), and to bypass the ED and transport the patient directly to the CL. To avoid abusive catheterisation, ECG is quickly reviewed at the door of the CL by the inhouse cardiologist.

During regular working hours (Monday–Friday 8:00 A.M. to 6:00 P.M.), STEMI patients admitted to the ED are directly transferred to the CL if available, or transiently evaluated and monitored in the ED before transfer to CL.

During off-peak hours, the "STEMI alarm" paged the CL staff and cardiology team at home. On-call CL technicians and physicians have 30 minutes to be at the hospital. In case of ED admission before CL team arrival to the hospital, the patient is monitored in the ED and transferred to the CL as soon as the CL team arrives.

Inclusion criteria

From March 2004 to February 2005 ("before" period) and October 2006 to October 2007 ("after" period), all patients (self-presenters and those admitted by ambulance) suspected to have STEMI were eligible to be included in the study, whether the diagnosis was made in the prehospital setting or at the ED. ECG criteria used for STEMI diagnosis were ST-elevation ≥1 mV in 2 or more contiguous limb leads, ST-elevation ≥2 mV in 2 or more contiguous precordial leads, or a new left bundle branch block. Patients were not included if the duration of the symptoms exceeded 12 hours, if there was a contraindication to PCI, if they were transferred from another hospital, if they refused PCI or if they died before admission to the CL.

Definitions and outcomes

The primary outcome was median DTBT, defined as the interval between the hospital admission time ("door time") and the time of first balloon inflation ("balloon time"). Secondary endpoints were: 1. the proportion of patients meeting AHA/ACC guidelines of DTBT <90 minutes; and 2. prehospital emergency physician accuracy of STEMI diagnosis. Data obtained from medical records included patient demographics, cardiac risk factors, treatments, clinical characteristics, admission mode and final diagnoses.

Outcomes from intervention period (after period) were compared to outcomes from the before-intervention period.

Data collection

A research nurse and two ED fellows collected data prospectively from the prehospital setting (EMS records), as well as from ED and CL records. All data were collected using a structured data form and entered into a computerised database.

Statistical analysis

SPSS (version 12.0 for Windows, SPSS Inc., Chicago, IL) was used for all analyses. Median time variables were reported. Categorical variables were compared using Fisher's exact test. Medians were compared using Mann-Whitney *U* test.

The study protocol was approved by our institution's Ethics Committee, and did not require written informed consent from the patients.

Results

Population

During both study periods, 299 patients were identified; 136 before and 163 after implementation of the alarm system. Of these, 103 patients were excluded because of either a duration of symptoms >12 hours, transfer from another hospital, contraindications to PCI or PCI refusal. A total of 77 patients were included before the intervention and 119 patients after the intervention. Their baseline characteristics and admission mode are presented in table 1.

During the intervention period, the EMS physician triggered the alarm system in the prehospital setting for 67 patients (56%) (fig. 1). Twenty-six (39%) of these patients were directly transferred to the CL for urgent PCI, but 41 (61%) were first evaluated in the ED and then transferred to the CL for urgent PCI, even though

Table 1

Baseline characteristics and admission mode of patients admitted with STEMI before and after implementation of the prehospital physician-based alarm system.

Characteristic	Before (n = 77)	After (n = 119)	p-value
Age (years), mean (SD)	60.2 (15.6)	62.8 (13.3)	0.2
Male gender, n (%)	66 (86)	94 (79)	0.3
Cardiac risk factors, %			
History of smoking	65	40	0.001
Dyslipidemia	48	45	0.8
Arterial hypertension	48	57	0.2
Diabetes mellitus	25	13	0.05
Family history of CAD	23	20	0.7
Known coronary disease	18	16	0.7
Previous myocardial infarction	11	13	0.8
Admission mode, n (%)			
Self-presenters	19 (25)	24 (20)	0.456
Ambulance			
– medically staffed	40 (52)	89 (75)	0.001
– non-medically staffed	18 (23)	6 (5)	0.000
"Off-peak hours" admission	41 (53)	70 (59)	0.4

Table 2

Median DTBT and proportion of STEMI patients with DTBT <90 minutes before and after intervention.

	Before intervention (n = 77)	After intervention (n = 119)	p-value
DTBT median (min.) (IQR)	109 (74.5–149.5)	71 (46–103)	< 0.001
% <90 min. (95% CI)	36.4 (26.5–47.6)	65.5 (56.6–73.5)	< 0.001

the alarm had been properly activated. This was mainly due to CL unavailability at the time of ED arrival, mostly during off-peak hours. For 22 other patients, the EMS physician did not trigger the prehospital alarm due to transitory clinical STEMI evidence or temporary absence of STEMI ECG criteria (patients without evidence of STEMI in the prehospital setting but with STEMI criteria at admission in the ED) (n = 7), no prehospital ECG (n = 3), patient's initial refusal to undergo PCI (n = 1) or for unknown reasons (n = 11). All other patients, mainly the self-presenters, were firstly evaluated in the ED before transfer to the CL. In the CL, all patients underwent PCI.

Door-to-balloon time (DTBT)

Implementation of the alarm system lead to a reduction of median DTBT from 109 to 71 minutes (p = <0.001). Overall, the 90-minute target was achieved in 65.5% of patients following the intervention versus 36.4% before the intervention (table 2).

When the prehospital "STEMI alarm" was activated (n = 67), median DTBT was reduced to 50 minutes with a targeted 90-minute DTBT achieved in 65 (95.5%) patients. When CL availability allowed bypassing the ED, 90-minute DTBT was achieved for all patients (n = 26). When patients had to wait in the ED before transfer to CL (n = 41), median DTBT was longer (64 [IQR 51–809] versus 34 minutes [IQR 29.5–45]), but a 90-minute target was still achieved in 92.7% (95% CI 80.5–97.3) of the patients. Admission by a non-medically staffed ambulance or by self-presenters was associated with similarly prolonged DTBT and a low proportion of patients achieving DTBT <90 minutes in both periods (115 and 119.5 minutes, 32% and 27%, respectively) (fig. 2).

False positive

A prehospital physician triggered the alarm system in 82 cases. In 15 cases, STEMI was not confirmed after hospital admission. In nine cases (11% of all alarm activations), the alarm was activated without any evidence of STEMI based on the prehospital ECG and was considered as a false positive. After a review of the ECG at the time of hospital admission, urgent PCI was performed on three of these nine patients (direct transfer to CL for two patients) because of ongoing chest pain and NSTEMI ECG criteria. In six other cases, the prehospital ECG showed STEMI criteria, but ED examination did not confirm this

Figure 1

Admission mode and in-hospital flow of STEMI patients, before and after intervention (ED = emergency department, CL = catheterisation laboratory, PCI = percutaneous coronary intervention).

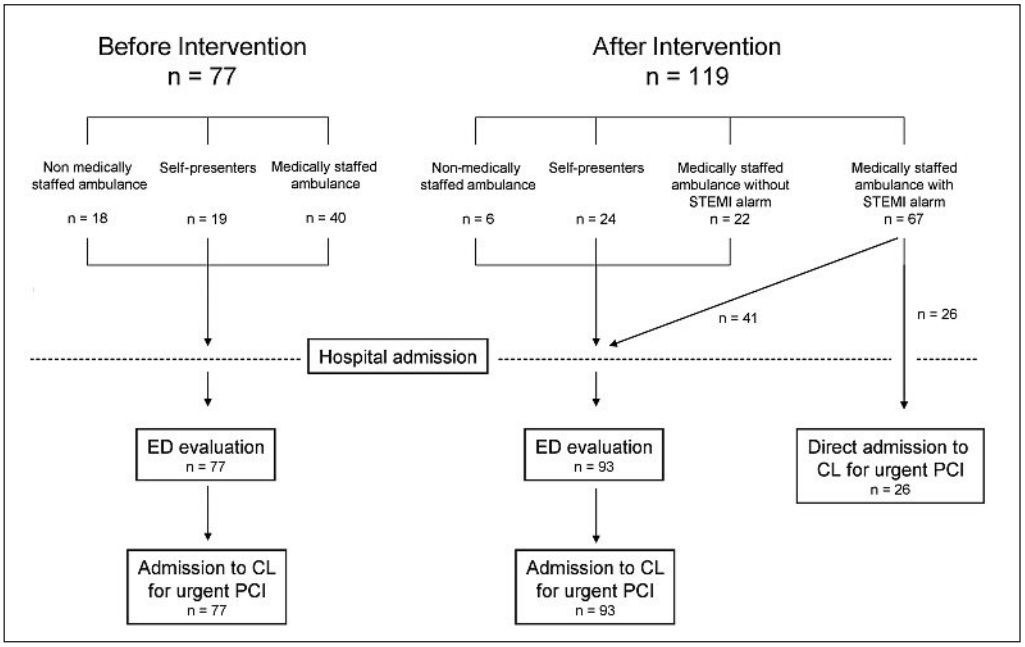
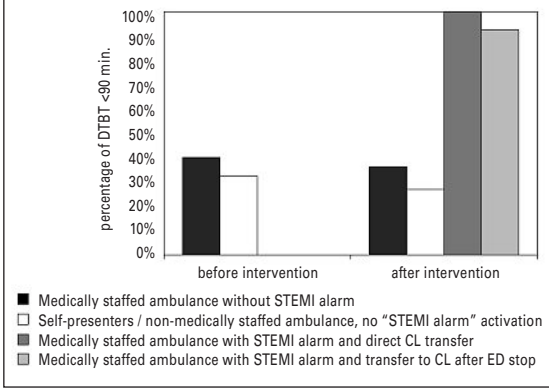


Figure 2

Proportion of STEMI patients with DTBT <90 minutes before and after intervention, depending on admission mode and activation of prehospital "STEMI alarm".



diagnosis. In this group, final diagnoses were pericarditis (n = 2), unstable angina (n = 1), acute HTA (n = 1), and rib fracture (n = 1). For these patients, alarm activation was considered appropriate according to our activation rules.

Discussion

This study shows that prehospital STEMI diagnosis and subsequent en route activation of the CL by a prehospital emergency physician globally reduces median DTBT by 38 minutes and more than doubles the proportion of patients treated within 90 minutes. The activation of "STEMI alarm" resulted in very short DTBT, whether the patients stopped in the ED before CL admission (92.7% of DTBT <90 min.) or were directly admitted to the CL (100% of DTBT <90 min., median DTBT 34 min.). In this latter group, median DTBT is comparable to that obtained in optimal randomised controlled trials [22] and is better than times obtained in an ongoing Swiss registry [23]. This suggests that the prehospital alarm was the delay-shortening measure.

Other interventions have been used to reduce DTBT in STEMI. In two recent studies, early activation of the CL from the ED resulted in reduced reperfusion delay [15, 19, 20]. These interventions focused on the reduction of in-hospital delays. In contrast, our prehospital alarm system aimed to optimise prehospital time in order to anticipate patient arrival and to bypass the ED when feasible.

Similarly, other studies have successfully assessed the effect on DTBT of prehospital CL activation by using specially trained paramedics [18, 24]. These interventions were no doubt efficient and adapted to their local medical environment. In Switzerland, as in other European countries, emergency physicians largely contribute to prehospital emergency care and don't need specific training for STEMI recognition, as opposed to paramedics. A direct comparison of paramedic- versus physician-triggered alarm systems should be performed to evaluate the added-value and the cost-effectiveness of prehospital emergency physicians. Specifically, the benefits of computerised algorithms for STEMI recognition and the potential of transmitting out of hospital ECG tracings for correct diagnostic classification could also be evaluated.

The current intervention has some limitations. Firstly, the "STEMI alarm" was beneficial to only a subgroup of STEMI patients, as self-presenters and patients admitted by non-medically staffed ambulances did not benefit from the alarm system. The proportion of self-presenters could be reduced by population-based educational campaigns.

Secondly, the "STEMI alarm" was inappropriately activated in 11% (n = 9) of patients due to ECG misinterpretation. This rate is comparable to other reports and was considered as acceptable [25]. Only 3 of these patients underwent an unnecessary coronarography, the others being denied for PCI after a quick ECG review by an emergency cardiologist at the door of CL.

Other limitations are related to the study design. Although the study prospectively assessed the DTBT reduction related to a prehospital alarm protocol implementation, it was not a randomised controlled study. Due to the before-and-after prospective cohort design, we cannot exclude unmeasured factors that could have contributed to positive results. However, no significant difference in DTBT was observed in patients without alarm activation during the before-and-after intervention periods. Thus, we considered that the implementation of the "STEMI alarm" was responsible for most of the DTBT reduction.

It is also noteworthy that more patients in the intervention cohort were admitted by a medically staffed ambulance. This difference could be related to an unexpected effect of the intervention. As a matter of fact, the dispatching centre was one of the cornerstones of the intervention and might have dispatched an ED physician to the prehospital scene more easily. However, as mentioned before, patients presenting with STEMI and admitted by a medically-staffed ambulance but without activation of the "STEMI alarm" had comparable DTBT in the baseline and intervention cohorts.

Moreover, implementing our protocol and reproducing our results would be possible in a small urban population with similar medical policies for PCI preference and medically-staffed ambulances. Our protocol may not translate easily to other environments.

Finally, STEMI patients admitted to the ED by their own means did not benefit from our procedure and represent more than a fifth (21.9%, n = 43) of our global cohort. Specific interventions within the ED should target this population.

Conclusion and future developments

Early prehospital CL activation by an emergency physician markedly reduces DTBT. The false positive rate is acceptable and counterbalanced by shorter delays to treatment and their known effects on survival.

According to recent and aforementioned evidence, our protocol will certainly also be implemented in the ED, as a significant proportion of STEMI patients in our cohort were admitted to the ED by their own means.

Finally, our procedure lacks formal feedback meetings. Implementing such meetings will hopefully limit the false positive activation rate whilst also decreasing the unexplained nonactivation rate, thereby increasing our intervention efficiency.

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