Multiple source surveillance incidence and aetiology of out-of-hospital sudden cardiac death in a rural population in the West of Ireland

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Aims

There is a paucity of published data on prospectively identified rates of out-of-hospital sudden cardiac death (SCD). We sought to determine the incidence, survival and aetiology of out-of-hospital SCD in the West of Ireland for the year 2005.

Methods and results

Data from emergency room resuscitation records were collected throughout the year from all hospitals in the West of Ireland and recorded according to pre-specified criteria. Hospital records of survivors were analysed. Simultaneously, autopsy reports from all pathology laboratories in the region were systematically reviewed and cases of SCD identified. Cardiac arrest associated with non-cardiac pathology was excluded. The population base was 414 277. There were 212 recorded cases of out-of-hospital SCD; 160 (75.5%) were male and the mean age was 63.3 years. The incidence rate was 51.2/100 000/year. The most common aetiology was coronary artery disease (161 cases; 75.9%). The majority of cases occurred in the home (152, 71.7%). Thirteen (6.1%) patients survived to admission of whom eight (3.8%) were alive at discharge. All survivors had ventricular fibrillation as the presenting rhythm.

Conclusion

The burden of SCD in the West of Ireland is considerable. The vast majority of cases occur in the home. Survival rates in this rural population cohort remain low.

Keywords

Sudden cardiac death \bullet Resuscitation \bullet Survival

Introduction

Cardiovascular disease is the leading cause of death in the developed world.\textsuperscript{1} Approximately 50% of cardiac deaths occur suddenly in the pre-hospital setting and in about half of these victims, sudden death is the first manifestation of cardiac disease.\textsuperscript{2,3} The societal impact of these deaths is very significant, and sudden cardiac death (SCD) is a major public health issue. Despite this, direct counting of rates of SCD remains a scientific gap.\textsuperscript{4}

The published incidence of SCD ranges between 36 and 128 deaths per 100 000 population per annum.\textsuperscript{5–11} The wide range in published incidence rates is likely due to methodological differences in data collection rather than interpopulation variation in terms of cardiovascular disease burden and emergency response and resuscitation services. Prospectively collected data using multiple cross-referenced data are the most accurate method for estimating rates of SCD.\textsuperscript{7} Data of this type are scant and contribute to the poorly defined burden of SCD.

No database for SCD currently exists in the Republic of Ireland and prevalence in our population is undefined. In this study, we report on the prevalence of SCD in a geographically defined region of Ireland over a 1 year period.

Methods

Study population

The Western Health Board serves a distinctly defined region comprising three counties in the West of Ireland. The population is...
predominantly rural with a ratio of urban-to-rural residents of approximately 30:70, and only one single population centre with in excess of 20,000 inhabitants. The study population is served by four acute hospitals, including a single regional tertiary referral centre. All emergent admissions in the region are triaged through the emergency departments of these hospitals. Emergency response services are provided from 12 ambulance stations, co-ordinated by a single dispatch centre under the control of the national Health Service Executive. There is a significant proportion of the region with ambulance response times in excess of 25 minutes (Figure 1). All post-mortem examinations are performed by eight consultant pathologists at three regional pathology centres, with involvement of a cardiac specialist pathologist in another jurisdiction in selected cases. Population data for the region were obtained from the National Census database 2006. At the time-point during which our study was conducted, facilities for implantable defibrillator insertion in our catchment area were in a developmental stage.

**Case ascertainment**

Patients suffering out-of-hospital cardiac arrest from 1 January 2005 to 31 December 2005 inclusive were screened, regardless of age. Investigators collected data from emergency room resuscitation records at all hospitals in the West of Ireland at a number of time points throughout the year. Cases of pre-hospital cardiac arrest were identified and screened for inclusion criteria for SCD. Emergency room notes, ambulance Patient Report Forms and medical records were examined and data were collected according to the modified Utstein criteria. Simultaneously, the reports of all autopsies performed for the region in the same time period were reviewed and screened to select patients who met criteria for SCD. Detailed information, including gross pathology, histological examination and toxicology reports, were analysed in all cases. Data from both sources were cross-related and matched, and entered on a single database chronologically organized by date of death. An in-house adjudication process was used to determine cases meeting criteria for SCD. Our study complies with the...
Definition of sudden cardiac death
World Health Organization criteria for SCD were employed. SCD was defined as unexpected death either within 1 h of symptom onset if witnessed or within 24 h of having been observed alive and symptom free if un-witnessed. Non-cardiac pathologies were excluded. Subjects with non-cardiac terminal illnesses were not considered on the basis that such deaths are not unexpected. In addition, sudden cardiac arrest associated with trauma, (including all road traffic accidents), violent death, overdose, drowning and suicide were excluded from analysis. Survivors of SCD were included if they met entry criteria.

Statistical analysis
Continuous data were expressed as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. Statistical calculations were performed using SPSS version 12.1 (SPSS Inc., Chicago, IL, USA).

Results
The population of counties Galway, Mayo and Roscommon (which comprise the West of Ireland region) including inhabited offshore islands was 414 277 of which 209 369 were male (50.5%). Total persons residing in aggregate town areas were 122 426 (29.6%). There were 212 recorded cases of out-of-hospital sudden cardiac arrest. A total of 160 (75.5%) were male and the mean age was 63.3 years. The overall incidence of pre-hospital cardiac arrest was 51.2/100 000. The corresponding rates for males and females were 76.5/100 000 and 25.3/100 000. There were 10 deaths in the age group 0–39, 24 in group 40–49, 47 in group 50–57, 61 in group 60–69, 46 in group 70–79 and 28 in those over age 80. Post-mortem data were available on 197 patients (96.6% of patients who died).

Resuscitation
There were 152 (71.7%) arrests occurring in the home, with 49 cases (23.1%) occurring in public places, including a single case in police custody; six cases (2.8%) in non-acute resident care; and five cases (2.4%) in general practice surgery/ambulance. The majority of patients were pronounced dead on the scene by the attending doctor. Forty-two patients had ongoing resuscitation efforts on arrival in the emergency department. Thirteen patients (6.1%) survived to admission of whom eight (3.8%) were alive at discharge. All survivors had ventricular fibrillation as the initial presenting rhythm; seven had witnessed cardiac arrests and in the single case where the patient survived an unwitnessed arrest neurological impairment was significant with persistent vegetative state.

Aetiology
Coronary heart disease accounted for the majority of cases comprising 161 cases (75.9%); it was the dominant cause of death across all age groups over the age of 40. (Table 1, Figure 2). Macroscopic or histological evidence of acute infarction was present in 90 cases. In four of these cases, there was evidence of cardiac tamponade due to rupture of the free wall of the left ventricle. Seventy-one cases had chronic ischaemic heart disease without findings of acute infarction. There was one case of fatal stent thrombosis and one case of thrombosis associated with myocardial bridging.

There were 10 cases of diagnostic cardiomyopathy, six patients with hypertrophic cardiomyopathy (HCM) and four cases of dilated cardiomyopathy. In one of these latter cases, the pathologist noted prominent dilated channels in the ventricular musculature, raising the question of ventricular non-compaction. Seven patients succumbed to acute aortic dissection, five of whom had an associated cardiac tamponade and one of whom had evidence of a secondary acute myocardial infarction due to shearing off of the ostium of the right coronary artery. There were five cases where severe aortic stenosis was the dominant pathology.

Six patients (2.8%) had evidence of right ventricular pathology. In two patients there were findings of cor pulmonale in association with chronic respiratory disease (though no acute respiratory process). One patient had primary pulmonary hypertension and one patient had unexplained right ventricular dilatation consistent with arrhythmogenic right ventricular cardiomyopathy (although definitive specialist cardiac pathological opinion was not available in this case). In two of these cases, there was evidence of small volume microthrombi in the pulmonary vasculature which was out of keeping with the degree of morphological abnormality of the right ventricle; these cases were included on the basis that a dual pathology could not be outruled.

Miscellaneous causes included single cases of isolated coronary vasculitis, acute granulomatous myocardial infiltration consistent with sarcoidosis, known accessory pathway disease, congenital heart disease and massive atrial lipoma. Two patients had evidence of isolated left ventricular hypertrophy but did not meet criteria for HCM, one of whom had haemochromatosis but no evidence of myocardial iron deposition. A total 14 cases (6.6%) were associated with acute or chronic alcohol excess. Only one of these showed classic alcoholic dilated cardiomyopathy.

There were seven cases of sudden death in patients with previously diagnosed epilepsy where the available clinical history and pathological findings did not support a diagnosis of status epilepticus or indeed provide evidence of co-morbid cardiac disease. Such
cases were classified under sudden death in epilepsy. Seven patients had a structurally normal heart. Causes of SCD in the population aged 0–39 years are shown in Table 2.

### Discussion

In this study, we utilized a multiple source surveillance model to determine the incidence and the aetiology of SCD in a rural population in the West of Ireland. The European Society of Cardiology Task Force on SCD estimates the incidence of SCD to be between 90 and 100 deaths per 100 000 population, whereas among residents of Okinawa, Japan the rate was reported as 37 per 100 000. Data from Oregon, USA, using a similar prospective data collection method to ours, found a rate of SCD of 53 residents per 100 000 over a 12 month period. More recent data from an urban population in Northern Ireland reported 300 cases of SCD, which represents a standardized annual incidence rate of 88/100 000 (122 per 100 000 males and 41 per 100 000 females).

There are likely two reasons for the variation in reported rates of out-of-hospital SCD. First, there is significant discrepancy in definitions employed in the description of SCD. The current definition of SCD is of death within 1 h of symptom onset. Pathologists tend to use a broader definition describing a death as sudden where it occurs within 24 h of a person known to be alive and functioning normally. This broader time window allows for the inclusion of unwitnessed cardiac arrest victims, the exclusion of who would bias incidence figures. This may be of particular import in a predominantly rural population where the incidence of witnessed cardiac arrest may be expected to be lower.

Secondly, the method of data collection influences observed incidence rates. Previous studies have demonstrated that death certificate data overestimates the true incidence of SCD, as sudden death may be incorrectly ascribed to a cardiac cause if post-mortem examination is not performed. The same problem occurs when data are collected solely from emergency medical service (EMS) records, which may also have a low proportion of patients proceeding to autopsy. On the other hand, EMS data may fail to capture unwitnessed cases where resuscitation was deemed futile and consequently the emergency services are not employed. Death in these cases is typically reported by local family doctors to the coroner who would direct autopsy study. Integration of prospectively collected data from multiple sources (emergency service resuscitation records, autopsy reports and hospital records) likely improves accuracy of SCD detection rates as was described by Chugh et al. in their Multnomah County population.

Coronary artery disease accounts for the majority of cases of SCD and our figure of 75.9% is in keeping with previously reported studies. Cardiomyopathy, aortic stenosis, dissection of the aorta and acute pulmonary embolism are also well represented causes of SCD. The association of SCD with epilepsy is a recurrent finding though the exact mechanism linking the conditions remains to be fully elucidated. Seven patients (3.3%) had a structurally normal heart and it is possible that some of these deaths may have been due to conditions such as ion-channel disorders, undiagnosed accessory pathway disease, coronary artery vasospasm and abnormalities of the microvasculature. It has been recently proposed that these should be classified as sudden arrhythmic death syndrome. A significant proportion of patients had primary or secondary right ventricular dysfunction. As we expected, causes of SCD in the youngest age group (0–39 years) were predominantly from conditions other than atherosclerotic coronary artery disease. Of note, the patient whose only finding was isolated left ventricular hypertrophy had intensive pathological investigations and specialist opinion in an attempt to distinguish the findings from those of HCM. The single case of myocardial bridging occurred in the absence of coronary atherosclerosis or infarction but is well

### Table 2 Aetiology of sudden cardiac death in age group 0–39 years

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>Number of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precocious atherosclerotic coronary artery disease</td>
<td>2</td>
</tr>
<tr>
<td>Myocardial bridging</td>
<td>1</td>
</tr>
<tr>
<td>Sudden cardiac death associated with epilepsy</td>
<td>2</td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>1</td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>1</td>
</tr>
<tr>
<td>Congenital heart disease</td>
<td>1</td>
</tr>
<tr>
<td>Arrhythmogenic right ventricular cardiomyopathy</td>
<td>1</td>
</tr>
<tr>
<td>No pathology found</td>
<td>1</td>
</tr>
</tbody>
</table>
described as a cause of SCD.30 Alcohol excess was involved in 6.6% of cases though typically was observed in the absence of classic alcoholic cardiomyopathy. The association of lethal arrhythmia with acute intoxication, alcohol withdrawal and QT prolongation in the setting of marked fatty liver disease are all reported.11,32

Survival in our population base was low though within the expected range, with eight patients (3.8%) alive at hospital discharge. Recently published Scottish survey data calculated that for a population of 5 million, 150 victims of out-of-hospital cardiac arrest were successfully resuscitated to hospital discharge every year.33 This was broadly in keeping with pan-European survey data and large scale clinical trials.34,35 Extrapolating this data to our population base, we expected survival would be in the region of 11 cases per year. Local factors predisposing to low survival rates may be postulated to include a higher proportion of unwitnessed arrests in a predominantly rural population and a more prolonged EMS call to response interval time in geographically rural areas.12 Furthermore, caution should be used when comparing with rates of survival from SCD databases comprised only of EMS-generated cases, as these cohorts will have significant inherent survival bias.

Survival from pre-hospital cardiac arrest is strongly associated with both presence of a witness at the arrest and the presence of ventricular fibrillation/ventricular tachycardia on arrival of EMS.7,8,16,37 In fact, all patients who survived to hospital discharge had ventricular fibrillation as the presenting rhythm. All bar one of the survivors suffered a witnessed cardiac arrest. The vast majority of SCD cases occurred in the home (71.7%) and these findings are consistent with many previously reported series.6,7,37–39 Therefore, the ability of community based first responder resuscitation and automated external defibrillation40,41 to impact on these deaths may be limited. Proposed strategies targeted at high-risk individuals may be more effective (for example, the provision of home automated defibrillator machines or educational measures aimed at increasing awareness of pre-arrest symptoms among patients and their relatives38,42).

Limitations of our study include the lack of a centralized EMS database. As a consequence, while we report the number of patients with resuscitation efforts on-going at arrival in hospital, we are unable to reliably describe the number of cases in which resuscitation was instigated, so that a more definitive comment on predictors of successful resuscitation is not possible. Secondly, a lack of rigour in the pursuit of a firm pathological diagnosis at a community level is understandable in certain cases. This may have caused an under-representation of cases of SCD, particularly in the older population in our data set, involving instances where instigation of resuscitation was deemed futile and death was notified by an attending general practitioner without an autopsy being performed. This is an inevitable feature of studies such as ours.

In conclusion, out-of-hospital cardiac arrest is a common occurrence and survival remains low. The vast majority of cases of pre-hospital cardiac arrest involve a coronary disease aetiology and occur in the home setting. This has implications for the provision of population based strategies aimed at improving survival, particularly in a geographically remote rural population such as we describe. The impact of individual patient-based strategies involving the use of implantable defibrillators for primary/secondary prophylaxis of SCD remains to be seen.

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References
