CARDIOVASCULAR MEDICINE

Presentation, management, and outcome of out of hospital cardiopulmonary arrest: comparison by underlying aetiology

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Objective: To describe and compare presentation, management, and survival by aetiology of cardiopulmonary arrest.

Design, setting, and patients: A retrospective cohort study was undertaken of all 21 175 first out of hospital cardiopulmonary arrests in Scotland between May 1991 and March 1998.

Main outcome measure: Discharge alive from hospital.

Results: Presumed cardiac disease accounted for 17 451 cases (82%), other internal aetiologies for 1814 (9%), and external aetiologies for 1910 (9%). Arrests caused by presumed cardiac disease had a better risk profile in terms of presence of a witness, bystander cardiopulmonary resuscitation, call–response interval, and use of defibrillation; 1265 (7%) of those who arrested from presumed cardiac disease were discharged alive, compared with only 77 (2%) of those with non-cardiac disorders ($p < 0.001$). Among those defibrillated, call–response interval was associated with survival following arrests from both presumed cardiac and non-cardiac causes ($p < 0.001$).

Conclusions: Out of hospital cardiopulmonary arrests from non-cardiac causes were associated with worse crude survival than arrests from cardiac causes. Improvements in call–response interval and basic life support skills in the community would improve survival irrespective of the aetiology and should therefore be encouraged.

Because cardiac disease accounts for the majority of cardiopulmonary arrests and has the most favourable prognosis,[1 2] most studies have either excluded arrests of non-cardiac aetiology or have reported only the overall results. Kuisma and Alaspää undertook a prospective cohort study of 276 out of hospital cardiopulmonary arrests of non-cardiac origin.[3] Their study was based on the experience of one city over a two year period, and they reported outcomes up to discharge from hospital. Using the HeartStart (Scotland) register we were able to analyse data on all out of hospital cardiopulmonary arrests in Scotland over a seven year period, including survival up to one year following discharge. The aim of our study was to compare presentation, management, and survival by underlying aetiology of cardiopulmonary arrest.

METHODS

The Scottish Ambulance Service is the sole provider of emergency prehospital ambulance care for the 5.1 million population of Scotland, and collects data prospectively on all resuscitation attempts following out of hospital cardiopulmonary arrest in Scotland. These data are collated to form the HeartStart (Scotland) register. The register does not collect data on in-hospital arrests.

The information collected includes demographic characteristics, arrest location, call–response interval, presence of a witness, use of cardiopulmonary resuscitation (CPR) and defibrillation, and admission to hospital. The Carstairs socioeconomic category was derived from postcode of residence.[4] Values range from 1 (most affluent) to 7 (most deprived). Since May 1991, the underlying aetiology has been classified in accordance with the Utstein convention, whereby patients in whom the cause of arrest is unknown are classified as having a presumed cardiac aetiology.[5] Within our study, known non-cardiac aetiologies were categorised into either other internal aetiologies or external aetiologies, thereby producing a total of three aetiology subgroups.

A second form is completed by the medical records staff of the hospitals to which patients are transferred, and provides information on survival to discharge. Flagging of records at the registrar general's office for Scotland provides information on all deaths following discharge, whether in the community or in hospital. The study cohort comprised all subjects suffering a first out of hospital cardiopulmonary arrest between the beginning of May 1991 and the end of March 1998. Arrests that occurred in a general practice surgery, dental surgery, or other healthcare setting were excluded. Follow up data on survival were available for at least one year on all subjects in the study.

Statistics

The case mix and clinical management of arrests of presumed cardiac aetiology were compared with those of other internal and external aetiologies using χ^2 tests and Mann–Whitney U tests for categorical and continuous data, respectively. Outcome was measured in terms of crude survival at several time points up to one year following discharge. Crude survival in the presumed cardiac aetiology subgroup was compared with that in the other two subgroups using χ^2 tests. Stepwise binary logistic regression analysis was used to determine the factors associated with survival to discharge in the separate aetiology subgroups and to determine whether aetiology itself was a factor after adjustment for differences in case mix. Arrests with a call–response interval in excess of 15 minutes were excluded from these analyses because the relation between the log odds of survival and call–response interval became non-linear beyond 15 minutes.

RESULTS

There were 21 475 out of hospital cardiopulmonary arrests in Scotland over the study period. Of these, 221 (1.0%) were excluded because they occurred in health care settings, 78

Table 1 Breakdown of out of hospital cardiopulmonary arrests by aetiology

	N (%) (n=21 175)	N (%) (n=21 175)
Presumed cardiac disease	17 451 (82.4)	17 451 (82.4)
Non-cardiac internal aetiologies	1814 (8.6)	
Lung disease		901 (4.3)
Cerebrovascular disease		457 (2.2)
Cancer		190 (0.9)
Gastrointestinal haemorrhage		71 (0.3)
Obstetric/paediatric		50 (0.2)
Pulmonary embolism		38 (0.2)
Epilepsy		36 (0.2)
Diabetes mellitus		30 (0.1)
Renal disease		23 (0.1)
Other internal		18 (0.1)
Non-cardiac external aetiologies	1910 (9.0)	
Trauma		657 (3.1)
Asphyxia		465 (2.2)
Drug overdose		411 (1.9)
Drowning		105 (0.5)
Electric shock/lightening		28 (0.1)
Other suicide		194 (0.9)
Other external		50 (0.2)

(0.4%) because the person had survived a previous cardiopulmonary arrest, and one because of both criteria. The remaining 21 175 were eligible for inclusion in the study. Presumed cardiac disease accounted for 82.4% of cardiopulmonary arrests (table 1). Other internal aetiologies accounted for a further 8.6%. These were predominantly lung and cerebrovascular disease. The remaining 9.0% had external aetiologies, of which trauma, asphyxia, and drug overdose were the most common. The annual incidence of resuscitation attempts for out of hospital cardiopulmonary arrest of cardiac aetiology in Scotland was 49.5 per 100 000 population. The corresponding figures for other internal and external aetiologies were 5.1 and 5.4 per 100 000 population, respectively.

Compared with people whose arrests were attributed to cardiac disease, those with other internal aetiologies were more likely to be female (χ^2 test, $p < 0.001$) (table 2). Their arrests more often occurred at home (χ^2 test, $p < 0.001$), were less likely to be witnessed by someone (χ^2 test, $p < 0.001$), and they were less likely to be defibrillated (χ^2 test, $p < 0.001$). Among arrests that were not crew witnessed, people with non-cardiac internal aetiologies waited longer for the ambulance to arrive (χ^2 test, $p = 0.012$) and were less likely to receive bystander CPR (χ^2 test, $p < 0.001$). Those who were defibrillated received fewer shocks (χ^2 test, $p < 0.001$).

In comparison with those who arrested as a result of presumed cardiac disease, those with external aetiologies were younger (Mann–Whitney U test, $p < 0.001$) and less likely to be female (χ^2 test, $p = 0.030$) (table 2). They were less likely to arrest at home (χ^2 test, $p < 0.001$), but also less likely to be witnessed by a bystander (χ^2 test, $p < 0.001$). They waited longer for the ambulance to arrive (χ^2 test, $p < 0.001$) and were less likely to be defibrillated (χ^2 test, $p < 0.001$). Those who were defibrillated received fewer shocks (χ^2 test, $p < 0.001$).

Compared with those who arrested from presumed cardiac disease, those with other internal aetiologies were less likely to be admitted to an emergency department (χ^2 test, $p < 0.001$) or hospital ward (χ^2 test, $p < 0.001$), less likely to be discharged alive (χ^2 test, $p < 0.001$), and less likely to be alive at one year following discharge (χ^2 test, $p < 0.001$) (table 3). Similarly, those who arrested as a result of external causes were less likely to be admitted to an emergency department (χ^2 test, $p = 0.002$) or hospital ward (χ^2 test, $p < 0.001$), or to be alive at discharge (χ^2 test, $p < 0.001$) or at a one year follow up (χ^2 test, $p < 0.001$).

Following admission to a hospital ward, 48% of patients with presumed cardiac disease were discharged alive, compared with only 23% of those with other internal aetiologies (χ^2 test, $p < 0.001$) and 17% of those with external aetiologies (χ^2 test, $p < 0.001$). Among those with a presumed cardiac aetiology, 6.0% (95% confidence interval (CI) 5.6% to 6.4%) were still alive at one year following discharge from hospital, compared with 2.0% (95% CI 1.3% to 2.6%) of those with other internal aetiologies, and 1.7% (95% CI 1.1% to 2.3%) of those with external aetiologies.

In the stepwise logistic regression analyses, 2100 arrests were excluded because they were crew witnessed. Of the remaining 19 075, 1383 (7.3%) were excluded because the call–response interval exceeded 15 minutes. Complete data on all variables were available for 12 756 arrests. Defibrillation was the most significant independent predictor of survival following all cause arrests ($p < 0.001$). Among those who were defibrillated, presumed cardiac aetiology was a significant predictor of survival following adjustment for age, presence of a bystander witness, use of bystander CPR, call–response interval, number of shocks, and arrest location ($p = 0.021$). However, there were significant statistical interactions between cause and both call–response interval ($p = 0.013$) and arrest location ($p = 0.014$). A shorter call–response interval was associated with improved survival following arrests of both presumed cardiac and non-cardiac aetiologies ($p < 0.001$).

DISCUSSION

Cardiac disease accounts for the majority of cases of cardiopulmonary arrest in the community and is associated with the best chance of survival following resuscitation.[1 2] Thus most studies on out of hospital cardiac arrest have excluded some or all arrests of non-cardiac aetiology,[6–10] or else have analysed all causes together.[11 12]

In 1997, Kuisma and Alaspää published a prospective cohort study that included only those arrests of non-cardiac aetiology.[3] Their study was based on arrests over a two year period in one medium sized city and, as such, had only a modest sample size of 276 subjects.[13] They reported outcome by cause up to discharge from hospital. By comparison, the HeartStart register provided us with data on all out of hospital cardiac arrests in a whole country over a seven year period. We were able to compare outcome between cardiac and

Table 2 Case mix of out of hospital cardiopulmonary arrests by aetiology

		Presumed cardiac disease (n=17 451)	Non-cardiac internal aetiologies (n=1814)	External aetiologies (n=1910)	Total (n=21 175)
Sex	Male	12 190 (70)	1052 (58)	1377 (72)	14 619 (69)
	Female	5234 (30)	757 (42)	526 (28)	6517 (31)
	Missing data	27	5	7	39
Age	Median (IQR)	67 (59 to 75)	67 (57 to 75)	35 (25 to 55)	66 (56 to 74)
	Missing data	0	0	0	0
Carstairs socioeconomic deprivation category	1–2	2298 (15)	207 (13)	208 (14)	2713 (15)
	3–5	10 034 (65)	1050 (66)	927 (61)	12 011 (65)
	6–7	3000 (20)	333 (21)	377 (25)	3710 (20)
	Missing data	2119	224	398	2741
Arrest site	Home	10 329 (59)	1389 (77)	885 (46)	12 603 (60)
	Other	7117 (41)	420 (23)	1020 (54)	8557 (40)
	Missing data	5	5	5	15
Witness	Crew	1669 (11)	263 (16)	168 (11)	2100 (11)
	Bystander	10 291 (67)	958 (60)	580 (40)	11 829 (64)
	No-one	3365 (22)	380 (24)	716 (49)	4461 (24)
	Missing data	2126	213	446	2785
Bystander CPR*	Yes	6147 (40)	444 (29)	645 (38)	7236 (39)
	No	9337 (60)	1072 (71)	1073 (62)	11 482 (61)
	Missing data	298	35	24	357
Call–response interval*	≤4 min	3245 (19)	294 (16)	284 (15)	3823 (18)
	>4 min	14 067 (81)	1506 (84)	1614 (85)	17 187 (82)
	Missing data	139	14	12	
Defibrillated	Yes	10 308 (59)	515 (28)	376 (20)	11 199 (53)
	No	7126 (41)	1294 (72)	1532 (80)	9952 (47)
	Missing data	17	5	2	24
Number of shocks†	1	2904 (28)	192 (38)	152 (42)	3248 (29)
	≥2	7293 (72)	314 (62)	210 (58)	7817 (71)
	Missing data	111	9	14	134

Values are n (%).
*Non-crew witnessed arrests only.
†Defibrillated patients only.
CPR, cardiopulmonary resuscitation; IQR, interquartile range.

Table 3 Survival following out of hospital cardiopulmonary arrest, by aetiology

	Presumed cardiac disease (n=17 451)	Non-cardiac internal aetiologies (n=1814)	External aetiologies (n=1910)	Total (n=21 175)
Admitted to emergency department	4564 (27)	365 (20)	432 (23)	5361 (26)
Admitted to a ward	2612 (15)	183 (10)	211 (11)	3006 (14)
Discharged alive	1265 (7)	42 (2)	35 (2)	1342 (6)
Unknown	279	16	51	346
Alive one year after discharge	1027 (6)	35 (2)	32 (2)	1094 (5)
Unknown	335	20	52	407

Values are n (%). Percentages relate to the total number in each subgroup.

non-cardiac aetiologies, and flagging of records provided survival data up to one year following discharge from hospital, as advocated under the Utstein convention.[5]

Most studies have suggested that around 20% of all cardiopulmonary arrests are of non-cardiac aetiology,[13] which is similar to our own figure of 18%. In the study by Kuisma and Alaspää,[3] a non-cardiac aetiology was suspected before admission in 22% of arrests. However, additional information from necropsies and in-hospital investigations increased this figure to 34%. A necropsy study of 322 unselected sudden "natural" deaths in the community also demonstrated that 34% were of non-cardiac aetiology.[14] In the HeartStart register, additional diagnostic information is collected on those discharged alive from hospital. In-hospital examination and investigations enable the cause of arrest to be diagnosed more accurately in these patients. However, we did not have access to necropsy and investigation findings to validate the presumed aetiology among those who died before or during admission. Therefore, in order to be consistent and prevent potential bias, our analysis was based on prehospital diagnosis of aetiology for all arrests. As a result, we cannot exclude the possibility that some cases have been misclassified. If so, this is likely to have been in the direction of overclassification to cardiac aetiology. If we apply the figures obtained from the studies by Kuisma and Alaspää[3] and Thomas and colleagues [14] to our own cohort, then 7200 arrests (34%) would have been of non-cardiac aetiology and 13 975 (66%) of cardiac aetiology. The additional discharge information showed that 1270 of those discharged alive arrested because of cardiac disease and 72 because of non-cardiac causes (Sirel J, personal communication). Applying these figures, survival to discharge would be 9% (1270 of 13 975) among those with cardiac

disease and 1% (72 of 7200) among those with a non-cardiac cause, confirming that any misclassification in our original analyses is likely to have overestimated survival among non-cardiac aetiologies compared with cardiac disease.

In our study, only 2% of those with a non-cardiac aetiology survived to discharge from hospital, compared with 11% in the study by Kuisma and Alaspää.[3] In the latter study, 47% of arrests from non-cardiac causes were a result of other internal disorders and 53% were from external events. This is comparable with our figures of 49% and 51%, respectively. The difference in survival between the two studies relates primarily to arrests of external aetiology. In our study, survival to discharge was 2% in both subgroups. Kuisma and Alaspää reported 5% survival among cases with non-cardiac internal aetiologies but 19% among those with external aetiologies. Our much poorer survival among those with external aetiologies may, in part, reflect differences in the specific causes. In Kuisma and Alaspää's cohort, 23% of arrests from external causes were the result of near drowning, which had a high survival rate of 38%, and only 17% were the result of trauma, from which no-one survived. By contrast, only 5% of our arrests from external causes resulted from drowning and 34% resulted from trauma.

The difference in survival between the studies can almost entirely be accounted for by differences in survival before reaching hospital. In our study, only 11% of people who arrested from non-cardiac causes were admitted to a ward, compared with 40% in Kuisma and Alaspää's study.[3] Following admission, differences in survival were greatly reduced. In our study, 20% of those admitted were discharged alive, compared with 28% in the study by Kuisma and Alaspää. One explanation for the different prognoses before admission is the geographical areas covered by the studies. Kuisma and Alaspää's study included only one urban area, whereas ours covered all urban, semirural, and rural areas within Scotland. In general, response times are longer, and therefore survival to hospital discharge poorer, among those who live in sparsely populated areas.[15] During the period studied, very few patients in Scotland received implantable cardiac defibrillators. Since then, their use has increased, which may have improved long term survival among patients who reach hospital alive following cardiopulmonary arrest.

Both research and clinical developments have focused on cardiopulmonary arrests resulting from cardiac causes. As with previous studies, our study suggests that non-cardiac aetiologies account for a sizeable proportion of out of hospital cardiopulmonary arrests. Compared with arrests from presumed cardiac disease, those of non-cardiac aetiology have a poorer crude prognosis. Comparable outcomes may not be achievable, as some of the adverse prognostic factors among cases of non-cardiac aetiology are not amenable to change, such as older age and greater comorbidity among people with lung and cerebrovascular disease, and deliberate attempts at concealment among assaults and attempted suicides. Also, previous studies have suggested that the percentage of patients with cardiac rhythms amenable to defibrillation is much lower among those with cardiac arrest of non-cardiac aetiology. In the study by Kuisma and Alaspää,[3] only 5% of patients had ventricular fibrillation. In our own study, 59% of those with presumed cardiac causes for arrest were suitable for defibrillation, compared with only 24% of those with non-cardiac causes. Nonetheless, our own regression analyses and those reported by Kuisma and Alaspää[3] suggest that modifiable factors, such as call–response interval, are associated with outcome in cases with a non-cardiac aetiology. Thus improvements in call–response interval can be expected to improve survival in cases with a non-cardiac aetiology as well as in those with cardiac disease, and should be encouraged.

Study limitations

Ideally, we would have compared time delays in terms of arrest–response interval as well as call–response interval. However, in common with arrest registers, data on time of arrest are incompletely recorded in HeartStart. More importantly, these data are most likely to be missing or inaccurate in unwitnessed and fatal arrests. This introduces a potential reporting bias in respect of cause of arrest. By contrast, data on the time at which the emergency telephone call is made are accurate and complete, and unlikely to be subject to reporting bias. For this reason, we chose to report data on only the call–response interval.

Conclusions

Out of hospital cardiopulmonary arrests from non-cardiac causes were associated with poorer crude survival than those of cardiac origin. However, improvements in basic life support skills in the community and reductions in call–response interval would improve survival irrespective of aetiology and should therefore be encouraged.

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REFERENCES

1 **Eisenberg MS**, Cummins RO, Larsen MP. Numerators, denominators and survival rates: reporting survival from out-of-hospital cardiac arrest. *Am J Emerg Med* 1991;**9**:544–6.
2 **Kuilman M**, Bleeker JK, Hartman JA, *et al*. Long-term survival out-of-hospital cardiac arrest: an 8-year follow-up. *Resuscitation* 1999;**41**:25–31.
3 **Kuisma M**, Alaspää A. Out of hospital cardiac arrest of non-cardiac origin. Epidemiology and outcome. *Eur Heart J* 1997;**18**:1122–8.
4 **McLoone P**, Boddy FA. Deprivation and mortality in Scotland, 1981 and 1991. *BMJ* 1994;**309**:1465–70.
5 **Cummins RO**, Chamberlain DA, Abramson NS, *et al*. Recommended guidelines for uniform reporting of data from out of hospital cardiac arrest: the Utstein Style. *Circulation* 1991;**84**:960–75.
6 **Bottiger BW**, Grabner C, Bauer H, *et al*. Long-term outcome after out-of-hospital cardiac arrest with physician staffed emergency medical services: the Utstein style applied to a mid-sized urban/suburban area. *Heart* 1999;**82**:674–9.
7 **Eisenberg MS**, Hallstrom A, Bergner L. Long-term survival after out-of-hospital cardiac arrest. *N Engl J Med* 1982;**306**:1340–3.
8 **Eisenberg MS**, Bergner L, Hallstrom A. Survivors of out-of-hospital cardiac arrest: morbidity and long term survival. *Am J Emerg Med* 1984;**2**:189–92.
9 **Goldstein S**, Landis JR, Leighton R, *et al*. Characteristics of the resuscitated out-of-hospital cardiac arrest victim with coronary heart disease. *Circulation* 1981;**64**:977–84.
10 **Rockswold G**, Sharma B, Ruiz E, *et al*. Follow-up of 514 consecutive patients with cardiopulmonary arrest outside the hospital. *J Am Coll Emerg Physicians* 1979;**8**:216–20.
11 **Holmberg M**, Holmberg S, Herlitz J, *et al*. Survival after cardiac arrest outside hospital in Sweden. *Resuscitation* 1998;**36**:29–36.
12 **Lund I**, Skulberg A. Resuscitation of cardiac arrest outside hospitals: experience with a mobile intensive care unit in Oslo. *Acta Anaesthesiol Scand* 1973;**53**(suppl):13–6.
13 **Herlitz J**, Graves JR. Non-cardiac origin of out of hospital cardiac arrests: do we underestimate their frequency and prognosis? *Eur Heart J* 1997;**18**:1047–9.
14 **Thomas AC**, Knapman PA, Krikler DM, *et al*. Community study of the causes of "natural" sudden death. *BMJ* 1988;**297**:1453–6.
15 **Stapczynski JS**, Svenson JE, Stone CK. Population density, automated external defibrillator use, and survival in rural cardiac arrest. *Acad Emerg Med* 1997;**4**:552–8.