CARDIOVASCULAR MEDICINE

Factors associated with survival to hospital discharge among patients hospitalised alive after out of hospital cardiac arrest: change in outcome over 20 years in the community of Göteborg, Sweden

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Objective: To describe the change in survival and factors associated with survival during a 20 year period among patients suffering from out of hospital cardiac arrest and being hospitalised alive.
Patients: All patients hospitalised alive in the community of Göteborg after out of hospital cardiac arrest between 1 October 1980 and 1 October 2000 were included.
Methods: Patient data were prospectively computerised with regard to factors at resuscitation. Data on medical history and hospitalisation were retrospectively recorded. Patients were divided into two groups (the first and second 10 year periods).
Setting: Community of Göteborg, Sweden.
Results: 5505 patients suffered from cardiac arrest during the time of the survey. Among them 1310 patients (24%) were hospitalised alive. Survival (discharged alive) was 37.5% during the first part and 35.1% during the second part (NS). The following were independent predictors of an increased chance of survival: ventricular fibrillation/tachycardia as the first recorded rhythm (odds ratio (OR) 3.46, 95% confidence interval (CI) 2.36 to 5.07); witnessed arrest (OR 2.50, 95% CI 1.52 to 4.10); bystander initiated cardiopulmonary resuscitation (OR 2.00, 95% CI 1.42 to 2.80); the patient being conscious on admission to hospital (OR 6.43, 95% CI 3.61 to 11.45); sinus rhythm on admission to hospital (OR 1.53, 95% CI 1.12 to 2.10); and treatment with lidocaine in the emergency department (OR 1.64, 95% CI 1.16 to 2.31). The following were independent predictors of a low chance of survival: age > 70 years (median) (OR 0.65, 95% CI 0.47 to 0.88); atropine required in the emergency department (OR 0.35, 95% CI 0.16 to 0.75); and chronic treatment with diuretics before hospital admission (OR 0.59, 95% CI 0.43 to 0.81).
Conclusion: There was no improvement in survival over time among initial survivors of out of hospital cardiac arrest during a 20 year period. Major indicators for an increased chance of survival were initial ventricular fibrillation/tachycardia, bystander cardiopulmonary resuscitation, arrest being witnessed, and the patient being conscious on admission. Major indicators for a lower chance were high age, requirement for atropine in the emergency department, and chronic treatment with diuretics before cardiac arrest.

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A large proportion of patients who die from ischaemic heart disease die outside hospital in sudden death.[1] Only a minority of patients are successfully resuscitated and can be discharged alive from hospital.[2 3]

To increase survival among these patients the concept of the chain of survival has emerged.[4] However, this chain (early access, early bystander cardiopulmonary resuscitation, early defibrillation, and early advanced cardiac life support) does not include the hospital care of initial survivors. Not much has been written about this aspect of the handling of these patients. Taking into account the vast variations in reported hospital survival,[5 6] we believe that more attention must be paid to the "fifth link" to view a complete chain from early access to hospital discharge.

This article describes experiences in the community of Göteborg over 20 years with regard to treatment, outcome, and predictors of outcome among patients hospitalised alive after out of hospital cardiac arrest. Our hypothesis was that among patients hospitalised alive after out of hospital cardiac arrest there would be an increase in survival to discharge over time and that factors associated with survival can be defined from history, factors at resuscitation, and status on admission to the emergency department. We have previously described this database in a preliminary report in 1994[7] and in a comparison of outcome between women and men in 1999.[8]

MATERIAL AND METHODS

Target population

Since 1974, the municipality of Göteborg has had an area of 455 km^2, excluding areas of water. The population increased from 427 644 to 457 400 between 1980 and 1996. Of the total population, 49% are men. The age distribution of the population is as follows: 0–4 years, 6.1%; 5–14 years, 10.6%; 15–24 years, 12.9%; 25–34 years 17.8%; 35–44 years, 13.5%; 45–54 years, 13.0%; 55–64 years, 8.8%; 65–74 years, 8.4%; 75–84 years, 67%; and > 85 years, 2.2% (1996 data).

In 1990, there were 5108 deaths in Göteborg, 1360 of which were attributable to ischaemic or coronary heart disease (*International classification of diseases*, injuries and causes of death codes 410–414).

Organisation and equipment

All the ambulances were dispatched by one ambulance centre according to a two tier system—that is, for each call judged to be for a cardiac arrest, a mobile coronary care unit, if available, and the nearest standard ambulance were dispatched simultaneously. The proportion of patients reached by both

Table 1 Age, sex, and medical history

	Period 1 (n=533)*	Period 2 (n=777)†	p Value
Age (years)			<0.0001
Median	69	71	
Mean (SD)	65 (16)	68 (14)	
Range	0–91	0–99	
Sex (%)			
Women	27	31	
Men	73	69	
History (%)			
Myocardial infarction	44	34	0.0001
Angina pectoris	43	35	0.002
Congestive heart failure	36	26	<0.0001
Hypertension	26	26	
Diabetes mellitus	13	14	
Bronchial asthma	10	11	
Cardiac arrest	5	3	
Stroke	12	11	
Smoking (230‡, 197§)	54	33	<0.0001
Chronic alcohol abuse (45‡, 35§)	6	9	

*In terms of history, except for smoking and chronic alcohol abuse, information was missing for four patients.
†In terms of history, except for smoking and chronic alcohol abuse, information was missing for 28 patients.
‡Number of patients with missing information during period 1.
§Number of patients with missing information during period 2.

tiers was similar during the two periods, nearly 100%. All patients suffering an out of hospital cardiac arrest arrived at one of the two city hospitals in Göteborg.

Selection for admission to one or the other hospital was based purely on geographical criteria.

Data collection

Patients suffering an out of hospital cardiac arrest between 1 October 1980 and 1 October 2000 were included in the survey, regardless of the cause of the arrest and the patient's age. Data on the entire cardiac arrest cohort were obtained from the Göteborg emergency medical service. Patients were excluded if the emergency medical service did not attempt resuscitation. Further medical data on patients admitted to hospital were obtained from hospital records and general practitioners' records. Information was gathered similarly for the two hospitals and for the two time periods. All the patients admitted alive to hospital were identified. The patients were recruited from the same municipality and resuscitated by the same emergency medical service but they were taken to one of the two city hospitals in the municipality of Göteborg: Sahlgrenska Hospital or Östra Hospital.

Being hospitalised alive was defined according to the Utstein criteria—that is, the patient had to be alive when admitted to a hospital ward.

Treatment and investigations

There were no guidelines for treatments and investigations in any of the two hospitals.

Rules for not starting and stopping resuscitation in the field

Rules for starting resuscitation and stopping resuscitation in the field did not change over time. The ambulance staff were only allowed to stop resuscitation after continuous asystole for 30 minutes with no sign of respiration or circulation.

Statistical analysis

In the correlation analyses Pitman's test was used.[9] All the analyses were performed using the Statistical Analysis System (SAS Institute Inc, Cary, North Carolina, USA). For comparison of dichotomous variables between groups Fisher's exact test was used, which is a special form of Pitman's test. For multivariate analysis, a stepwise logistic regression procedure was used. In the multivariate analysis of factors up to and including hospital admission, only those for which information was missing for < 15% of patients were included in the model. Thus, the following were excluded from the multivariate analysis: history of smoking and interval between collapse and arrival of an ambulance.

All significance tests were two tailed. Because of the large number of p values calculated no formal significance level is stated. In the tables only $p < 0.05$ is denoted. To compare differences in outcome over time, patients were divided into groups with an equal time of inclusion—that is, two 10 year periods. Thus, the cut off date was 31 October 1990, which means that the first time interval was 31 October 1980 to 31 October 1990 and the second time interval was 31 October 1990 to 31 October 2000.

RESULTS

In all, 1310 patients (24%) of 5505 patients suffering from out of hospital cardiac arrest were admitted alive to hospital during the time of the survey. During period 1, there were 670 admittances and during period 2 there were 639. Among all 5505 patients the mean (SD) age during period 1 was 65 (17) years compared with 68 (16) years during period 2 ($p < 0.0001$). During period 1 the response time—that is, the time between cardiac arrest and arrival of the ambulance—was 6.4 (5.5) minutes compared with 6.3 (4.9) minutes during period 2 (NS). During period 1 the mean interval between cardiac arrest and defibrillation was 9.4 (5.4) minutes compared with 6.7 (4.2) minutes during period 2 ($p < 0.0001$). The remaining part of the survey included only patients hospitalised alive.

Comparison of the periods

Age, sex, and medical history

Patients during the second period were older but had a lower prevalence of previous acute myocardial infarction, angina pectoris, congestive heart failure, and smoking (table 1).

Chronic medication before hospital admission

There was a decrease in the proportion of patients chronically treated with digitalis and diuretics and an increase in the proportion chronically treatment with aspirin and angiotensin converting enzyme inhibitors (table 2).

Factors at resuscitation

During the second period fewer patients were found in ventricular fibrillation/tachycardia (table 3).

Table 2 Number of patients chronically treated with various medications before hospital admission

	Period 1 (n=533)*	Period 2 (n=777)†	p Value
β Blockers	29	30	
β Stimulants	6	7	
Calcium channel blockers	8	11	
Long acting nitrates	14	13	
Diuretics	46	36	0.0008
Digitalis	37	22	<0.0001
Other antiarrhythmics	3	3	
ACE inhibitors	5	18	<0.0001
Aspirin	9	26	<0.0001
Anticoagulants	11	13	
Lipid lowering drugs	1	4	0.001
Antidiabetics	10	11	
Psychopharmaceuticals	13	11	
Other medication	63	47	<0.0001

*Information missing for seven patients.
†Information missing for 53 patients.
ACE, angiotensin converting enzyme.

Table 3 Factors at resuscitation

	Period 1 (n=533)	Period 2 (n=777)	p Value
Initial ventricular fibrillation/tachycardia (%)	72	58	<0.0001
Bystander CPR (%) (7*, 52†)	21	24	
Witnessed arrest (%) (82*, 54†)	86	82	
Interval between cardiac arrest and arrival of ambulance (minutes)			
Mean (SD)	4.8 (3.3)	4.9 (3.7)	
Median	5	5	
Range	0–20	1–25	
Interval between cardiac arrest and first defibrillation (minutes)			
Mean (SD)	7.8 (4.3)	5.5 (3.3)	<0.0001
Median	7	5	
Range	0–36	0–23	

*Number of patients with missing information during period 1.
†Number of patients with missing information during period 2.
CPR, cardiopulmonary resuscitation.

Table 4 Status on admission to hospital

	Period 1 (n=533)	Period 2 (n=777)	p Value
Consciousness (2*, 22†)			0.009
Awake	6	12	
Unconscious (superficially)	18	17	
Unconscious (deeply)	76	72	
Breathing (%) (0*, 20†)			0.0007
Unassisted	25	34	
Assisted	75	66	<0.0001
Palpable pulse (%) (36*, 20†)	76	89	<0.0001
Ongoing CPR (2*, 20†)	22	10	<0.0001
ECG pattern (27*, 32†)			
Non-pathological	9	9	
Pathological but no ischaemia	36	38	
Sign of acute ischaemia	55	53	
Treatment in emergency department (%) (5*, 20†)			
Defibrillation	16	9	0.0001
Adrenaline	16	11	0.004
Atropine	9	6	0.011
Lidocaine	43	16	<0.0001
Initial rhythm (%) (7*, 30†)			NS
Sinus rhythm	54	58	
Supraventricular arrhythmia	20	26	
Nodal rhythm	2	2	
Slow ventricular rhythm	2	2	
Atrioventricular block III	0	0.8	
Pacemaker rhythm	0	1	
Ventricular tachycardia	3	2	
Ventricular fibrillation	6	3	
Pulseless electrical activity	3	3	
Asystole with p waves	1	0.3	
Asystole without p waves	7	1	

*Number of patients with missing information during period 1.
†Number of patients with missing information during period 2.
ED, ermergency department.

Findings on admission to hospital

There was a slight decrease in the proportion of patients requiring assisted breathing (table 4). Ongoing cardiopulmonary resuscitation was used less frequently during the second study interval. Defibrillation and treatment with various medications were also required less frequently.

Survival

Despite these changes over time in the characteristics of patients being admitted alive to hospital after out of hospital cardiac arrest, the proportion of initial survivors who were discharged from hospital did not change (37.5% during period 1 and 34.5% during period 2).

Use of medical resources while in hospital

There were pronounced changes in the use of various investigational procedures and treatments (table 5). Thus, there was an increase in the use of echocardiography, thrombolysis, percutaneous transluminal coronary angioplasty, and implantable cardioverter defibrillators. On the other hand, there was a decrease in the use of exercise test, electrophysiological testing, and Holter monitoring.

Predictors of survival

Univariate analysis

As table 6 shows, a large number of factors (age, previous history, chronic medication before cardiac arrest, events at resuscitation, and status on admission to hospital) were associated with the chance of surviving to hospital discharge.

Multivariate analysis

The following were independent predictors of an increased chance of survival: chronic treatment with diuretics and antidiabetics before hospital admission, initial ventricular fibrillation/tachycardia, bystander cardiopulmonary resuscitation, witnessed cardiac arrest, consciousness on admission to

Table 5 Investigation and treatment in hospital

	Period 1 (n=533)	Period 2 (n=777)	p Value
Exercise test	14	9	0.004
Coronary angiography	11	11	
Electrophysiological testing	13	6	<0.0001
Holter monitoring	10	4	<0.0001
Echocardiography	16	26	<0.0001
Thrombolysis	0.4	6	<0.0001
PTCA	0.2	4	<0.0001
CABG	4	4	
Electrophysiological testing after CABG (4‡, 50§)	0.6	1	
Implantable cardioverter defibrillator	0.4	4	<0.0001

*Number of patients with missing information during period 1, except for electrophysiological testing after CABG, was 0.
†Number of patients with missing information during period 2, except for electrophysiological testing after CABG, was 18.
‡Number of patients with missing information during period 1.
§Number of patients with missing information during period 2.
CABG, coronary artery bypass grafting; PTCA, percutaneous transluminal coronary angioplasty.

Table 6 Factors associated with survival in univariate analysis

	OR	95% CI
Medical history		
Smoking	1.60	1.22 to 2.12
Stroke	0.67	0.45 to 0.97
Diabetes	0.54	0.37 to 0.77
Angina pectoris	1.28	1.01 to 1.62
Age > median (70 years)	0.71	0.56 to 0.89
Asthma	0.63	0.42 to 0.93
Female sex	0.67	0.52 to 0.87
Cardiac arrest	2.28	1.13 to 4.71
Chronic medication before admission		
Psychopharmaceuticals	0.63	0.42 to 0.91
Antidiabetics	0.51	0.33 to 0.77
Digitalis	0.75	0.57 to 0.97
Diuretics	0.68	0.54 to 0.87
β Stimulants	0.54	0.31 to 0.92
Lipid lowering drugs	2.08	1.08 to 4.06
Factors at resuscitation		
Interval between cardiac arrest and arrival of ambulance > median (5 mins)	0.45	0.32 to 0.61
VF/VT as first recorded arrhythmia	4.51	3.43 to 5.98
Bystander initiated CPR	2.26	1.72 to 2.97
Witnessed arrest	4.41	2.89 to 7.00
Status on admission		
Unassisted breathing	2.70	2.10 to 3.45
Conscious	9.18	5.84 to 15.04
Ongoing CPR	0.35	0.24 to 0.52
Palpable pulse	3.27	2.23 to 4.92
Sinus rhythm	2.07	1.64 to 2.64
Treatment on admission		
Lidocaine	1.64	1.27 to 2.11
Atropine	0.26	0.13 to 0.46
Adrenaline	0.30	0.19 to 0.46
Defibrillation	0.65	0.43 to 0.95

OR, odds ratio; VF, ventricular fibrillation; VT, ventricular tachycardia.

hospital, sinus rhythm on admission to hospital, and requirement for atropine and lidocaine in the emergency department (table 7).

A separate analysis of the interval between cardiac arrest and arrival of an ambulance found that a prolonged interval (defined as > 5 minutes) was inversely related to survival (odds ratio (OR) 0.85, 95% confidence interval (CI) 0.80 to 0.91, $p < 0.0001$).

In a further separate analysis treatment with thrombolysis was included in the model. Such treatment was an independent predictor of increased survival (OR 4.26, 95% CI 1.49 to 12.13, $p = 0.007$).

DISCUSSION

This is the largest sample published so far of patients who were hospitalised alive after out of hospital cardiac arrest from a well defined area. We found that among patients who were hospitalised alive after out of hospital cardiac arrest, a little more than one third were discharged alive. Previous studies indicate that this figure varies between 12–68%.[5 10–15] Today we do not know anything about why survival rates differ between hospitals. In a paper from Scotland[15] evaluating patients admitted to two different hospitals, the short term outcome was better among patients admitted to one of the hospitals. Witnessed arrest, bystander cardiopulmonary resuscitation, and shorter ambulance response times were assumed to contribute to the prognosis. There have been some indications from our own group that a more ambitious evaluation of these patients while in hospital may be associated with an increased survival.[16]

Very few studies have determined whether characteristics of this patient population change over time. In a paper on

Table 7 Factors associated with survival in multivariate analysis

	OR	95% CI	p Value
Age > median (70 years)	0.65	0.47 to 0.88	0.006
Chronic medication before admission			
Diuretics	0.59	0.43 to 0.81	0.001
Antidiabetics	0.53	0.31 to 0.91	0.020
Factors at resuscitation			
Initial VF/VT	3.46	2.36 to 5.07	<0.0001
Bystander CPR	2.00	1.42 to 2.80	<0.0001
Witnessed cardiac arrest	2.50	1.52 to 4.10	0.0003
Status on admission			
Conscious	6.43	3.61 to 11.45	<0.0001
Sinus rhythm	1.53	1.12 to 2.10	0.008
Treatment on admission			
Atropine	0.35	0.16 to 0.75	0.008
Lidocaine	1.64	1.16 to 2.31	0.005

patients with out of hospital ventricular fibrillation, Cobb and colleagues[17] also noted an increase in mean age over time among hospital survivors. Hospital survival did not change over time. We found that in the latter part of the survey patients were older and less frequently had ventricular fibrillation/tachycardia as the initial rhythm. Although this is in agreement with the overall finding of our patients suffering from out of hospital cardiac arrest and where cardiopulmonary resuscitation efforts were attempted,[18] the finding of a greatly reduced proportion over time of patients with ventricular fibrillation as the first noted arrhythmia is somewhat puzzling under these circumstances. Changes in comorbidity favour period 2, and there are no significant differences in ambulance activation times, in proportions of bystander cardiopulmonary resuscitation, or in shares of witnessed arrests. One may speculate about the effect of age on initial arrhythmia in our population. Despite these observations we did not find any indication that the patients in the second part of the survey had more risk indicators in terms of medical history. With regard to status on admission to hospital we found that ongoing cardiopulmonary resuscitation was less frequent in the second part of the survey.

In terms of treatment and investigational procedures we found an increased rate of echocardiography, thrombolysis, percutaneous transluminal coronary angioplasty, and implantable cardioverter defibrillator implantation during the second part of the survey. This was an expected finding. However, as previously reported, there was a discrepancy between the two hospitals: more investigations were carried out in one of the hospitals than in the other.[16] There was no indication of an increased survival during the hospital phase during the second part of the survey. This was a disappointing finding. The increase in various interventions may have been too small to have any major impact on survival. However, one can assume that, to have a major impact on survival in hospital, the intervention must take place very soon after admission to hospital. Although thrombolysis and the majority of percutaneous transluminal coronary angioplasty procedures were used early, internal defibrillators were implanted later in the course of hospitalisation.

Therefore, the variables in table 5 were not included in the multivariate analysis. In a separate analysis that included thrombolysis in the multivariate model, such treatment was associated with an increase in survival. However, one must take care in interpreting these data because of the low number of patients receiving the treatment and because we do not know whether all patients received the treatment immediately after admission to hospital. However, our data indicate that an increased use of thrombolysis may increase survival among patients hospitalised after out of hospital cardiac arrest.

We found nine major contributors to an increased or decreased chance of survival:

- *Ventricular fibrillation/tachycardia as the initial rhythm*—such a rhythm has repeatedly been shown to be a strong predictor of survival among patients suffering from out of hospital cardiac arrest.[19 20] This study confirms that an initial ventricular fibrillation/tachycardia rhythm is also a strong indicator of an increased chance of survival among patients who are hospitalised alive.
- *Bystander cardiopulmonary resuscitation*—increasing evidence indicates that cardiopulmonary resuscitation initiated by a bystander before arrival of the ambulance crew is of ultimate importance for survival among patients suffering out of hospital cardiac arrest.[21–23] Data from this survey also strongly support the notion that, among patients who are hospitalised alive, bystander initiated cardiopulmonary resuscitation greatly increases the chance of survival.
- *Degree of consciousness on admission to hospital*—the observation that consciousness is strongly associated with an increased chance of survival is not controversial and has been shown by many others.[6 24–26]
- *Age*—the importance of age as a predictor of outcome among patients suffering from out of hospital cardiac arrest has been conflicting. Whereas some studies have found that older age is an important contributor,[27 28] others have not been able to confirm this.[29] Our data indicate that among patients surviving out of hospital cardiac arrest until hospital admission a lower age is strongly associated with an increased chance of further survival.
- *Witnessed cardiac arrest*—this is in agreement with several previous studies showing a higher survival rate if the arrest was witnessed.[30 31]
- *Patients who are in sinus rhythm on admission to hospital*—this mostly indicates return of spontaneous circulation and is therefore expected to be associated with a favourable outcome.
- *Treatment with atropine*—there is no convincing evidence that treatment with atropine increases the chance of survival among patients suffering from out of hospital cardiac arrest. On the contrary, treatment with atropine has been associated with an adverse outcome in observational studies of patients with out of hospital cardiac arrest found in asystole.[32] Our observation is in agreement with these findings. It may be that confounding factors were not recorded and our findings may simply reflect that the patients who require atropine are those in whom the resuscitation attempt was not immediately successful.
- *Treatment with lidocaine*—lidocaine is usually given prophylactically to patients whose rhythm has been successfully converted to sinus rhythm, indicating a selection bias.

- *Chronic treatment with diuretics*—this may be associated with more severe cases of congestive heart failure and therefore explain the association with an adverse outcome.

We found one further factor indicating an adverse outcome with borderline significance in multivariate analysis:

- *Chronic treatment with antidiabetic medication*—this most likely reflects that patients with more severe diabetes requiring treatment have an adverse outcome. This is not contradictory to other reports of an adverse outcome among diabetic patients with various manifestations of ischaemic heart disease.[33–35]

The data collected during the two time periods were of uniform quality. Discrepancies in the number of patients with missing information is a result of variability in data availability in the medical journals.

Conclusion

Analysis of the initial survivors of out of hospital cardiac arrest over 20 years found no improvement in survival over time. Major indicators of an increased chance of survival were initial ventricular fibrillation/tachycardia, bystander cardiopulmonary resuscitation, witnessed arrest, and consciousness on admission. Major indicators of a lower chance of survival were advanced age and requirement of atropine in the emergency department and chronic treatment with diuretics before the cardiac arrest.

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