

# Primary Percutaneous Coronary Intervention as a National Reperfusion Strategy in Patients With ST-Segment Elevation Myocardial Infarction

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**Background**—In Denmark, primary percutaneous coronary intervention (PPCI) was chosen as a national reperfusion strategy for patients with ST-segment elevation myocardial infarction in 2003. This study describes the temporal implementation of PPCI in Western Denmark, the gradual introduction of field triage for PPCI (patients rerouted from the scene of the event directly to the invasive center), and the associated outcome.

**Methods and Results**—The study population comprised 9514 patients treated with PPCI from 1999 to 2009 with symptom duration  $\leq 12$  hours and either a delay from the emergency medical service (EMS) call to PPCI (healthcare system delay) of  $\leq 6$  hours or as self-presenters. The median follow-up time was 3.7 years. The number of patients treated with PPCI increased from 190 in 1999 to 1212 in 2009. Among patients transported by the EMS from the scene of the event, the proportion who were field triaged directly to a PCI center increased from 33% (34/103) to 72% (616/851,  $P < 0.001$ ). Patients who were field triaged had lower long-term mortality, with adjusted hazard ratios (95% CI) of 1.26 (1.12–1.43) among patients transported by the EMS to a local hospital and then transferred, 1.28 (1.10–1.49) among patients self-presenting at a local hospital and then transferred, and 1.37 (1.18–1.58) among patients self-presenting at a PCI center.

**Conclusions**—A reperfusion strategy with PPCI only for patients with ST-segment elevation myocardial infarction was successfully implemented in Western Denmark, and the majority of patients transported by the EMS are now triaged directly to the PPCI centers. This strategy is associated with lower mortality. (*Circ Cardiovasc Interv.* 2011;4:570-576.)

**Key Words:** angioplasty ■ death ■ myocardial infarction

In 2003, primary percutaneous coronary intervention (PPCI) was chosen as a national reperfusion strategy for patients with ST-segment elevation myocardial infarction (STEMI) in Denmark.<sup>1</sup> To facilitate triage of patients directly to the PPCI centers, a prehospital diagnostic program was launched. The purpose of the present study was to describe the gradual implementation of PPCI from 1999 until 2009, the temporal change in triage of patients directly to PPCI centers, and the associated clinical outcome.

## Methods

### Geographical Area

The study was conducted in Western Denmark, which has a population of 3 034 740, corresponding to 55% of the Danish population. The region has 3 PPCI centers located in the 3 largest cities (Aalborg, Aarhus, and Odense). The cities have populations of 123 432, 242 914, and 166 305, respectively, and the total catchment

areas of the 3 PPCI centers are 580 515, 1 253 998, and 1 200 227, respectively, when including rural areas. The region has 22 somatic hospitals without PPCI facilities. All PPCI centers offer 24-hours/day, 7-days/week services. The distance from north to south is 400 km and from east to west, 190 km. The longest transport distance to a PPCI center is 180 km. One major emergency medical service (EMS) provider (Falck A/S; Copenhagen, Denmark) covers >90% of all EMS calls in Western Denmark.

### Design

This historical follow-up study was based on public medical databases covering the entire population of Western Denmark. The Danish National Health Service provides tax-supported free health care for all inhabitants, guaranteeing free access to EMS services, treatment by general practitioners, and free hospital treatment. Unambiguous, individual-level linkage between the databases used in this study was possible through the civil registration number, which is a unique, 10-digit personal identification number assigned to every Danish citizen at birth.<sup>2,3</sup>

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## WHAT IS KNOWN

- Primary percutaneous coronary intervention (PPCI) is recommended as the preferred reperfusion strategy in patients with ST-segment elevation myocardial infarction if initiated in a timely manner.

## WHAT THE STUDY ADDS

- Successful implementation of PPCI is the only reperfusion strategy used in Denmark.
- When combining prehospital diagnosis with field triage, the majority of patients with ST-segment elevation myocardial infarction are admitted directly to the invasive center for PPCI.

## Patients and Procedures

The study population consisted of patients with STEMI or presumed bundle branch block myocardial infarction admitted for PPCI in Western Denmark between January 1, 1999, and December 31, 2009. Patients were identified in the Western Denmark Heart Registry, which collects baseline characteristics and patient- and procedure-specific information on all angiographies and coronary interventions performed in the region. In Denmark, PPCI for STEMI was chosen as the preferred reperfusion strategy after publication of the Danish Trial of Acute Myocardial Infarction-2 (DANAMI-2) in 2003.<sup>1</sup> Patients must meet the following criteria to be eligible for PPCI: symptom duration of  $\leq 12$  hours and ST-segment elevation  $\geq 0.1$  mV in at least 2 contiguous leads ( $\geq 0.2$  mV in  $V_1$ - $V_3$ ) or presumed new-onset left bundle branch block. In 1999, prehospital diagnosis using telemedicine was introduced,<sup>4</sup> and in 2000, the National Board of Health decided that before 2006, all EMS vehicles should have equipment for 12-lead ECG acquisition and wireless transmission to a physician at the hospital. Field triage of patients directly to PPCI centers was introduced in 2003.<sup>5-8</sup> Ambulance physicians were gradually introduced in the larger cities within the study area. During the study period, 18 410 patients with suspected STEMI or bundle branch block myocardial infarction were transferred from other hospitals or admitted directly to 1 of the 3 PPCI centers. The first index contact during the study period ( $n=17\ 513$ ) was included in the analyses, of which 12 403 patients underwent PPCI. Mortality data were not available in 216 patients, who were foreign citizens or had emigrated. Patients with a treatment delay of  $>12$  hours ( $n=2154$ ) or with missing treatment delay data ( $n=189$ ), patients transported with the EMS and with a system delay of  $>6$  hours ( $n=292$ ), and patients with missing system delay data ( $n=38$ ) were excluded. Thus, the study cohort comprised 9514 patients.

## Time Delays

The estimation of various delays to initiation of reperfusion therapy was based on prehospital data registered by the EMS provider (Falck A/S) and time of symptom onset and first catheterization with a guiding catheter during PPCI registered in the Western Denmark Heart Registry. Treatment delay was calculated as the time from symptom onset to first catheterization with a guiding catheter during PPCI, patient delay as the time from symptom onset to EMS call, system delay as the time from EMS call to first catheterization with a guiding catheter during PPCI, and door-to-balloon delay as the time from arrival at the PPCI center to the first catheterization with a guiding catheter during PPCI (Figure 1).

## Mortality

Data on mortality was obtained from the Danish Civil Registration System, which has kept electronic records on the sex, date of birth, change of address, date of emigration, and changes in vital status of the entire Danish population since 1968.<sup>9</sup>

## Covariates

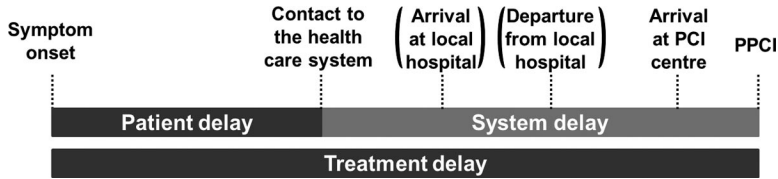
Baseline characteristics and other covariates (Table 1) were derived from the Danish Civil Registration System and the Western Denmark Heart Registry.

## Statistical Analysis

Dichotomous data are presented as percentages. Continuous variables are presented as median (interquartile range). The Fisher exact test,  $\chi^2$  test, Mann-Whitney test, and Kruskal-Wallis test were used for comparisons of categorical and continuous variables as appropriate. Significance was set at  $P<0.05$  (2-sided test). Follow-up began on the date of PPCI and ended on the date of death; emigration; June 25, 2010; or after 7 years of follow-up (to ensure at least 10% of the study population at risk), whichever came first. Kaplan-Meier curves were constructed and stratified according to availability of EMS data and mode of prehospital triage. Comparisons between groups were made using log-rank statistics. Cox proportional hazards regression analysis was used to examine the association between possible predictors of outcome (see Table 1 for complete list) and time to death. Hazard ratios (HRs) with 95% CIs are presented. The proportional hazard assumption was checked for each categorical variable through visual inspection and by the method described by Grambsch and Therneau<sup>10</sup> using the scaled Schoenfeld residuals. For continuous variables, the linearity assumption was checked graphically using the Martingale residuals. Cox-Snell residuals were used to assess the overall model fit. Systolic and diastolic blood pressure levels were converted to categorical values ( $<110$ , 110–129, 130–144, and  $\geq 145$  mm Hg) because they did not fulfill the linearity assumption. Crude and mutually adjusted HRs with 95% CIs were computed. Variables associated with time to death in the univariable Cox regression analyses (Wald test  $P<0.05$ ) were included in multivariable Cox regression models. In the multivariable models, missing values were replaced with their conditional means. These values were obtained as predictions from a regression model using all nonmissing covariates for each subject.<sup>11,12</sup> The same method for assigning missing values was used for categorical variables without rounding the binary outcome, as previously proposed by Allison<sup>13</sup> when proportions are not close to 0 or 1. All statistical analyses were performed using STATA 11.0 (StataCorp LP; College Station, TX).

## Results

The study cohort comprised 9514 patients with STEMI. Prehospital data from the EMS provider were available in 7858 (83%) patients, whereas 1656 (17%) had no EMS data and were presumed to be self-presenters at the PPCI centers. The number of patients included in the study cohort increased from 190 in 1999 to 1212 patients in 2009 (Figure 2). Among patients transported by the EMS from the scene of the event, the proportion triaged directly to a PPCI center increased from 33% (34/103) in 1999 to 72% (616/851) in 2009 ( $P<0.001$ ). When stratifying according to whether EMS data were available and whether patients transported by the EMS were transferred from local hospitals or field triaged directly to the PPCI center, there were significant differences in several baseline characteristics (Table 1). In patients triaged directly to a PPCI center ( $n=3053$ ) the median (interquartile range) system delay was 99 (80–127) minutes; in patients transported by the EMS to the local hospital and transferred to a PPCI center ( $n=3291$ ), it was 159 (130–199) minutes; and in patients self-presenting at a local hospital and transferred ( $n=1514$ ), it was 92 (72–119) minutes. The corresponding door-to-balloon delays were 39 (24–69), 33 (23–92), and 26 (20–69) minutes, respectively (Table 1). For the same groups, the proportion of patients treated with a system



**Figure 1.** Various delays to reperfusion with PPCI in patients with ST-segment elevation myocardial infarction. PCI, percutaneous coronary intervention; PPCI, primary PCI.

delay of  $\leq 120$  minutes was 70% (n=2136), 17% (n=572), and 76% (n=1146), respectively, and the proportion of patients treated with a door-to-balloon delay of  $\leq 90$  minutes was 86% (n=2017), 74% (n=1941), and 94% (n=911), respectively. The median follow-up time was 3.7 years

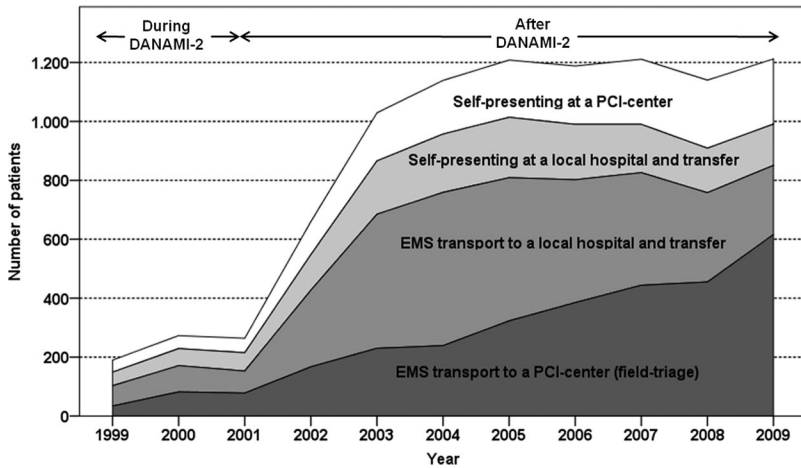
(interquartile range, 1.7–5.9 years), with a 1-year absolute mortality of 9.8% (n=937) and long-term absolute mortality (median follow-up, 3.7 years) of 18.5% (n=1764). For patients triaged directly to the PPCI center, transported by the EMS to a local hospital and transferred, self-presenting at a

**Table 1. Characteristics of Patients With STEMI Treated With PPCI, Stratified According to Prehospital Triage (n=9514)**

Characteristics	EMS Transport to a PCI Center (Field Triage) (n=3053)		Self-Presenting at a PCI Center (n=1656)		EMS Transport to a Local Hospital and Transfer (n=3291)		Self-Presenting at a Local Hospital and Transfer (n=1514)		P
	Value	Valid Cases	Value	Valid Cases	Value	Valid Cases	Value	Valid Cases	
<b>Demographics</b>									
Age, y	64 (56–74)	3053	63 (54–73)	1656	65 (57–75)	3291	63 (53–73)	1514	<0.001
Female sex	790 (26)	3053	433 (26)	1656	894 (27)	3291	401 (26)	1514	0.69
<b>Comorbidities</b>									
Treatment for hypertension	866 (32)	2730	478 (32)	1486	912 (31)	2950	418 (30)	1376	0.68
Diabetes	306 (11)	2821	204 (13)	1549	353 (12)	3057	162 (11)	1433	0.14
Previous myocardial infarction	271 (10)	2712	201 (14)	1481	362 (12)	2932	163 (12)	1365	0.003
Previous PCI	194 (7.2)	2706	129 (8.7)	1484	193 (6.7)	2920	92 (6.8)	1363	0.075
Previous congestive heart failure	79 (2.6)	3053	64 (3.9)	1656	125 (3.8)	3291	51 (3.4)	1514	0.031
Active or previous smoker	2025 (77)	2620	1045 (76)	1374	2157 (77)	2806	1049 (78)	1337	0.50
<b>Delays and transportation</b>									
Treatment delay, min	175 (120–265)	3053	180 (118–277)	1656	235 (171–327)	3291	248 (175–373)	1514	<0.001
Patient delay, min	76 (33–162)	2728	NA		80 (36–171)	2763	155 (87–276)	1457	<0.001
System delay, min	99 (80–127)	3053	NA		159 (130–199)	3291	92 (72–119)	1514	<0.001
Door-to-balloon delay, min	39 (24–69)	2333	NA		33 (23–92)	2620	26 (20–39)	1055	<0.001
Transportation, km	26 (7–50)	3053	NA		77 (48–111)	3291	54 (37–97)	1514	<0.001
<b>Clinical characteristics</b>									
Body mass index, kg/m <sup>2</sup>	26 (24–29)	1726	26 (24–29)	676	26 (24–29)	1568	26 (20–39)	1055	0.81
Systolic blood pressure, mm Hg	130 (112–145)	2373	130 (111–145)	1229	125 (110–140)	2253	128 (110–141)	1071	<0.001
Diastolic blood pressure, mm Hg	75 (65–85)	2364	75 (65–83)	1220	75 (64–80)	2243	75 (65–81)	1065	<0.001
Killip class		2936		1586		3187		1440	
I	2657 (91)		1404 (89)		2888 (91)		1294 (90)		
II	156 (5.3)		88 (5.6)		149 (4.7)		70 (4.9)		0.11
III	56 (1.9)		41 (2.6)		73 (2.3)		44 (3.1)		
IV	67 (2.3)		53 (3.3)		77 (2.4)		32 (2.2)		
Anterior STEMI or BBBMI	1222 (45)	2748	593 (41)	1445	1266 (44)	2884	588 (45)	1314	0.14
Culprit vessel		2959		1605		3206		1466	
Left main	49 (1.7)		32 (2.0)		51 (1.6)		21 (1.4)		
Left anterior descending artery	1293 (44)		658 (41)		1377 (43)		672 (46)		0.39
Circumflex artery	413 (14)		219 (14)		449 (14)		194 (13)		
Right coronary artery	1204 (41)		696 (43)		1329 (41)		579 (40)		
Multivessel disease	1265	2961	711 (46%)	1561	1498 (47)	3183	652 (45)	1435	0.008

Data are presented as median (interquartile range) or n (%). BBBMI indicates bundle branch block myocardial infarction; door-to-balloon delay, time from arrival at PPCI center to PPCI; EMS, emergency medical service; patient delay, time from symptom onset to EMS; PPCI, primary percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; system delay, time from EMS call to PPCI; treatment delay, time from symptom onset to PPCI.

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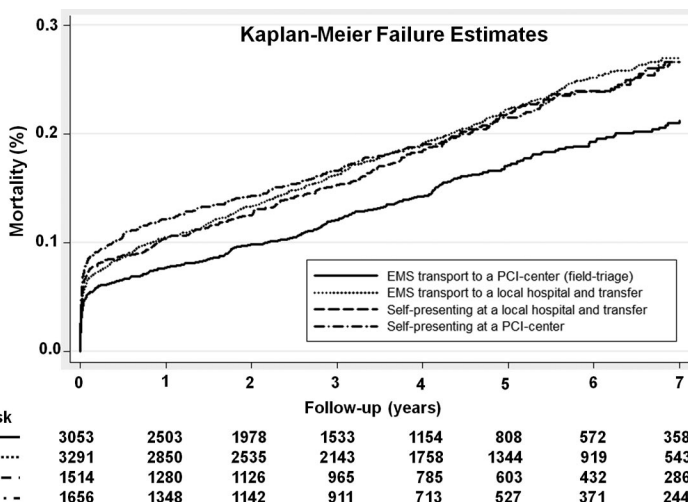
**Figure 2.** Patients with ST-segment elevation myocardial infarction treated with PPCI during and after DANAMI-2 (Danish Trial of Acute Myocardial Infarction-2), stratified according to prehospital triage and whether patients were transported by EMS. EMS indicates emergency medical service. Other abbreviations as in Figure 1.

local hospital and transferred, and self-presenting at a PPCI center, 1-year cumulative mortality was 8.1% (n=234), 10.7% (n=346), 10.6 (n=156), and 12.5% (n=201), respectively (log-rank  $P < 0.001$ ), and long-term cumulative mortality was 21.3% (n=424), 27.1% (n=702), 26.9% (n=309), and 26.9% (n=328), respectively (log-rank  $P < 0.001$ ) (Figure 3). After adjustment for other risk factors, including treatment delay, field-triaged patients had the lowest long-term mortality, with adjusted HRs (95% CI) of 1.26 (1.12–1.43) in patients transported by the EMS to a local hospital and transferred to a PPCI center, 1.28 (1.10–1.49) in patients self-presenting at a local hospital and transferred to a PPCI center, and 1.37 (1.18–1.58) in patients self-presenting at a PPCI center (Figure 4, Table 2). When restricting analyses to patients with available EMS data and adjusting for system delay, field-triaged patients still had lower mortality compared with patients transferred from other hospitals (Table 2).

**Discussion**

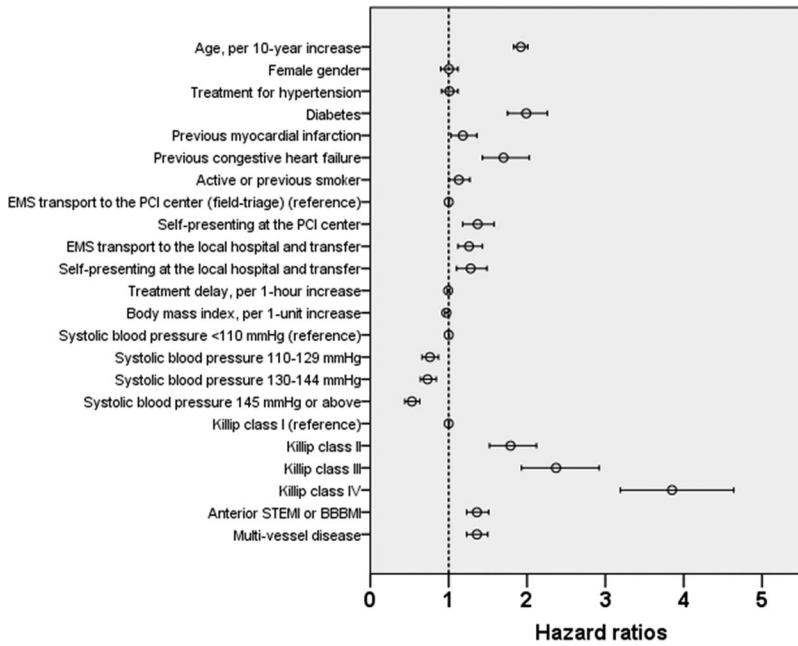
The main findings in the present study is that prehospital diagnosis and triage of patients with STEMI can be successfully implemented at a national level to ensure that the majority of patients are triaged directly to a PPCI center with an associated lower mortality. In 2003, Denmark was the first country to implement PPCI as a national reperfusion strategy.

This decision was based on the DANAMI-2 trial, which documented that PPCI was superior to fibrinolysis when looking at a combined end point of death, reinfarction, and stroke.<sup>1</sup> This strategy is supported by American and European guidelines that recommend PPCI as the preferred reperfusion strategy when performed in a timely manner.<sup>14–17</sup> It is also supported by a meta-analysis from Boersma and colleagues<sup>18</sup> based on randomized controlled trials comparing fibrinolysis with PPCI, documenting a significant reduction in mortality achieved by PPCI compared with fibrinolysis. However, in the Boersma et al meta-analysis, a mortality benefit was achieved by PPCI despite that prehospital diagnosis and field triage of patients was not performed in the large majority of the trials implemented. Thus, a substantial delay was seen at the local hospitals before transfer of patients. In the DANAMI-2 trial, this delay was 50 minutes,<sup>1</sup> and no diagnoses were made for patients in the prehospital phase. From 1999, when the DANAMI-2 trial was still ongoing, prehospital diagnosis was gradually introduced in Denmark.<sup>4</sup> From 2006, all EMS vehicles had equipment for ECG transmission, and when combining prehospital diagnosis with field triage directly to PPCI centers, a >1-hour reduction in overall delay from the EMS call to PPCI (system delay) was observed.<sup>6,19</sup> Accordingly, triage of patients with STEMI for PPCI has improved considerably after the DANAMI-2 trial and the



**Figure 3.** Kaplan-Meier cumulative mortality estimates for patients with ST-segment elevation myocardial infarction treated with PPCI (n=9514), stratified according to prehospital triage and whether EMS data were available. Abbreviations as in Figures 1 and 2.





**Figure 4.** Hazard ratios for the association between various covariates and mortality during follow-up as derived from model 1 in Table 2 (n=9514). BBBMI indicates bundle branch block myocardial infarction; STEMI, ST-segment elevation myocardial infarction. Other abbreviations as in Figures 1 and 2.

other trials included in the Boersma et al meta-analysis. We have previously documented that each 1-hour increase in system delay is associated with a 10% relative increase in mortality.<sup>20</sup> With a 1-year mortality of  $\approx 10\%$  to  $11\%$ , this means that the number of patients saved by a 1-hour earlier reperfusion therapy is estimated to be 10 per 1000 treated. The HR of 1.26 (95% CI, 1.12–1.43) observed in the present study among patients transported by the EMS to a local hospital and then transferred could indicate that the benefit of triaging patients directly to PPCI centers may not only be explained by a reduction in system delay. There is, of course, the risk of selection bias and residual confounding, but another possibility is that prompt admission to tertiary centers provides benefit in addition to the mortality reduction achieved by earlier PPCI. The observed HR of 1.084 per 1-hour increase in system delay (Table 2, model 2) does not contradict this because system delay and mode of triage are highly correlated, and when implementing both parameters in the analysis, there is a risk of overadjustment (ie, the risk that we underestimate the impact of both covariates on outcome).

The present study documents that a widespread implementation of a prehospital diagnostic program is possible with the use of telemedicine and ambulance physicians, enabling field triage directly to PPCI centers in the majority of patients with STEMI. However, there is still room for improvement. Thus, at the end of the study period, 30% of patients transported by the EMS from the scene of the event were still driven to the local hospital and then transferred for PPCI. The overall aim is to field triage  $>90\%$  of patients with STEMI, which is achievable in regions with a special focus on prehospital diagnosis.<sup>19</sup> Whereas previous studies have mainly addressed regional initiatives for improving triage of patients, the present study is considered to reflect the current use of prehospital diagnosis and field triage of patients at a national level because (1) it represents the majority of the Danish people; (2) the prehospital diagnostic strategy was implemented at a national level; (3) the same strategy of

implementing telemedicine in all ambulance vehicles and implementing ambulance physicians in larger cities was prioritized throughout Denmark; and (4) in eastern Denmark, treatment with PPCI has been centralized at large PPCI centers (Copenhagen and Gentofte) that run 24 hours/day, 7 days/week. It is clear that field triage directly to PPCI centers is mandatory to ensure that the majority of patients with STEMI are treated within 2 hours of an EMS call, as recommended by the American and European guidelines,<sup>14–17</sup> and further efforts should be put into ensuring that the remaining patients transported by the EMS from the scene of the event also are triaged directly to a PPCI center. Although there are numerous data on the use of PPCI in different countries, there is limited information regarding actual triage of patients with STEMI, which is of importance for outcome.<sup>21</sup> We should consider implementing prehospital triage of patients with STEMI directly to PPCI centers as a general quality-of-care measure.

### Limitations

After PPCI was fully implemented as the preferred reperfusion therapy in 2004, patients with STEMI were routinely admitted or transferred for PPCI. Fibrinolysis may have been used in a small number of patients, but unfortunately, there are no registries recording the use of fibrinolysis. Among patients transferred from a local hospital to a PPCI center, there were no data on EMS transportation to the local hospital in 32% of cases. These patients were assumed to be self-presenters at the local hospital. However, from previous studies, we know that  $\approx 16\%$  are self-presenters at the local hospital,<sup>22</sup> and thus, the group of patients classified as self-presenters at the local hospital is a mixed group that also comprises some patients with missing EMS data for the transport to the local hospital. Likewise, the number of patients classified as self-presenting at a PPCI center is larger than expected, and herein, a group of patients with missing EMS data for transportation to the PPCI center has been classified as

**Table 2. Multivariable Cox Regression Analysis of Covariates Associated With Long-Term Mortality in Patients With STEMI or BBBMI Treated With PPCI**

Covariates	Model 1, All Patients (n=9514)*		Model 2, Patients With EMS Data (n=7858)*	
	HR (95% CI)	P	HR (95% CI)	P
<b>Demographics</b>				
Age, per 10-y increase	1.92 (1.83–2.01)	<0.001	1.96 (1.86–2.07)	<0.001
Female sex	1.004 (0.90–1.12)	0.94	1.004 (0.89–1.13)	0.94
<b>Comorbid conditions</b>				
Treatment for hypertension	1.009 (0.91–1.12)	0.87	1.06 (0.94–1.20)	0.31
Diabetes	1.99 (1.75–2.26)	<0.001	1.90 (1.64–2.19)	<0.001
Previous myocardial infarction	1.18 (1.03–1.36)	0.016	1.10 (0.94–1.29)	0.24
Previous congestive heart failure	1.70 (1.43–2.03)	<0.001	1.64 (1.35–2.00)	<0.001
Active or previous smoker	1.13 (1.003–1.27)	0.045	1.14 (1.001–1.30)	0.049
<b>Triage of patients</b>				
EMS transport to a PCI center (field triage)	1 (reference)		1 (reference)	
Self-presenting at a PCI center	1.37 (1.18–1.58)	<0.001	NA	
EMS transport to a local hospital and transfer	1.26 (1.12–1.43)	<0.001	1.14 (0.997–1.31)	0.056
Self-presenting at a local hospital and transfer	1.28 (1.10–1.49)	0.001	1.28 (1.10–1.49)	0.001
<b>Delays, per 1-h increase</b>				
Treatment delay	0.994 (0.98–1.013)	0.54	...	
Patient delay	...		1.004 (0.98–1.029)	0.76
System delay	...		1.084 (1.021–1.15)	0.008
<b>Clinical characteristics</b>				
Body mass index, per 1-unit increase	0.97 (0.95–0.99)	0.002	0.97 (0.95–0.99)	0.007
<b>Systolic blood pressure, mm Hg</b>				
<110	1 (reference)		1 (reference)	
110–129	0.76 (0.66–0.87)	<0.001	0.81 (0.70–0.95)	0.009
130–144	0.73 (0.64–0.84)	<0.001	0.72 (0.61–0.85)	<0.001
≥145	0.53 (0.44–0.63)	<0.001	0.51 (0.42–0.62)	<0.001
<b>Killip class</b>				
I	1 (reference)		1 (reference)	
II	1.79 (1.52–2.12)	<0.001	1.70 (1.41–2.06)	<0.001
III	2.37 (1.93–2.92)	<0.001	2.33 (1.87–2.91)	<0.001
IV	3.85 (3.19–4.64)	<0.001	4.29 (3.46–5.33)	<0.001
Anterior STEMI or BBBMI	1.36 (1.23–1.51)	<0.001	1.36 (1.22–1.53)	<0.001
Multivessel disease	1.36 (1.23–1.50)	<0.001	1.40 (1.26–1.57)	<0.001

NA indicates not available. Other abbreviations as in Table 1.

\*Nonoverlapping intervals of treatment delay were considered for inclusion in the multivariable models: model 1, implemented treatment delay; model 2, implemented patient delay and system delay.

self-presenters. There is no reason to believe that this has any impact on the main conclusions because it results in an underestimation of the proportion of patients transported by the EMS and underestimates the association between the mode of triage or system delay and mortality. There is no registry on patients with STEMI who are not receiving reperfusion therapy and no data on deaths before PCI. Regarding timing of reperfusion in PPCI, time of first balloon inflation normally is used as the time of reperfusion. However, reperfusion often is achieved already during wiring or thrombectomy. Because data on first wiring or thrombectomy were available in only a minority of patients and because insertion of the guiding catheter is followed within a few

minutes by the first coronary intervention, we routinely use time of guiding catheter insertion as the time of first intervention. Further, because the phrase *door to balloon* is a widely accepted term, we decided to use this term synonymously with time from arrival at the PPCI center to first guiding catheter insertion.

**Conclusions**

A reperfusion strategy with PPCI only for STEMI was successfully implemented in Western Denmark, and a pre-hospital diagnostic program has ensured that the majority of patients transported by the EMS are triaged directly to PPCI centers, which is associated with lower mortality.

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## Disclosures

None.

## References

- Andersen HR, Nielsen TT, Rasmussen K, Thuesen L, Kelbaek H, Thayssen P, Abildgaard U, Pedersen F, Madsen JK, Grande P, Villadsen AB, Kruse LR, Hagfeldt T, Lomholt P, Husted SE, Vigholt E, Kjaergard HK, Mortensen LS; DANAMI-2 Investigators. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. *N Engl J Med*. 2003;349:733-742.
- Frank L. Epidemiology. When an entire country is a cohort. *Science*. 2000;287:2398-2399.
- Sorensen HT. Regional administrative health registries as a resource in clinical epidemiology. A study of options, strengths, limitations and data quality provided with examples of use. *Int J Risk Safety Med*. 1997; 10:1-22.
- Terkelsen CJ, Norgaard BL, Lassen JF, Gerdes JC, Ankersen JP, Romer F, Nielsen TT, Andersen HR. Telemedicine used for remote prehospital diagnosing in patients suspected of acute myocardial infarction. *J Intern Med*. 2002;252:412-420.
- Terkelsen CJ, Jorgensen HA, Lassen JF, Norgaard BL, Gerdes JC, Andersen HR. Telemedicine in prehospital remote diagnosis and re-routing of a patient with acute ST-elevation myocardial infarction to primary percutaneous coronary intervention. *Ugeskr Laeger*. 2003;165: 4028-4029.
- Terkelsen CJ, Lassen JF, Norgaard BL, Gerdes JC, Poulsen SH, Bendix K, Ankersen JP, Gotzsche LB-H, Romer FK, Nielsen TT, Andersen HR. Reduction of treatment delay in patients with ST-elevation myocardial infarction: impact of pre-hospital diagnosis and direct referral to primary percutaneous coronary intervention. *Eur Heart J*. 2005;26:770-777.
- Pedersen SH, Galatius S, Hansen PR, Mogelvang R, Abildstrom SZ, Sorensen R, Davidsen U, Galloe A, Abildgaard U, Iversen A, Bech J, Madsen JK, Jensen JS. 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. *J Am Coll Cardiol*. 2009;54:2296-2302.
- Clemmensen P, Sillesen M, Ripa MS, Strange S, Loumann-Nielsen S. Prehospital diversion to hospital with acute PCI set-up using wireless 12-lead ECG transmission. *J Electrocardiol*. 2004;37(suppl):222.
- Pedersen CB, Gotzsche H, Moller JO, Mortensen PB. The Danish Civil Registration System. A cohort of eight million persons. *Dan Med Bull*. 2006;53:441-449.
- Grambsch PM, Therneau TM. Proportional hazard tests and diagnostics based on weighted residuals. *Biometrika*. 1994;81:515-526.
- Schemper M, Smith TL. Efficient evaluation of treatment effects in the presence of missing covariate values. *Stat Med*. 1990;9:777-784.
- Schemper M, Heinze G. Probability imputation revisited for prognostic factor studies. *Stat Med*. 1997;16:73-80.
- Allison PD. *Missing Data*. Thousand Oaks, CA: Sage; 2002.
- Wijns W, Kolh P, Danchin N, Di MC, Falk V, Folliguet T, Garg S, Huber K, James S, Knuuti J, Lopez-Sendon J, Marco J, Menicanti L, Ostojic M, Piepoli MF, Pirllet C, Pomar JL, Reifart N, Ribichini FL, Schalij MJ, Sergeant P, Serruys PW, Silber S, Sousa UM, Taggart D, Vahanian A, Auricchio A, Bax J, Ceconi C, Dean V, Filippatos G, Funck-Brentano C, Hobbs R, Kearney P, McDonagh T, Popescu BA, Reiner Z, Sechtem U, Simes PA, Tendera M, Vardas PE, Widimsky P, Kolh P, Alfieri O, Dunning J, Elia S, Kappetein P, Lockowandt U, Sarris G, Vouhe P, Kearney P, von SL, Agewall S, Aladashvili A, Alexopoulos D, Antunes MJ, Atalar E, Brutel de la RA, Doganov A, Eha J, Fajadet J, Ferreira R, Garot J, Halcox J, Hasin Y, Janssens S, Kervinen K, Laufer G, Legrand V, Nashef SA, Neumann FJ, Niemela K, Nihoyannopoulos P, Noc M, Piek JJ, Pirk J, Rozenman Y, Sabate M, Starc R, Thielmann M, Wheatley DJ, Windecker S, Zembala M. Guidelines on myocardial revascularization: the Task Force on Myocardial Revascularization of the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS). *Eur Heart J*. 2010;31: 2501-2555.
- Silber S, Albertsson P, Aviles FF, Camici PG, Colombo A, Hamm C, Jorgensen E, Marco J, Nordrehaug JE, Ruzyllo W, Urban P, Stone GW, Wijns W. Guidelines for percutaneous coronary interventions. The Task Force for Percutaneous Coronary Interventions of the European Society of Cardiology. *Eur Heart J*. 2005;26:804-847.
- Kushner FG, Hand M, Smith SC Jr, King SB III, Anderson JL, Antman EM, Bailey SR, Bates ER, Blankenship JC, Casey DE Jr, Green LA, Hochman JS, Jacobs AK, Krumholz HM, Morrison DA, Ornato JP, Pearle DL, Peterson ED, Sloan MA, Whitlow PL, Williams DO. 2009 focused updates: ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction (updating the 2004 guideline and 2007 focused update) and ACC/AHA/SCAI guidelines on percutaneous coronary intervention (updating the 2005 guideline and 2007 focused update): a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2009;120:2271-2306.
- Antman EM, Hand M, Armstrong PW, Bates ER, Green LA, Halasyamani LK, Hochman JS, Krumholz HM, Lamas GA, Mullany CJ, Pearle DL, Sloan MA, Smith SC Jr, Anbe DT, Kushner FG, Ornato JP, Pearle DL, Sloan MA, Jacobs AK, Adams CD, Anderson JL, Buller CE, Creager MA, Ettinger SM, Halperin JL, Hunt SA, Lytle BW, Nishimura R, Page RL, Riegel B, Tarkington LG, Yancy CW. 2007 focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol*. 2008;51:210-247.
- Boersma E; Primary Coronary Angioplasty vs. Thrombolysis (PCAT)-2 Trialists' Collaborative Group. Does time matter? A pooled analysis of randomized clinical trials comparing primary percutaneous coronary intervention and in-hospital fibrinolysis in acute myocardial infarction patients. *Eur Heart J*. 2006;27:779-788.
- Sorensen JT, Terkelsen CJ, Norgaard BL, Trautner S, Hansen TM, Botker HE, Lassen JF, Andersen HR. Urban and rural implementation of pre-hospital diagnosis and direct referral for primary percutaneous coronary intervention in patients with acute ST-elevation myocardial infarction. *Eur Heart J*. 2011;32:430-436.
- Terkelsen CJ, Sorensen JT, Maeng M, Jensen LO, Tilsted HH, Trautner S, Vach W, Johnsen SP, Thuesen L, Lassen JF. System delay and mortality among patients with STEMI treated with primary percutaneous coronary intervention. *JAMA*. 2010;304:763-771.
- Widimsky P, Wijns W, Fajadet J, de BM, Knot J, Aaberge L, Andrikopoulos G, Baz JA, Betriu A, Claeys M, Danchin N, Djambazov S, Erne P, Hartikainen J, Huber K, Kala P, Klineva M, Kristensen SD, Ludman P, Ferre JM, Merkely B, Milicic D, Morais J, Noc M, Opolski G, Ostojic M, Radovanovic D, De SS, Stenestrand U, Studencan M, Tubaro M, Vasiljevic Z, Weidinger F, Witkowski A, Zeymer U. Reperfusion therapy for ST elevation acute myocardial infarction in Europe: description of the current situation in 30 countries. *Eur Heart J*. 2010;31:943-957.
- Terkelsen CJ, Lassen JF, Norgaard BL, Gerdes JC, Jensen T, Gotzsche LB-H, Nielsen TT, Andersen HR. Mortality rates in patients with ST-elevation vs. non-ST-elevation acute myocardial infarction: observations from an unselected cohort. *Eur Heart J*. 2005;26:18-26.

## Primary Percutaneous Coronary Intervention as a National Reperfusion Strategy in Patients With ST-Segment Elevation Myocardial Infarction

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