Demographic and temporal trends in out-of-hospital sudden cardiac death in Belfast.


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Keywords: Sudden Cardiac Death

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Abstract

OBJECTIVE: To determine the epidemiology of Out-of-Hospital Sudden Cardiac Death (OHSCD) in Belfast from 1st August 2003 to 31st July 2004.

DESIGN: Prospectively we examined out-of-hospital cardiac arrests using the Utstein style and autopsy reports. By applying the World Health Organisation criteria we determined the number of sudden cardiac deaths.

RESULTS: There were 300 OHSCD’s, 197(66%) male, mean age (SD) 68 (14) years; 234(78%) occurred at home. The Emergency Medical Services (EMS) attended 279(93%). Rhythm on EMS arrival was Ventricular Fibrillation (VF) in 75(27%). The call to response interval (CRI) was mean (SD) 8 (3) min. In those attended by the EMS, resuscitation was 9.7% and survival to leave hospital alive 7.2%. The CRI for survivors was mean (SD) 5 (2) min and non survivors mean (SD) 8 (3) min, (p<0.001). Ninety one (30%) OHSCD’s were witnessed; of these 48(53%) had VF on EMS arrival. The survival rate for witnessed VF arrests was 20/48(41.7%); all 20 survivors had VF as the presenting rhythm and CRI ≤7min. The European Age-Standardised Incidence Rate for OHSCD was 122/100,000(95% CI 111-133) for males and 41/100,000(95% CI 36-46) for females.

CONCLUSION: Despite a 37% reduction in heart attack mortality in Ireland over the last 20 years, the incidence of OHSCD in Belfast has not fallen. In this study, 78% of OHSCD’s occurred at home.

Keywords: Sudden Cardiac Death.
Introduction
Despite improvements in diagnosis and management over the last three decades, Coronary Artery Disease (CAD) is the major cause of death in the Western world.[1] The majority of CAD deaths occur outside hospital,[2] with the largest component as Sudden Cardiac Death (SCD).[3]

The current definition of SCD describes death within 1 hour of onset of symptoms.[4] From a practical viewpoint it is often very difficult to estimate the duration of the symptoms that preceded death, among patients found ‘dead on arrival’. Often there is lack of information about the occurrence and timing of any symptoms and for many Out-of-Hospital SCD’s (OHSCD) the Emergency Medical Services (EMS) are not deployed. For these reasons the true incidence of OHSCD is difficult to ascertain. Forensic pathologists studying unwitnessed deaths may use the definition ‘sudden’ for a person known to be alive and functioning normally 24 hours before. [5] The exclusion of unwitnessed deaths will seriously bias any study of OHSCD.[6] World Health Organisation criteria define SCD as unexpected death either within 1 hour of symptom onset if witnessed, or within 24 hours of having been observed alive and symptom free if unwitnessed.[7] For these reasons many studies of the incidence of SCD and Out-of-Hospital Cardiac Arrest (OHCA) using only witnessed cases (or the ‘1 hour definition’) may be underestimating the full extent of the problem.

Investigators have shown that prospective evaluation of SCD using autopsy reports, EMS Patient Report Forms (PRFs) and medical records appear to give a more accurate determination of incidence than retrospective evaluation of death certification data which can overestimate SCD incidence.[7]

World Health Organisation statistics show that deaths from heart attacks in Ireland have fallen by 37% in the last 20 years.[8] Finnish investigators have claimed that a decline in out-of-hospital CAD deaths has been the leading contributor to the decrease in CAD deaths.[2] Using EMS Patient Report Forms (PRFs), Becker et al.[9] noted that the incidence of OHCA attended by EMS varied between 36 and 128/100,000 per year. Investigators in Maastricht found the mean yearly incidence of OHCA to be 97/100,000.[10] The Task Force on SCD of the European Society of Cardiology states that the incidence of SCD ranges between 36 and 128/100,000 inhabitants per year.[11] Investigators assessed deaths from CAD in Belfast and nearby Castlereagh local government districts in 1982[12] by checking EMS PRFs, death certification data and autopsy reports. Of 335 OHSCD’s, 82% occurred in the home and 67% were due to a ‘presumed ventricular arrhythmia’. In 1966, earlier investigators had shown that there were 297 CAD deaths within 1 hour of symptom onset in Belfast City.[13]

The initial rhythm for most OHCA’s (65% to 85%) is Ventricular Fibrillation (VF).[14] The greatest determinant of survival from OHCA is early defibrillation.[15] Work in the United Kingdom has shown that less than 5% of victims of OHCA have been resuscitated with the commonly used EMS approach.[16] However this figure arises from an assessment of all OHCA’s. In Gothenburg, a 19 year study showed a 13% survival rate for patients suffering a witnessed OHCA and 20% for witnessed OHCA with VF as the initial rhythm.[17]

The Utstein guidelines recommend reporting the survival rate from witnessed OHCA of cardiac aetiologies with VF as the initial rhythm, for intersystem comparisons.[17]
It has been shown that survival from OHCA can be improved significantly by means of a PAD scheme using Automated External Defibrillators (AEDs).[19]

The joint European Society of Cardiology / European Resuscitation Council guidelines on the use of (AEDs) in the community[20] state an analysis of local conditions should be performed prior to setting up a PAD scheme to help decide on the best strategy for AED deployment in the community.

The purpose of this study was to determine the incidence and demographics of OHSCD occurring in Belfast city and Castlereagh local government districts over 1 year (August 2003 to July 2004), to determine the current survival rate from OHSCD and to use the demographics of OHSCD to help determine the best strategy for AED deployment for the implementation of a PAD scheme. In Belfast OHSCD had not been looked at since 1966 and 1982.

Methods
Between August 2003 and July 2004 data were collected prospectively for OHCA’s of a suspected cardiac aetiology in Belfast City and neighbouring Castlereagh local government districts in which the EMS system responded and attempted resuscitation. A manual search was performed for all PRFs in these areas. OHCA’s were reported in the ‘Utstein style’.\[18\] In addition, investigators prospectively searched through all autopsy reports at the department of Forensic Medicine, based at the Royal Victoria Hospital, Belfast. No age groups were excluded from the investigation.

Data collected from EMS PRFs included patient demographics, past medical history, the timing of symptoms and when the patient was last seen alive. Details gathered on the arrests included witnessed or not, bystander Cardiopulmonary Resuscitation (BCPR), rhythm on EMS arrival, attempted defibrillation, resuscitation status (defined as admission to hospital alive) and survival status (discharged from hospital alive). Investigators also recorded the time of emergency telephone call and the time that the EMS vehicle reached the site of the OHCA, the time difference defined as the Call-to-Response interval (CRI),\[18\] (a surrogate measurement of collapse to shock time). At the time of the study, most of the EMS vehicles in Belfast did not have data reading facilities for defibrillators and the ‘time of collapse’ is only available for witnessed arrests (which can be unreliable). CRI was rounded to the nearest minute.

For each OHCA, investigators also recorded the site of the event including home (any private place of residence), nursing homes, indoor public place, outdoor public place and public or private transport.

For patients admitted to hospital, medical records were checked and if discharged alive, the neurological status on discharge was noted. Neurological status coding was based on work by previous investigators and used 4 functional levels.[19] [21] Level 1 (full or nearly full neurological recovery, including patients with minor short term memory loss); level 2 (major memory deficit, naming difficulty, coordination difficulty, requiring some help with Activities of Daily Living (ADLs)); level 3 (patient alert and awake but with major neurological impairment and fully dependent for ADLs); level 4 (unresponsive and comatose).
For those cases where past medical history was not available from the PRF the patient’s general practitioner was contacted.

To help ascertain that each OHCA was of a cardiac aetiology and satisfied criteria for SCD, all cases obviously non cardiac were excluded, including overdoses, suicides, smoke inhalation, trauma, obvious severe asthma attacks and patients known to be dying of terminal cancer. Clarification of the cardiac aetiology of OHCA’s was made using autopsy reports and death certification data. Independent assessments were made by 3 cardiologists in order to reach a consensus opinion on whether or not each case (300) met the criteria for SCD.

Cases were deemed to be ‘Sudden’ and therefore OHSCD’s if they satisfied World Health Organisation criteria. [7] We also included autopsies, reporting cardiac pathology, which had been performed on victims for whom the EMS was not called but the victim had been seen alive and asymptomatic within 24 hours of being found collapsed. Death certificates with cardiac causes for patients found dead for whom the EMS was not called and who had no post mortem were not included in the analysis as previous work has shown that reliance on death certificate diagnoses alone over estimates the true rate of SCD.

THE STUDY AREA
Belfast is a medium sized city. According to mid-year population estimates in 2003 the population of Belfast City local government district was 271,596. Castlereagh is a neighbouring suburban area to the east of the city with a population of 66,076, therefore the combined population of the study area is 337,672.[22] According to the 1971 census the population of Belfast City was 416,679.[22] As the boundaries of Belfast City local government district have changed and now cover a smaller area, so the decline in population from 1971 is apparent. In 1971 some of Belfast City included parts of what is now Castlereagh.

THE EMERGENCY MEDICAL SERVICES
Belfast and Castlereagh local government districts had no PAD scheme in place at the time of the study and the police and fire brigade were not a part of the EMS system. Belfast and it’s surrounding suburbs are served by 2 Mobile Coronary Care Units (MCCU’s), (doctor-led), one based at the Royal Victoria Hospital which covers the North, West and South of the city and the other at the Ulster Hospital which covers the east of the city and Castlereagh. The MCCU’s provide rapid out-of-hospital assessment of acute ischaemic-type chest pain and those with collapse including thrombolytic therapy and defibrillation. Belfast city is also served by 4 ambulance stations which house emergency Paramedic-Led Ambulances (PLAs). The PLAs provide a rapid defibrillation service. For most OHCA’s the emergency dispatcher will send an emergency PLA in conjunction with the MCCU, aiming to reach all cases within 8 minutes of the call. In most cases the PLA’s administer initial defibrillatory shocks and CPR. The EMS in Belfast City use biphasic defibrillators with 150 joules non escalating energy protocols.

There are a small number of fixed AEDs in Belfast City. Most of these static AEDs are present in locations such as golf clubs and private leisure centres. During this
study none of these static AEDs were used for collapse victims. Some general practitioner practices have AEDs and 1 of these resulted in survival from OHSCD during the study.

STATISTICS
European age-standardised incidence rates (EASR) and World age-standardised incidence rates (WASR) were calculated for males and females. The 95% confidence intervals (CI) associated with each rate are also presented. Population denominators used in the calculation of these rates were obtained from the Northern Ireland Statistics and Research Agency website 2004.

Statistical significance for means was calculated using the t test in the statistical package SPSS version 12.

Results
There were 300 OHSCD’s over the 12 months, 197 (66%) male. Age (mean (SD) 68 (14) years), range 27-96 years; age for females was mean (SD) 72 (13) years and for males, mean (SD) 65 (14) years, (table 1).

Table 1. Distribution of all cases by age and gender

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age (years)</th>
<th>0 - 49</th>
<th>50-59</th>
<th>60-69</th>
<th>70-79</th>
<th>80-89</th>
<th>90+</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Male</td>
<td>29 (14.7)</td>
<td>39 (19.8)</td>
<td>45 (22.8)</td>
<td>49 (24.9)</td>
<td>31 (15.7)</td>
<td>4 (2)</td>
<td>197</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>7 (6.8)</td>
<td>9 (8.7)</td>
<td>22 (21.4)</td>
<td>32 (31.1)</td>
<td>23 (22.3)</td>
<td>10 (9.7)</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>36 (12)</td>
<td>48 (16)</td>
<td>67 (22.3)</td>
<td>81 (27)</td>
<td>54 (18)</td>
<td>14 (4.7)</td>
<td>300</td>
<td></td>
</tr>
</tbody>
</table>

One hundred and thirty (43%) had a medical history of cardiac disease; for 8 / 300 (2.7%) past history was unobtainable. Two hundred and thirty four (78%) OHSCD’s occurred at home, 24 (8%) in outdoor public places and 23 (7.7%) in indoor public places and 19 (6.3%) in nursing homes. Two hundred and seventy nine (93%) of the OHSCD’s were attended by the EMS. Of the 279 EMS-attended cases, initial rhythm on EMS arrival was asystole in 190 (68%), VF in 75 (27%) and pulseless electrical activity (PEA) in 14 (5%), (Table 2).
Table 2. Rhythm on arrival of Emergency Medical Services

<table>
<thead>
<tr>
<th>Total number of events</th>
<th>Witnessed and Unwitnessed events</th>
<th>Witnessed events only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of events</td>
<td>279</td>
<td>91</td>
</tr>
<tr>
<td>Ventricular Fibrillation (%)</td>
<td>75 (27)</td>
<td>48 (53)</td>
</tr>
<tr>
<td>Asystole (%)</td>
<td>190 (68)</td>
<td>35 (38)</td>
</tr>
<tr>
<td>Pulseless Electrical Activity (%)</td>
<td>14 (5)</td>
<td>8 (9)</td>
</tr>
</tbody>
</table>

The CRIs ranged from 1 to 36 minutes (mean (SD) 8 (3) minutes). Median CRI was 7 (interquartile range (IQR) 6 to 9) minutes. Two hundred (71.7%) of the 279 cases had a CRI ≤ 8 minutes, (figure 1). In those attended by the EMS, resuscitation rate was 27 / 279 (9.7%) and survival rate 20 / 279 (7.2%). The CRI for survivors was mean (SD) 5 (2) minutes and non survivors mean (SD) 8 (3) minutes, (p<0.001). Median CRI for survivors was 5 (IQR 4 to 6) minutes and non survivors 7.5 (IQR 7 to 9) minutes. Ninety one (30%) OHSCD’s were witnessed. Forty eight (53%) of the witnessed arrests had VF on EMS arrival (table 2). Only 92 / 279 (33%) arrests received BCPR, and for 12/279 (4.3%) BCPR status was not known. The survival rate for those with arrests receiving BCPR was 13 / 92 (14.1%). Survival rate for witnessed VF arrests was 20/48 (41.7%). All 20 survivors were witnessed, had VF as initial rhythm and a CRI ≤ 7 minutes.

EASR for OHSCD in males was 122/100,000 (95% CI 111-133). The analogous rate for females was 41/100,000 (95% CI 36-46). WASR for OHSCD was 89/100,000 (95% CI 81-97) and 29/100,000 (95% CI 25-32) for males and females respectively.
Of the 20 survivors, 13 (65%) had full neurological recovery with a neuro-score of 1, one patient had a neuro-score of 2, two had a neuro-score of 3 and four (20%) cases were comatose with neuro-scores of 4.

Of the 300 OHSCD’s, 110 autopsy reports were available (table 3).
Table 3. Autopsy findings for out-of-hospital sudden cardiac deaths (n=110)

<table>
<thead>
<tr>
<th>Findings</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery atheroma (≥70% stenosis in at least 1 vessel)</td>
<td>103</td>
</tr>
<tr>
<td>Coronary artery thrombus</td>
<td>28</td>
</tr>
<tr>
<td>Healed myocardial infarction</td>
<td>28</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>53</td>
</tr>
<tr>
<td>Acute myocardial infarction</td>
<td>26</td>
</tr>
<tr>
<td>Ruptured myocardial infarction</td>
<td>4</td>
</tr>
<tr>
<td>Alcoholic cardiomyopathy</td>
<td>2</td>
</tr>
<tr>
<td>Ruptured thoracic aortic aneurysm</td>
<td>2</td>
</tr>
<tr>
<td>Aortic stenosis</td>
<td>1</td>
</tr>
<tr>
<td>Myocarditis</td>
<td>1</td>
</tr>
<tr>
<td>Amyloid heart disease</td>
<td>1</td>
</tr>
<tr>
<td>No structural abnormality identified</td>
<td>1</td>
</tr>
</tbody>
</table>
One hundred and three (93.6%) autopsies reported coronary artery atheroma with \( \geq 70\% \) stenosis in at least one of the 3 main coronary arteries, 28 (25.4%) reported coronary artery thrombus and plaque rupture, 28 (25.4%) revealed healed or fibrotic myocardial infarcts, 26 (23.6%) acute myocardial infarcts were noted, 53 (48%) cases of left ventricular hypertrophy, 4 cases of ruptured myocardial infarct with haemopericardium and in one 27 year old male, the heart was grossly and histologically normal.[24] Of the 7 cases without a coronary stenosis of \( \geq 70\% \) in at least one vessel, one had moderate coronary artery atheromatous disease with 30% stenoses and 6 had no significant coronary artery atheroma.

Of the 20 survivors to discharge, 8 had ST segment elevation myocardial infarction, 4 non ST segment elevation myocardial infarction, 3 idiopathic dilated cardiomyopathy, 2 ischaemic cardiomyopathy, 1 severe mitral valve disease, 1 atrial leiomyosarcoma and in 1 patient the diagnosis was uncertain.

Discussion
The premise of the National Service Framework for CAD in the United Kingdom was to reduce the death rate from circulatory diseases such as myocardial infarction in people under 75 years by 40% by 2010. The death rate has already been reduced by 23.4% from the 1995-7 baseline.[24] Since 1970 CAD deaths have fallen in general across Western Europe. [25] Nevertheless, the percentage of CAD deaths that are sudden has increased from 38% to 47%.[26] In spite of recent advances in technology survival from OHSCD remains low throughout the world at approximately 5%.[19][26]

OHSCD is often unexpected and may be the first and only manifestation of CAD, occurring in apparently healthy, asymptomatic individuals and therein lies the problem for its prevention. In this study 162 of the 300 OHSCDs (54%) had no known history of cardiac disease. However almost 94% of the autopsy reports showed severe CAD with at least 70% stenosis in one or more of the 3 main coronary arteries. The greatest opportunity therefore to reduce the population burden of OHSCD lies in further reduction in the prevalence of CAD in the population by prevention and risk factor modification. It has been shown that the risk factors for SCD are largely the same as those for CAD.[11] Hypertension plays a disproportionate role with regards to SCD compared to CAD.[27] The hazard ratio of hypertension for SCD was 1.45 (95% CI 1.10-1.92, \( p=0.008 \)) for each 50-g/m increment in left ventricular mass in the Framingham study.[28] In our study 48% of autopsies performed on OHSCD victims showed left ventricular hypertrophy.

Previous investigators have looked at supplying AEDs to the homes of people with known CAD and at risk of ventricular arrhythmias and training family members in their use. Some early experience with home AEDs showed no benefit.[29] Most SCD’s occur in those without known CAD, and patients with known CAD who are at risk of SCD may be eligible for implantable cardioverter defibrillators,[30] thereby limiting the potential for home AEDs.

The greatest impediment to survival from OHSCD is currently prolonged CRI’s for the EMS. One of the solutions suggested would be to increase EMS capabilities and vehicles. But to improve EMS response times would be costly and it has been estimated that every second of improved EMS response would cost approximately
£28,000.[31] A more cost effective means of improving time to defibrillation may be PAD since most OHSCD’s occur in the home. Such programs will require mobile AEDs and first responders linked to a dual dispatch system with the local EMS.[19]

This study and others have shown a decline in the proportion of OHSCD’s with VF as the initial rhythm.[32] However, as the percentage of witnessed OHSCD’s with VF as initial rhythm was much higher (53%) suggests that the initial mechanism for most OHSCD’s is still arrhythmic in nature. High levels of asystole are due to prolonged CRI’s and the high proportion of unwitnessed arrests (which may have been pulseless for an undetermined period of time).

The limitations of this study are common to many, mainly arising from incomplete data. We have tried to minimise this. The study did not include any death certificates of people found dead for whom the EMS was not called, meaning that a small number of OHSCD’s may have been missed. However, to have included all these cases would have resulted in overestimation of the incidence of OHSCD.

The EASR for OHSCD in our study was 122/100,000 for males and 41/100,000 for females. The age-standardised incidence of OHSCD in Belfast in 1966 is not available. However there were 71 OHSCD’s per 100,000 population in Belfast in 1966. Because there are no age-standardised incidences available for OHSCD in 1966 a direct comparison with our data cannot be made. However, even allowing for an aging population, the incidence of OHSCD in Belfast City over the last 38 years does not appear to have fallen.

Acknowledgements
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Competing interest statement
None of the authors have any competing interests to declare.

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Ethics
The study complied with the Declaration of Helsinki and received approval from the local research ethics committee, Royal Victoria Hospital, Belfast.
Legends

Figure 1: Scatter graph shows the distribution of Call to Response Intervals (CRI) for the emergency medical services.
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Figure 1.
Demographic and temporal trends in out-of-hospital sudden cardiac death in Belfast

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