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Effect of bystander initiated cardiopulmonary resuscitation on ventricular fibrillation and survival after witnessed cardiac arrest outside hospital

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Abstract

***Objective*—To describe the proportion of patients who were discharged from hospital after witnessed cardiac arrest outside hospital in relation to whether a bystander initiated cardiopulmonary resuscitation.**

***Patients*—All patients with witnessed cardiac arrest outside hospital before arrival of the ambulance and in whom cardiopulmonary resuscitation was attempted by the emergency medical service in Gothenburg during 1980–92.**

***Results*—Cardiopulmonary resuscitation was initiated by a bystander in 18% (303) of 1660 cases. In this group 69% had ventricular fibrillation at first recording compared with 51% in the remaining patients ($P < 0.001$). Among patients in whom cardiopulmonary resuscitation had been initiated by a bystander 25% were discharged alive versus 8% of the remaining patients ($P < 0.001$). Independent predictors of survival were in order of significance: initial arrhythmia ($P < 0.001$), interval between collapse and arrival of first ambulance ($P < 0.001$), cardiopulmonary resuscitation initiated by a bystander ($P < 0.001$), and age ($P < 0.01$). Among patients who were admitted to hospital alive 30% of patients in whom cardiopulmonary resuscitation had been initiated by a bystander compared with 58% of remaining patients ($P < 0.001$) had brain damage and died in hospital. Corresponding figures for death in association with myocardial damage were 18% and 29% respectively ($P < 0.01$).**

***Conclusions*—Cardiopulmonary resuscitation initiated by a bystander maintains ventricular fibrillation and triples the chance of surviving a cardiac arrest outside hospital. Furthermore, it seems to protect against death in association with brain damage as well as with myocardial damage.**

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Most deaths from ischaemic heart disease occur outside hospital and are mainly due to ventricular fibrillation.[1 2] During the past two decades strong efforts have been made to improve the prognosis in this patient population.[3 4] In Gothenburg, as well as in many other parts of the world, educational programmes have been initiated with the aim of teaching people in the community how to perform cardiopulmonary resuscitation when indicated. We describe the proportion of patients with witnessed cardiac arrest outside hospital in whom cardiopulmonary resuscitation was initiated by a bystander; we compared the outcome in such patients with those in whom resuscitation was not initiated.

Patients and methods

The city of Gothenburg has an area of 449 km^2 and 434 000 inhabitants. Of these, 48% are men. The age distribution is as follows: 0–12 months 1%, 1–4 years 5%, 5–14 years 10%, 15–24 years 13%, 25–34 years 17%, 35–44 years 14%, 45–54 years 12%, 55–64 years 9%, 65–74 years 10%, 75–84 years 7%, $\geqslant$ 85 years 2%.

Nine per cent of the population are below the poverty level—that is, they require financial support from the community. Sixty five percent of the population continues their education past the compulsory school level. In 1990 there were 5108 deaths per year. Of these, 1360 were attributable to ischaemic or coronary heart disease, (International Classification of Diseases codes 410–414). There were 1177 deaths per 100 000 people per year from all causes. For men aged 55–64 there were 67 deaths from ischaemic heart disease and for women 17 per 100 000 people.

ORGANISATION AND EQUIPMENT

All emergency patients arrived in the two city hospitals (Sahlgrenska and Östra Hospitals). All ambulances were dispatched by one ambulance centre. Ambulances were dispatched according to a two tiered system—that is, for each call judged to be a cardiac arrest a mobile coronary care unit, if available, and the nearest standard ambulance were dispatched simultaneously. During the first years one mobile coronary care unit was operating full time and one part time. During the later part of the study both mobile coronary care units were operating full time. There were 11 available standard ambulances placed in six fire departments. The fire departments are localised so that 50% of patients will be reached within five minutes and 97% will be reached within 10 minutes. The median time between alarm and until the patient was reached was 5 minutes for the standard ambulance and 8 minutes for the mobile coronary care unit.

Table 1 Variables related to witnessed cardiac arrest in patients in whom cardiopulmonary resuscitation was initiated by bystander and in those in whom it was not. Values are numbers (percentages) of patients unless stated otherwise

	Bystander cardiopulmonary resuscitation (n = 303)	*No bystander cardiopulmonary resuscitation (n = 1357)*	*P value*
Age (years):			
Median	69	71	< 0·01
Range	0–93	0–95	
Sex:			
Male	79 (n = 239)	74 (n = 1004)	
Female	21 (n = 64)	26 (n = 353)	
Initial rhythm:			
Ventricular fibrillation	69 (n = 209)	51 (n = 692)	< 0·001
Electromechanical dissociation	14 (n = 42)	22 (n = 299)	< 0·001
Asystole	16 (n = 48)	25 (n = 339)	< 0·001
Median time from:			
Collapse to arrival of standard ambulance (minutes)	6	6	
Collapse to arrival of paramedical staff (minutes)	8	9	
Nurse present	28 (n = 85)	21 (n = 285)	< 0·01
Time of collapse:			
0–6	6 (n = 18)	12 (n = 163)	
7–12	31 (n = 95)	28 (n = 380)	
13–18	39 (n = 119)	34 (n = 461)	< 0·01
19–24	23 (n = 71)	26 (n = 353)	
Cause of arrest:			
Cardiac disease	93 (n = 282)	90 (n = 1221)	< 0·05

One mobile coronary care unit was staffed by one nurse on weekdays from 0800–1700. During 1991 and 1992 the other mobile coronary care unit was staffed by a nurse part time on weekdays. The nurses were delegated to give adrenaline, atropine, lignocaine, morphine, frusemide, and bicarbonate according to a standard protocol.

Each mobile coronary care unit had two paramedical staff who had received 39 weeks of medical training that included resuscitation techniques and intubation. During the later part of the study some of the paramedical staff were delegated to give lignocaine, adrenaline, atropine, and bicarbonate according to a standard protocol.

The standard ambulances had two ambulance crew who had had seven weeks of medical training. During 1986–8 more and more of the standard ambulances became equipped with semiautomatic defibrillators. Before then the standard ambulances could only give cardiopulmonary resuscitation and were not equipped with defibrillators.

Since 1985 there has been organised teaching of cardiopulmonary resuscitation for lay people, and in 1989, 100 000 people had been taught. In the past three years another 25 000 people have completed such training.

Treatment and cardiac arrest

Treatment varied over the course of the study but has always complied with the recommendations of the American Heart Association. Exceptions to this were the cases in which the staff did not have the delegated right to give drugs on board the ambulances. At those times only cardiopulmonary resuscitation and defibrillation were given.

Definitions

Cerebral performance categories were scored as follows:

(1) Good cerebral performance: conscious, alert, able to work, and live a normal life. Patient may have minor psychological or neurological deficits (mild dysphasia, nonincapacitating hemiparesis, or minor cranial nerve abnormalities.

(2) Moderate cerebral disability: conscious, sufficient cerebral function for part time work in sheltered environment or independent activities of daily life (dressing, travelling by public transport, and preparing food. Patient may have hemiplegia, seizures, ataxia, dysarthria, dysphasia, or permanent memory or mental changes.

(3) Severe cerebral disability: conscious, dependent on others for daily support because of impaired brain function (in an institution or at home with exceptional family effort). Patient may have some (limited) cognition. This category includes a wide range of cerebral abnormalities ranging from being able to walk but having severe memory disturbance

Table 2 Proportion of patients who were discharged from hospital in relation to whether cardiopulmonary resuscitation was initiated by a bystander

	Bystander cardiopulmonary resuscitation					
	Yes		*No*			
	No of patients evaluated	*No (%) of patients discharged from hospital*	*No of patients evaluated*	*No (%) of patients discharged from hospital*	*Relative risk*	*P value*
All patients	303	77 (25)	1357	110 (8)	3·2	< 0·001
Age (years):						
0–62	102	20 (20)	298	39 (13)	1·6	> 0·05
63–71	63	18 (29)	342	27 (8)	4·9	< 0·001
72–77	60	20 (33)	331	30 (9)	5·2	< 0·001
78–95	70	19 (27)	354	14 (4)	9·0	< 0·001
Sex:						
Male	240	65 (27)	1008	85 (8)	3·2	< 0·001
Female	63	12 (19)	349	23 (7)	2·9	< 0·01
Initial rhythm:						
Ventricular fibrillation	208	71 (34)	695	100 (14)	2·4	< 0·001
Electromechanical dissociation	42	2 (5)	306	2 (0·6)	7·3	> 0·05
Asystole	48	1 (2)	335	4 (1)	1·7	> 0·05
Presence of nurse:						
Yes	85	22 (26)	280	32 (11)	2·3	< 0·01
No	218	55 (25)	1077	76 (7)	3·6	< 0·001
Cause of cardiac arrest:						
Cardiac disease:						
Yes	283	75 (26)	1215	104 (9)	3·1	< 0·001
No	20	2 (10)	142	4 (3)	3·6	> 0·05

Table 3 Proportion of patients who were discharged from hospital in relation to whether cardiopulmonary resuscitation was initiated by a bystander

	Bystander cardiopulmonary resuscitation					
	Yes		*No*			
	No of patients evaluated	*No (%) of patients discharged from hospital*	*No of patients evaluated*	*No (%) of patients discharged from hospital*	*Relative risk*	*P value*
Time of day:						
24–06	19	3 (16)	165	12 (7)	2·2	> 0·05
07–12	95	30 (32)	376	36 (10)	3·3	< 0·001
13–18	119	28 (24)	467	36 (8)	3·1	< 0·001
19–24	70	16 (23)	348	24 (7)	3·3	< 0·001
Time from collapse to arrival of first ambulance (minutes):						
1–4	69	27 (39)	238	33 (14)	2·8	< 0·001
5	48	18 (38)	233	35 (15)	2·5	< 0·01
6–8	68	12 (18)	348	23 (7)	2·7	< 0·05
9–65	56	5 (9)	277	6 (2)	4·1	< 0·05

or dementia that precludes independent existence to paralysis and the ability to communicate only with eyes, as in the locked in syndrome.

(4) Coma or vegetative state: not conscious, unaware of surroundings, no cognition. Patients have no verbal or psychological interactions with the environment.

(5) Death: Certification of brain stem death or death by traditional criteria.

Death associated with brain damage was defined if the best cerebral performance score before death was 4 or 5. Death associated with myocardial damage was defined if death was associated with either cardiogenic shock or congestive heart failure. A few patients were thus classified as dying both from brain and myocardial damage.

TREATMENT AND CLINICAL INVESTIGATION AFTER ADMISSION TO HOSPITAL

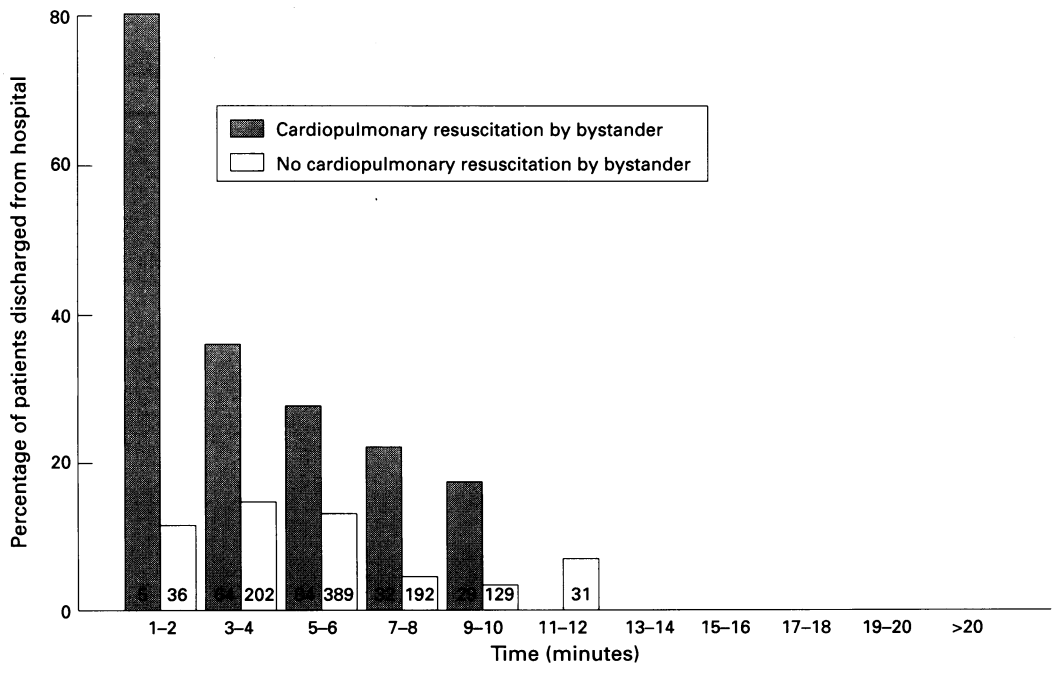
There were no general recommendations in terms of antiarrhythmic treatment of this patient population. Treatment for myocardial ischaemia and pump failure was given according to clinical routine. There were no strict indications for coronary angiography or electrophysiological evaluation.

STATISTICAL METHODS

Fisher's non-parametric permutation test was used to test for differences between groups. For comparison of proportions between groups Fisher's exact test was used, which is a special case of Fisher's permutation test. Since there were differences at baseline between the two groups, the influence of these factors were eliminated in the analysis by an extension of Mantel's technique of pooling applied to Fisher's permutation test.[5]

Results

In all, 3434 cardiac arrests outside hospital were reached by the emergency medical service and cardiopulmonary resuscitation was initiated. Of these, 1890 were judged to be witnessed; of these 1890 cases, 1660 occurred before the arrival of the first ambulance. This report deals with these 1660 cases and relates



Proportion of patients being discharged from hospital in relation to whether cardiopulmonary resuscitation was initiated by a bystander and to the time between cardiac arrest and arrival of first ambulance. Numbers are the number of patients evaluated.

Table 4 Mortality in hospital among patients admitted alive in relation to whether cardiopulmonary resuscitation was initiated by a bystander

	Bystander cardiopulmonary resuscitation				
	Yes		*No*		
	No of patients evaluated	*No (%) of patients admitted alive who died*	*No of patients evaluated*	*No (%) of patients admitted alive who died*	*P value*
Patients admitted alive	303	124 (41)	1357	317 (23)	< 0·001
Hospital phase*					
Death	124	47 (38)	317	209 (66)	< 0·001
Death due to brain damage	124	37 (30)	317	184 (58)	< 0·001
Death due to myocardial damage†	124	23 (18)	317	93 (29)	< 0·01

*Including only patients admitted alive.
†Some patients were judged to die in association with both brain and myocardial damage.

the outcome to whether cardiopulmonary resuscitation was initiated by a bystander before arrival of the ambulance. In all, cardiopulmonary resuscitation was initiated by a bystander in 18% of the cases. The proportion of patients in whom such cardiopulmonary resuscitation was initiated has increased moderately over time, being about 10–15% at the beginning of the 1980s and 20–25% at the beginning of the 1990s.

BASELINE CHARACTERISTICS

There were some differences in the baseline characteristics between patients who did and did not have cardiopulmonary resuscitation initiated by a bystander. Patients treated by a bystander were younger and more often showed ventricular fibrillation in their first electrocardiograms. A nurse was more often accompanying the mobile coronary care unit in these cases. In such cases the cardiac arrest was more likely to have occurred during daytime and the cardiac arrest was more often judged to have been caused by a cardiac disease.

SURVIVAL

Univariate analysis (tables 2–4)

In all, 25% of patients in whom cardiopulmonary resuscitation was initiated by bystanders were discharged from hospital versus 8% of the remaining patients (odds ratio 3,2; 95% confidence interval 2,5–4,2; P < 0·001). The discrepancy between the two groups seemed to increase with age but was similar in males and females.

Patients in whom cardiopulmonary resuscitation was initiated by a bystander had a higher likelihood of survival regardless of previous history and circumstances at the time of cardiac arrest. The difference between patients who did and did not receive such resuscitation was fairly similar regardless of the interval between cardiac arrest and arrival of the first ambulance (table 3 and figure 1).

Among patients who were given cardiopulmonary resuscitation by a bystander and were discharged from hospital, 78% survived one year compared with 80% in the remaining patients (P > 0·2). Overall, 21% of patients who had been resuscitated by a bystander were alive after one year compared with 7% of the rest (P < 0·001).

As shown in table 4, the overall death rate and death in association with brain damage as well as myocardial damage were less frequent in patients who had received cardiopulmonary resuscitation from a bystander.

Multivariate analysis

We simultaneously considered all factors listed in tables 2 and 3 to find independent predictors of death; these are listed in table 5 in order of significance.

Table 5 Independent predictors of survival

	Parameter estimate	*SE*	*P value*
Intercept	–1·14	0·58	< 0·001
Initial arrhythmia	2·34	0·33	< 0·001
Interval between collapse and arrival of first ambulance	–0·26	0·04	< 0·001
Cardiopulmonary resuscitation initiated by bystander	1·15	0·20	< 0·001
Age	–0·02	0·01	< 0·01

Discussion

This study describes the outcome among patients with witnessed cardiac arrest outside hospital in relation to whether cardiopulmonary resuscitation was initiated by a bystander. In all 18% of all victims received such help from a bystander. This figure is somewhat lower when compared with that in many previous reports.[6–9] As we have described in the methods section, strong efforts have been made since 1985 to teach people in Gothenburg how to perform cardiopulmonary resuscitation. However, the increase in the use of such resuscitation by bystanders since then has been quite modest.

Patients in whom cardiopulmonary resuscitation was initiated by a bystander were younger than the remaining patients. Furthermore, they more frequently suffered cardiac arrest during the day, when a nurse more often accompanied the mobile coronary unit.

Among the factors that differed between the two groups at baseline only age was independently associated with survival. The difference in ventricular fibrillation was judged to be caused by the cardiopulmonary resuscitation from a bystander rather than being a different baseline variable.

When the difference in age was corrected for patients who had cardiopulmonary resus-

citation from a bystander were three times more likely to survive compared with the remaining patients. Indeed, one out of four patients in whom cardiopulmonary resuscitation was initiated by a bystander were discharged from hospital. The mechanism by which cardiopulmonary resuscitation increases survival after a cardiac arrest has been debated.[10] It may postpone the conversion of ventricular fibrillation to a more refractory arrhythmia. In two previous studies patients in whom cardiopulmonary resuscitation was initiated by a bystander had a higher frequency of ventricular fibrillation as the first recorded arrhythmia.[7 11] We found such patients to have a significantly higher frequency of ventricular fibrillation as the first recorded arrhythmia when compared with the remaining patients. A possible but hopefully trivial bias is that patients with end stage heart disease might be more likely to have asystole than ventricular fibrillation. Bystanders are more likely to resuscitate victims of unexpected cardiac arrest, who are intrinsically more likely to have ventricular fibrillation.

Our results are in agreement with those of previous studies, which show cardiopulmonary resuscitation from bystanders to be associated with an increase in survival after cardiac arrest outside hospital.[7 10–12] However, many of the previous studies showing benefit from such resuscitation were based on less well defined patient populations and included patients with unwitnessed cardiac arrest.

Resuscitation by a bystander was associated with a marked reduction of mortality in hospital among patients who were admitted alive. Patients seemed to be protected from death associated with brain damage as well as myocardial damage. Our data are supported by Weaver *et al*, who found improved neurologic recovery after the efforts of bystanders.

Among patients being discharged from hospital the prognosis during the first year was similar regardless of whether cardiopulmonary resuscitation had been initiated by a bystander. These observations were based on a smaller sample size. They do, however, suggest that the effect of such resuscitation in terms of survival is shown during the first weeks and that this effect is then maintained, without further improvement in survival.

We had expected a time trend showing a more obvious effect of cardiopulmonary resuscitation initiated by a bystander on survival among patients with a longer interval between their cardiac arrest and the arrival of the first ambulance. The relative risk tended to be only slightly more affected in patients with a longer interval.

Surprisingly, we found a more marked effect of resuscitation by a bystander in older patients. We have no explanation for this observation; we thus suggest cautiousness in its interpretation, as we are not aware of any previous study showing similar results.

CONCLUSION

Among 1660 patients with a witnessed cardiac arrest before arrival of first ambulance and in whom efforts at cardiopulmonary resuscitation were attempted, resuscitation by a bystander seemed to maintain ventricular fibrillation and was associated with a threefold increase in the proportion of patients being discharged from hospital.

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