Clinical research

A short delay from out of hospital cardiac arrest to call for ambulance increases survival

Johan Herlitz[a]*, Johan Engdahl[a], Leif Svensson[b], Marie Young[c], Karl-Axel Ängquist[d], Stig Holmberg[a]

[a] *Division of Cardiology, SU/Sahlgrenska, Göteborg, Sweden*
[b] *Division of Cardiology, South Hospital, Stockholm, Sweden*
[c] *Department of Anaesthesiology, Malmö University Hospital, Malmö, Sweden*
[d] *Surgery Department, Umeå University Hospital, Umeå, Sweden*

Aim To describe the relative impact on survival of the delay from estimated time of collapse to call for an ambulance among patients who suffer from a bystander witnessed out of hospital cardiac arrest of a cardiac aetiology.
Methods A majority of all ambulance organizations in Sweden (covering 85% of Sweden inhabitants) participate in a National survey of out of hospital cardiac arrest.
Results In all there were 9340 patients with a bystander witnessed cardiac arrest of a cardiac aetiology in whom cardiopulmonary resuscitation (CPR) was attempted participating in this survey. Survival at one month among patients with a delay between estimated time of collapse and call for ambulance of ≤4 min (median) was 6.9% versus 2.8% among patients with a median of >4 min ($P<0.0001$). When adjusting for age, sex, initial rhythm, estimated interval between collapse and start of CPR, place of arrest and the interval between call for ambulance and arrival of the rescue team, the odds ratio for survival was 0.70 (0.95% CI. 0.58–0.84) per unit increase of the natural logarithm of delay in minutes between collapse and call.
Conclusion Among patients with a bystander witnessed out of hospital cardiac arrest of a cardiac aetiology increased delay from estimated time of collapse to call for an ambulance decreased the chance of survival.
© 2003 Published by Elsevier Ltd on behalf of The European Society of Cardiology.

Introduction

During the last several decades strong efforts have been made to improve survival after hospital cardiac arrest. If a person who suffers from out of hospital cardiac arrest should have a fair chance to survive various efforts must be optimal, which are described as the chain of survival.[1] The four links are described as follows:

1 Early access;
2 Early bystander CPR;
3 Early defibrillation;
4 Early advanced cardiac life support.

The first link in this chain is the interval between estimated time of collapse and call for an ambulance. As compared with the other links of the chain of survival, the relative importance of the first link is less well described in the literature and was only approached by a few authors.[2,3] Various weak elements in this link in the chain of survival have been identified.[4] The ideal situation would be that patients or bystanders decide to call for an ambulance prior to the cardiac arrest because of warning symptoms.

However, it has been shown that such patients have less often a shockable rhythm.[5] This report aims at describing the relative impact on survival of the delay

* Correspondence to: Johan Herlitz MD, Division of Cardiology, Sahlgrenska University Hospital, SE-413 45 Göteborg, Sweden. Tel: +46 31 3421000; Fax: +46 31 829650
E-mail address: johan.herlitz@hjl.gu.se (J. Herlitz).

from estimated time of collapse to call for an ambulance among patients who suffer from a bystander witnessed out of hospital cardiac arrest of a cardiac aetiology in Sweden.

Methods

This study is based on material collected by the Swedish Cardiac Arrest Registry, which is a collaboration between The Federation of Leaders in Swedish Ambulance and emergency services (FLISA) and the Working group on CPR within the Swedish Society of Cardiology. Since 1993 the registry has been funded by The National Board of Health and Welfare. The registry, which is voluntary, started in 1990 with a few ambulance services. It has been successively joined by more and in 1995 the registry was based on reports from 57 ambulance services. At the end of the collection period the registry covers 85% of the total population in Sweden.

Patients

As a rule patients with a cardiac arrest for whom the ambulance was called were included in the registry. Patients who had obviously been dead for a long time and whose bodies were not brought to hospital by the ambulance crew were excluded. For the others, a standardized form was completed by the ambulance crew. In this survey, crew witnessed cases, non witnessed cases, cases with a non cardiac aetiology and patients in whom CPR was not started were excluded. Patients who suffered from cardiac arrest within the hospitals in the community were not included. However, sometimes the ambulance was called upon to service houses and other institutions and these patients were included in the survey.

Study design

For each case of out-of-hospital cardiac arrest, the ambulance crew filled in a form with information such as age, place of arrest, probable background to the arrest, bystander occupation and a standardized description of the resuscitation procedure, including intervention times and interventions such as bystander-CPR (a bystander was defined as someone starting CPR before the arrival of the first ambulance, regardless of profession), defibrillation, intubation, drug treatment and status at the first contact.

In ambulances with manual defibrillators, the rhythm was defined as ventricular fibrillation (VF), pulseless electrical activity (PEA) or asystole. For automated external defibrillators (AEDs), the rhythm was defined as shockable rhythm (ventricular fibrillation (VF)) or non-shockable rhythm. In this study, VF includes patients with pulseless ventricular tachycardia (VT).

To establish the time of cardiac arrest in witnessed cases, the ambulance crew was instructed to interview the bystanders about the delay from arrest to call. It was stressed in written instructions that a maximum effort had to be made to obtain these times. The ambulance crew recorded the time of arrival at the patients' side, the time of starting CPR, the time of the first defibrillation, the time of a palpable pulse, the time of starting transport to hospital and arrival at hospital. The number of direct current (DC) shocks was recorded. The ambulance crew also classified the aetiology of the arrest in nine different diagnostic categories (heart disease, lung disease, trauma, drug overdose, suicide, drowning, suffocation, sudden infant death syndrome (SIDS) and other) based on clinical assessment and bystander information. Their diagnosis was accepted for this

study and no further control was made among initial survivors during hospitalization. Immediate outcome was reported by the ambulance crew as dead on arrival, dead in the emergency room (ER) or admitted alive to hospital.

The form was filled in during and immediately after the acute event. Each form was sent to the medical director and a copy was sent to the central registry in Göteborg. Another copy was subsequently sent with additional information about whether the patient was dead or alive after one month. If there was uncertainty about survival this was controlled according to the National Registry of Deaths. All data were computerized in a data base in Göteborg.

No absolute validation of adherence to the protocol was performed, as it would have been extremely complicated and expensive to do this in 57 different ambulance districts. Instead, a questionnaire was sent to all the medical directors of the ambulance organizations participating in the registry. They were asked to estimate the accuracy of the representation of the study population. They estimated the percentage of the study population that was wrongly omitted from the study in their own district. Percentage values from this survey varied from 0% to 30% (mean 5%).

Statistical methods
Descriptive statistics
Distribution of variables are represented as percentages and mean±standard deviation. Patients were divided into two groups of equal size according to the median delay between time of cardiac arrest and call for ambulance. Information on 1-month survival was available in 98% of all cases.

Statistical analyses

For comparison between the two groups e.g. patients with a delay between cardiac arrest and call ≤median and >median regarding continuous variables Fisher's non-parametric permutation test[6] was used. For comparison of dichotomous variables between groups, Fisher′s exact test was used. Significance level in the study was *P*<0.01.

Multivariate statistical analyses

Since we aimed at describing the relative impact of the estimated interval between collapse and call for ambulance on one month survival when other confounders were taken into account all variables listed in Table 1 were included in a multivariate analysis. They were defined as follows:

1 Age (year);
2 Sex (women, men);
3 Natural logarithm of estimated interval between collapse and start of CPR (in minutes);
4 Ventricular fibrillation on admission of the ambulance crew (yes, no);
5 Cardiac arrest at home (yes, no);
6 Natural logarithm of interval between call for and arrival of the rescue team (in minutes);
7 Natural logarithm of estimated interval between collapse and call for ambulance (in minutes).

Due to missing information in some of the variables the multivariate analysis only included 79% of possible cases.

Results

This survey includes the time between 1990 and 2001. The mean annual number of patients included in the

Table 1 Age, sex, factors of resuscitation and outcome in relation to the interval between collapse and call for ambulance

| | Time between collapse and call | | |
	≤4 min n=4897	>4 min n=4443	P
Age (years; mean±SD)	70.3±12.1	71.0±11.6	0.005
Sex (women; %)	23.6	23.5	0.909
Initial ventricular fibrillation (%)	53.6	37.8	<0.0001
Cardiac arrest at home (%)	60.1	66.5	<0.0001
Interval between:			
Collapse and start of CPR			
(mean±SD; min)	8.5±21.0	17.4±42.0	<0.0001
(median)	7	15	
Call and arrival of rescue team			
(mean±SD; min)	7.8±20.5	9.2±31.3	0.010
(median)	6	6	
Hospitalized alive (%)	23.9	11.0	<0.0001
Alive	6.9	2.8	<0.0001
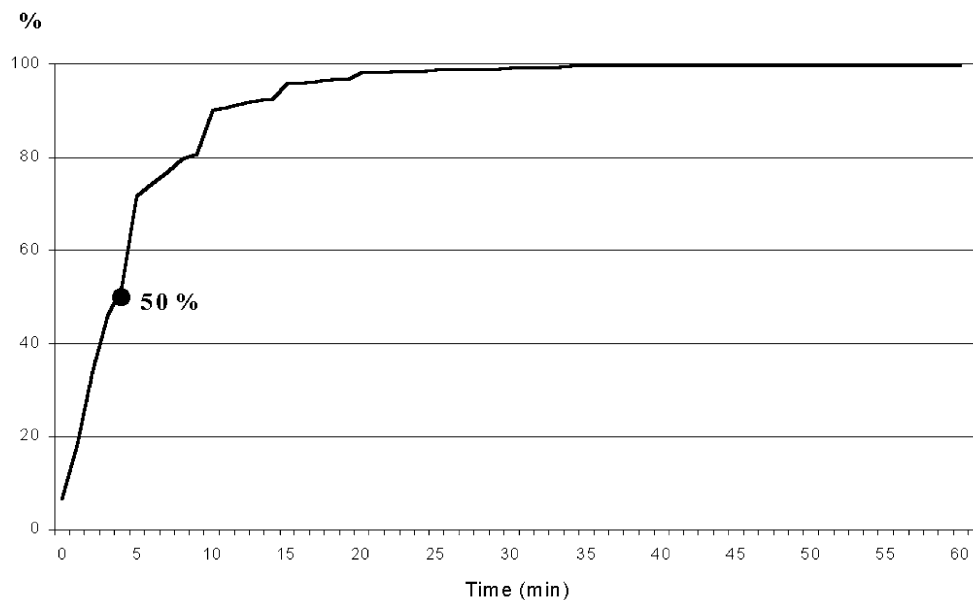
Fig. 1 Cumulative percentage of patients for whom the ambulance was called upon within various time limits after estimated time of collapse.

registry was 2553. The highest number was 3323 (1996) and the lowest was 461 (first year).

In all there were 38 750 patients in the registry. Among them CPR was started in 30 639 patients (79%).

Among these patients witnessed status was available in 28 016 cases (91%). Among these patients 15 606 were witnessed by a bystander (56%); 3374 cases were witnessed by the EMS (12%) and the remaining 9036 patients were non witnessed (32%). Among those witnessed by a bystander information on aetiology was available in 93%. Among them 77% had a cardiac aetiology.

This survey will only deal with those which were witnessed by a bystander and were of a cardiac aetiology and in whom information on the interval between estimated time of collapse and call for ambulance was available (n=9340), which conformed 84% of all bystander witnessed cases of a cardiac aetiology.

In Fig. 1 is shown the cumulative percentage of patients for whom the ambulance was called upon within various time limits after the estimated time of collapse.

The median delay between collapse and call for ambulance was 4 min and the median delay between call for and arrival of the ambulance was 6 min.

In Fig. 2 is shown the proportion of patients with various delay time between collapse and call for ambulance.

Age, sex and factors at resuscitation (Table 1)

In this table patients in whom the interval between estimated time of collapse and call was ≤the median (4 min) are compared with those in whom this interval was >4 min. We thought it was appropriate to divide the cohort into two groups according to the median. The two
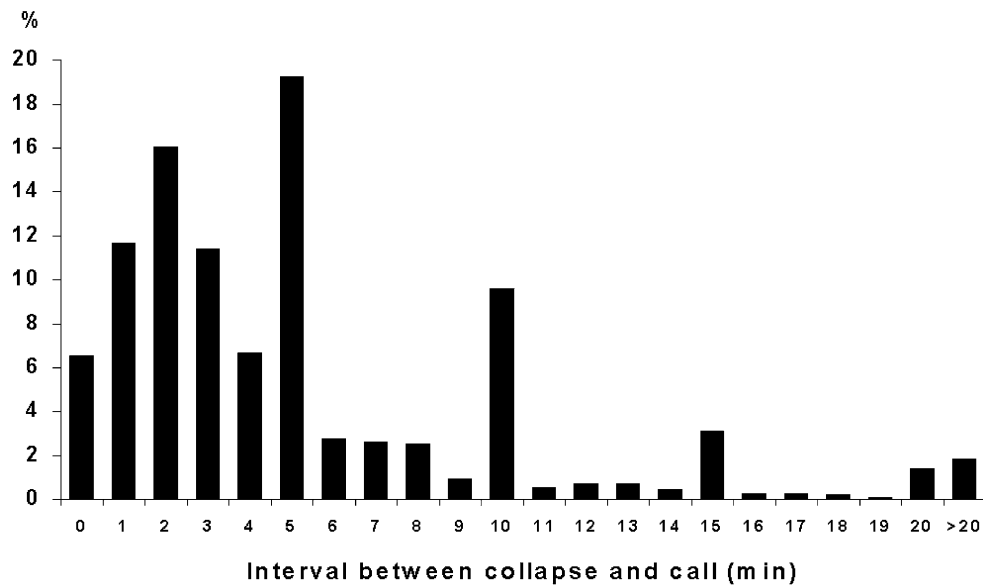
Fig. 2 Distribution of patients according to estimated interval between collapse and call for ambulance.
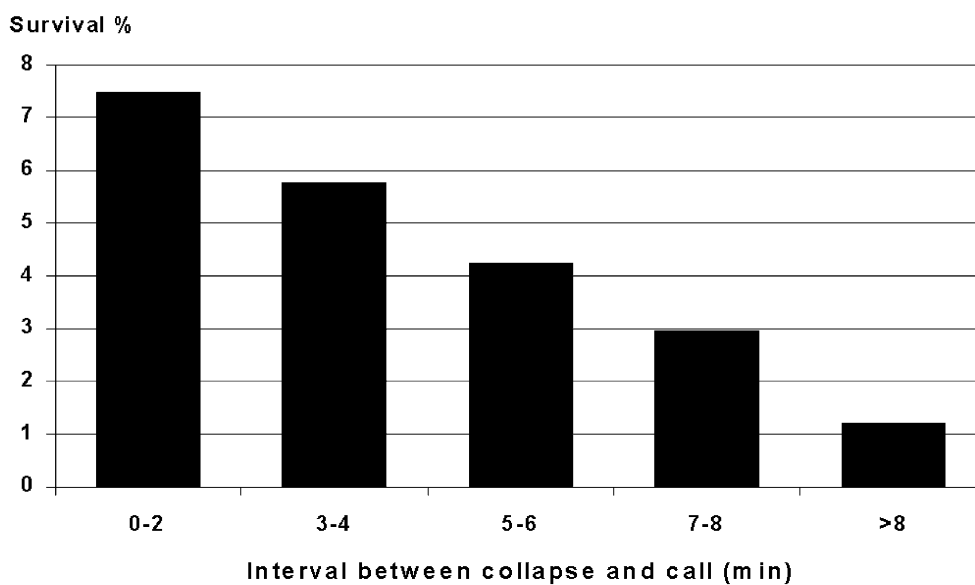

Fig. 3 Relationship between survival and interval between collapse and call among patients with a bystander witnessed out of hospital cardiac arrest.

groups did not differ with regard to sex, but those with a shorter interval were younger.

Patients in whom the interval was ≤4 min had a shorter interval between collapse and start of CPR, more often had ventricular fibrillation as the initial arrhythmia, less often suffered from the cardiac arrest at home, and finally had a shorter interval between call for ambulance and arrival of the rescue team.

Among patients who received bystander CPR the median delay from collapse to call for an ambulance was 4 min vs 5 min among patients who did not receive bystander CPR (P=0.001).

Survival (Table 1, Fig. 3)

In Table 1 and Fig. 3 is shown that there was a strong association between the interval between collapse and call for an ambulance and survival 30 days after cardiac arrest.

Multivariate analysis

When adjusting for age, sex, initial rhythm, estimated interval between collapse and start of CPR, place of arrest and the interval between call for ambulance and
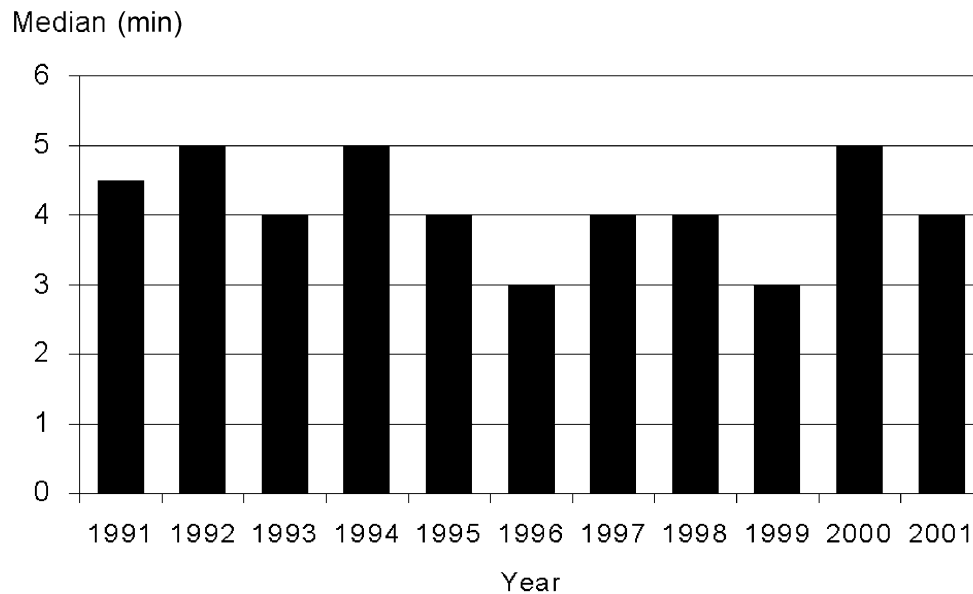
Median (min)

Fig. 4 Change in median interval between collapse and call for an ambulance over time.

arrival of the rescue team the odds ratio for survival was 0.70 (95% CI 0.58–0.84) per unit increase of the natural logarithm of delay in minutes between collapse and call.

Change in the interval between estimated time of collapse and call for ambulance between 1991 and 2001 (Fig. 4)

The median interval between estimated time of collapse and call for an ambulance remained similar over time.

Discussion

There is an ongoing debate about which are the most important factors for survival among patients who suffer from an out of hospital cardiac arrest.

It has been convincingly shown that the delay time from estimated time of collapse until defibrillation is of ultimate importance among patients who are found in ventricular fibrillation.[7,8]

Furthermore it has been shown that the interval between estimated time of collapse and start of CPR also is of ultimate importance for survival among all patients in whom CPR was started[9] and among patients who received bystander CPR.[10]

If CPR is not initiated prior to arrival of the rescue team, then both the delay to defibrillation as well as the delay to start of CPR ought to be strongly influenced by the first link in the chain of survival i.e the delay between cardiac arrest to call for an ambulance.

Some have suggested that it is not meaningful to record this link since the time of collapse can not be measured accurately.[11] It seems reasonable to think that in a small number of out of hospital cardiac arrest patients the time of out of hospital cardiac arrest was accurately measured and that in the majority this time was estimated. Unfortunately, we do not know the

distribution of patients in these two groups. One can assume that standardization of measurement of this time delay was not consistent.

An important observation in this survey was that the interval between collapse and call for ambulance conformed 40% of the overall delay between collapse and arrival of ambulance. Thus, if only measuring the interval between call for and arrival of the ambulance a little bit more than half of the overall delay time from collapse until arrival of the ambulance would be included in the analysis.

We found that the interval between estimated time of collapse and call for ambulance independent of the interval between collapse and start of CPR and the interval between call for and arrival of the ambulance significantly influenced the chance of survival.

Our survey clearly indicated that patients in whom the interval between collapse and call for ambulance was shorter had a more favourable risk profile. Thus, they had a shorter interval between collapse and start of CPR, they had a higher occurrence of ventricular fibrillation, a shorter ambulance response time and they less frequency suffered from cardiac arrest at home.

However, one might argue whether the higher occurrence of ventricular fibrillation at least to some extent was caused by the fact that delay to call for ambulance was short (the earlier the rhythm analysis is performed after cardiac arrest the higher is the likelihood of finding the patient in ventricular fibrillation). One can assume, that to some extent a short delay between collapse and call for ambulance is a surrogate marker for early defibrillation.

We had hoped that the delay from collapse to call would be much shorter among patients who received bystander CPR, since in Sweden standardized education to lay people as well as medical professionals highlights the importance of immediately dialling 112 if suspecting

a cardiac arrest. However, the delay to call was only marginally shorter in this subset of patients indicating that perhaps the CPR education in Sweden does not underscore this aspect enough.

Our data support the importance of trying to shorten the first link in the chain of survival as much as possible. Previous efforts have been less successful.[12]

There are two ways to achieve this goal:

a To initiate mass media campaigns in order to educate people about the importance of quickly dialling 112 if they suspect a cardiac arrest.
b To, when giving CPR courses to lay people even further stress the importance of 'phone first'.

One way of approaching this problem is to initiate educational campaigns in order to educate people to quickly dial 112 if suffering from acute chest pain. A few of these patients will suffer from ventricular fibrillation prior to hospital admission. However, such educational campaigns have not shown to increase survival.[12–16]

Limitation

This survey was an observational study and not a randomized trial. Therefore, one cannot exclude the possibility of bias (unknown factors which influence the final results).

As previously stated, there are often difficulties to accurately estimate the time of collapse. Therefore, we consistently use the formulation estimated time of collapse.

The proportion of patients of those who were alive 30 days after cardiac arrest who were neurologically intact was not known.

The number of patients excluded from the analysis was only estimated by each ambulance organization.

Conclusion

With each minute of increased delay from estimated time of collapse to call for an ambulance in out of hospital cardiac arrest the chance of survival decreased substantially. Thus, in all cases of cardiac arrest regardless whether it is ventricular fibrillation or asystole it seems appropriate to recommend: ALERT, then start CPR when there is only one witness. If there are more than one witness one can ALERT and one start CPR. Delay from collapse to call for an ambulance conformed 40% of the overall delay from collapse to arrival of the ambulance.

Acknowledgements

References

1. Cummins RO, Ornato JP, Thies WH et al. Improving survival from sudden cardiac arrest: the 'chain of survival' concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. *Circulation* 1991;**83**(5):1832–47.

2. Stults KR. Phone first. *J Emerg Med Services* 1987;**12**:28.

3. Walters G, Glucksman E. Planning a pre-hospital cardiac resuscitation programme: an analysis of community and system factors in London. *JR Coll Physicians Lond* 1989;**23**(2):107–10.

4. Calle P, Vanhaute O, Lagaert L et al. The 'early access' link in the chain of survival for cardiac arrest victims in Ghent, Belgium. *Eur J Emerg Med*. 1994;**1**(3):145–8.

5. Eisenberg MS, Cummins RO, Litwin PE et al. Out-of-hospital cardiac arrest: significance of symptoms in patients collapsing before and after arrival of paramedics. *Am J Emerg Med* 1986;**4**(2):116–20.

6. Bradley JV. Distribution Free Statistical Test. London: Prentice-Hall Inc, 1968 pp. 73–78.

7. Herlitz J, Ekström L., Wennerblom B et al. Survival in patients found to have ventricular fibrillation after cardiac arrest witnessed outside hospital. *Eur Heart J* 1994;**15**:1628–33.

8. Holmberg M, Holmberg S, Herlitz J et al. Incidence, duration and survival of ventricular fibrillation in out-of-hospital cardiac arrest patients in Sweden. *Resuscitation* 2000;**44**:7–17.

9. Waalewijn RA, Tijssen JGP, Koster RW. Bystander initiated actions in out-of-hospital cardiopulmonary resuscitation. Results from the Amsterdam resuscitation study (ARREST). *Resuscitation* 2001;**50**: 273–9.

10. Holmberg M, Holmberg S, Herlitz J. Factors modifying the effect of bystander-CPR on survival in out-of-hospital cardiac arrest patients. *Eur Heart J* 2001;**22**:511–9.

11. Kuisma M, Maatta T. Out-of hospital cardiac arrests in Helsinki: Utstein style reporting. *Heart* 1996;**76**(1):18–23.

12. Eppler E, Eisenberg MS, Schaeffer S et al. 911 and emergency department use for chest pain: results of a media-campaign. *Ann Emerg Med* 1994;**24**(2):202–8.

13. Blohm M, Herlitz J, Hartford M et al. Consequences of a media campaign focusing on delay in acute myocardial infarction. *Am J Cardiol* 1992;**69**(4):411–3.

14. Meischke H, Dulberg EM, Schaeffer SS et al. Call fast, Call 911': a direct mail campaign to reduce patient delay in acute myocardial infarction. *Am J Public Health* 1997;**87**(10):1705–9.

15. Ho MT, Eisenberg MS, Litwin PE et al. Delay between onset of chest pain and seeking medical care: the effect of public education. *Ann Emerg Med* 1989;**18**(7):727–31.

16. Luepker RV, Raczynski JM, Osganian S et al. Effect of a community intervention on patient delay and emergency medical service use in acute coronary heart disease: The Rapid Early Action for Coronary Treatment (REACT) Trial. *JAMA* 2000;**284**(1):60–7.