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, 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. 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. 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. 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 χ² 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 χ² 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...
(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 (χ² test, p < 0.001) (table 2). Their arrests more often occurred at home (χ² test, p < 0.001), were less likely to be witnessed by someone (χ² test, p < 0.001), and they were less likely to be defibrillated (χ² test, p < 0.001). Among arrests that were not crew witnessed, people with non-cardiac internal aetiologies waited longer for the ambulance to arrive (χ² test, p = 0.012) and were less likely to receive bystander CPR (χ² test, p < 0.001). Those who were defibrillated received fewer shocks (χ² 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 (χ² test, p = 0.030) (table 2). They were less likely to arrest at home (χ² test, p < 0.001), but also less likely to be witnessed by a bystander (χ² test, p < 0.001). They waited longer for the ambulance to arrive (χ² test, p < 0.001) and were less likely to be defibrillated (χ² test, p < 0.001). Those who were defibrillated received fewer shocks (χ² 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 (χ² test, p < 0.001) or hospital ward (χ² test, p < 0.001), less likely to be discharged alive (χ² test, p < 0.001), and less likely to be alive at one year following discharge (χ² 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 (χ² test, p = 0.002) or hospital ward (χ² test, p < 0.001), or to be alive at discharge (χ² test, p < 0.001) or at a one year follow up (χ² 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 (χ² test, p < 0.001) and 17% of those with external aetiologies (χ² 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. Thus most studies on out of hospital cardiac arrest have excluded some or all arrests of non-cardiac aetiology, or else have analysed all causes together.

In 1997, Kuistma and Alaspää published a prospective cohort study that included only those arrests of non-cardiac aetiology. 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. 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...
non-cardiac aetiologies, and flagging of records provided survival data up to one year following discharge from hospital, as advocated under the Utstein convention.

Most studies have suggested that around 20% of all cardiopulmonary arrests are of non-cardiac aetiology,\textsuperscript{13} which is similar to our own figure of 18%. In the study by Kuisma and Alaspää,\textsuperscript{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.\textsuperscript{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\textsuperscript{3} and Thomas and colleagues\textsuperscript{14} to our own cohort, then 7200 arrests (34%) would have been of non-cardiac aetiology and 13 975 (66%) of cardiac aetiology.

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

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>Presumed cardiac disease (n=17 451)</th>
<th>Non-cardiac internal aetiologies (n=1814)</th>
<th>External aetiologies (n=1910)</th>
<th>Total (n=21 175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>12 190 (70)</td>
<td>1052 (58)</td>
<td>1377 (72)</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>5234 (30)</td>
<td>757 (42)</td>
<td>526 (28)</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>27</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Age</td>
<td>Median (IQR)</td>
<td>67 (59 to 75)</td>
<td>67 (57 to 75)</td>
<td>35 (25 to 55)</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Carstairs socioeconomic deprivation category</td>
<td>1–2</td>
<td>2298 (15)</td>
<td>207 (13)</td>
<td>208 (14)</td>
</tr>
<tr>
<td></td>
<td>3–5</td>
<td>10 034 (65)</td>
<td>1050 (66)</td>
<td>927 (61)</td>
</tr>
<tr>
<td></td>
<td>6–7</td>
<td>3000 (20)</td>
<td>333 (21)</td>
<td>377 (25)</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>2119</td>
<td>224</td>
<td>398</td>
</tr>
<tr>
<td>Arrest site</td>
<td>Home</td>
<td>10 329 (59)</td>
<td>1389 (77)</td>
<td>885 (46)</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>7117 [41]</td>
<td>420 [23]</td>
<td>1020 [54]</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Bystander</td>
<td>10 291 [67]</td>
<td>938 [60]</td>
<td>580 [40]</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>2126</td>
<td>213</td>
<td>446</td>
</tr>
<tr>
<td>Bystander CPR*</td>
<td>Yes</td>
<td>6147 [40]</td>
<td>444 [29]</td>
<td>645 [38]</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>298</td>
<td>35</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>&gt;4 min</td>
<td>14 067 [81]</td>
<td>2606 [84]</td>
<td>1614 [85]</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>139</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>7126 [41]</td>
<td>1294 [72]</td>
<td>1353 [80]</td>
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<td></td>
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<td>17</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Number of shocks†</td>
<td>1</td>
<td>2904 [28]</td>
<td>192 [38]</td>
<td>152 [42]</td>
</tr>
<tr>
<td></td>
<td>Missing data</td>
<td>111</td>
<td>9</td>
<td>14</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>Presumed cardiac disease (n=17 451)</th>
<th>Non-cardiac internal aetiologies (n=1814)</th>
<th>External aetiologies (n=1910)</th>
<th>Total (n=21 175)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admitted to emergency department</td>
<td>4564 (27)</td>
<td>365 (20)</td>
<td>432 (23)</td>
<td>5361 (26)</td>
</tr>
<tr>
<td>Unknown</td>
<td>279</td>
<td>16</td>
<td>51</td>
<td>346</td>
</tr>
<tr>
<td>Unknown</td>
<td>335</td>
<td>20</td>
<td>52</td>
<td>407</td>
</tr>
</tbody>
</table>

Values are n (%). Percentages relate to the total number in each subgroup.
improvements in call–response interval can be expected to
modifiable factors, such as call–response interval, are associ-
ated 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 impor-
tantly, 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 inter-
val would improve survival irrespective of aetiology and
should therefore be encouraged.

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