EPIDEMIOLOGY

Chronic health conditions and survival after out-of-hospital ventricular fibrillation cardiac arrest

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Objective: To investigate whether chronic clinical comorbidity, as collected from emergency medical services (EMS) reports, influences survival after out-of-hospital ventricular fibrillation (VF) cardiac arrest.
Methods: In this observational retrospective cohort study in King County, Washington, USA 1043 people who suffered out-of-hospital VF arrest due to heart disease between 1 January 1999 and 31 December 2003 were studied. Chronic conditions were ascertained and tallied from EMS reports using a uniform abstraction form by people blinded to outcome status. The outcome was survival to hospital discharge.
Results: 75% (776/1043) of patients had at least one chronic health condition and 51% (529/1043) had prior clinically recognised heart disease. Overall, the increasing count of chronic conditions was inversely associated with the odds of survival to hospital discharge after adjustment for potential confounders (OR 0.84 (95% CI 0.74 to 0.95) for each additional chronic condition). The chronic condition–outcome association tended to be more prominent among those with longer EMS response intervals ($p = 0.07$ for interaction term between condition count and response interval). For example, the OR of survival was 0.72 (95% CI 0.59 to 0.88) for each additional chronic condition when the EMS response interval was 8 min compared with an OR of 0.95 (95% CI 0.79 to 1.14) when the EMS response interval was 3 min.
Conclusion: In this cohort, an increasing burden of clinical comorbidity based on a review of EMS reports was associated with a lower odds of survival after VF arrest. This finding suggests that chronic conditions influence arrest pathophysiology and in turn could help guide resuscitation care.

Out-of-hospital cardiac arrest is a leading cause of mortality.[1] In the community, ventricular fibrillation (VF) is the most common initial cardiac arrest dysrhythmia.[2] Although resuscitation is attempted in hundreds of thousands of patients with cardiac arrest annually, survival after VF cardiac arrest is <20% in most communities.[3 4] To some extent, poor survival may be attributed to the substantial challenges of successfully implementing the chain of survival.[5] Efforts to improve early emergency activation, early cardiopulmonary resuscitation (CPR), rapid defibrillation and timely advanced care are important and provide means for community leaders and health providers to directly impact outcome.

However, these factors probably account for only a portion of the variability in survival after VF.[6] Understanding other important predictors may ultimately help improve resuscitation care. Increasing evidence indicates that the best care for VF cardiac arrest incorporates information about the arrest circumstances as a reflection of the physiological state of the patient.[7] The patient's physiological substrate for cardiac arrest differs from individual to individual—just as the links in the chain of survival may differ for each patient—presumably influencing the physiological phase and, in turn, optimal treatment.

Yet, little is known about the prognostic role of the patient's clinical comorbidity in resuscitation after VF cardiac arrest. Importantly, although pre-existing clinical conditions predict the risk of cardiac arrest, half of the people who have an arrest may not have a history of prior clinically recognised heart disease, indicating a measure of variability in the clinical profile of the population with cardiac arrest.[8] A better understanding of if and how clinical factors influence outcome may help explain outcome differences across individuals that would otherwise seem similar while enabling a more precise estimate of the effects of treatment or circumstance characteristics. Ultimately, such an understanding may provide the basis to further individualise or customise patient care to favourably affect outcome.

Part of the challenge then is to understand whether and how the patient's clinical characteristics influence outcome while striving for an ascertainment approach that would potentially enable efficiency and wide implementation. We hypothesised that increasing clinical morbidity collected solely from emergency medical services (EMS) reports would predict a lower likelihood of survival after out-of-hospital VF cardiac arrest.

METHODS

Study design, population and setting

This investigation was a retrospective cohort study of patients ⩾18 years who had out-of-hospital VF cardiac arrest due to heart disease between 1 January 1999 and 31 December 2003 in King County, Washington, USA, excluding the city of Seattle, and treated by EMS. King County (excluding Seattle) measures approximately 2000 square miles, includes urban, suburban and rural areas, and has a population of approximately 1.2 million people.[9] The study was approved by the University of Washington Human Subjects Committee.

During the study period, King County EMS followed the American Heart Association guidelines for cardiac arrest, which included analysis of condition and giving shock treatment as soon as possible for VF, stacked shocks and 1 min CPR intervals between rhythm and pulse checks.[10] The system is activated by calling 9-1-1. Emergency medical dispatchers use a uniform approach to identify and treat cardiac arrest. In the case of cardiac arrest where no CPR is occurring, dispatchers offer and provide telephone CPR instruction.[11] King County is served by a two-tiered EMS response system. The first tier includes fire fighter-emergency medical technicians who are trained in basic

Abbreviations: CPR, cardiopulmonary resuscitation; EMS, emergency medical services; VF, ventricular fibrillation life support and defibrillation. The second tier consists of paramedics who are trained in advanced life support. First-tier EMS providers typically arrive on the scene 5 min after dispatch and 5 min before the arrival of paramedics.

Data collection and definitions

King County EMS reviews each case of EMS-treated cardiac arrest as part of an ongoing quality assurance programme. First- and second-tier EMS personnel complete report forms that provide information about the patients' demographics (age and sex), event circumstances (witness status and location), care received (citizen CPR status, arrest before/after EMS arrival, EMS response intervals (call receipt to arrival at scene), presenting rhythm and immediate outcome (admit to hospital vs death on scene), which is abstracted in a standard manner.[12] Aetiology of the cardiac arrest is categorised using the EMS reports as well as information from death certificates and hospital records. People are presumed to have an aetiology of heart disease unless information indicates a specific alternate cause. Using this classification approach to aetiology, 90% of VF arrests are due to presumed heart disease. This information is recorded in a computerised format.

The EMS form also includes a narrative section that reports chronic health conditions. We systematically reviewed this section of the EMS report form to assess pre-existing chronic health conditions using a uniform data collection form. Abstractors were blinded to outcome status. Chronic conditions were grouped as any and type-specific heart disease (eg, congestive heart failure, valvular disease, atrial fibrillation, myocardial infarction, angina and/or coronary revascularisation), hypertension, diabetes, chronic lung disease (eg, asthma and chronic obstructive lung disease), stroke, cancer, gastrointestinal or liver disease, kidney disease (eg, kidney failure or dialysis), substance misuse, psychiatric disorders or other major health conditions (eg, treatment for venous thrombosis or dementia). Patients were considered to have no chronic conditions if the EMS report did not record any chronic health conditions or explicitly noted no medical history.

Data analysis

We used descriptive statistics to assess the proportion of patients with VF cardiac arrest who had various chronic health conditions. To assess how the collection of chronic conditions related to survival, each patient was assigned a score based on the cumulative total count of conditions. Any form of heart disease received a single point (ie, a patient with prior myocardial infarction and atrial fibrillation would receive a single point). The exceptions were those who had congestive heart failure. We a priori assigned an individual with congestive heart failure an additional point. Thus, a patient with prior myocardial infarction and congestive heart failure would receive a point for heart disease and an additional point for congestive heart failure. Because nursing home residence may be associated with poor functional health status, we a priori also assigned nursing home residents an additional point. We grouped those patients with $\geqslant 4$ conditions together as one group because the number of patients in each count category beyond four was small. We used descriptive statistics to assess characteristics according to chronic condition count. We used logistic regression analysis to assess how the chronic condition count related to survival to hospital discharge after VF arrest. To assess whether the relationship differed by subgroups defined by age, gender or EMS response interval, we added an interaction term between chronic condition count and the covariate of interest to the logistic model. Analyses were performed using STATA V.8.0.

RESULTS

A total of 1043 persons had out-of-hospital VF arrest due to heart disease and were treated by EMS during the study period. Table 1 presents the overall distribution of chronic conditions based on a review of the EMS reports. At least one chronic health condition was recorded in approximately three-quarters, whereas half of the patients had a history of some type of heart disease.

Overall, average age of the patients was 65 years and approximately three-quarters were men.

Table 2 presents the distribution of demographic, circumstance and care characteristics according to the total number of chronic conditions. Increasing count of chronic conditions was associated with older age, female gender, unwitnessed arrest and non-public location.

The proportion of patients who survived to hospital discharge decreased as the number of chronic conditions increased (table 3). In unadjusted models, the odds ratio (OR) of survival for each successive increase in chronic condition group was 0.75 (95% CI 0.68 to 0.84). After adjustment for demographic, circumstance and care characteristics, the OR for each successive increase in chronic condition count group was 0.84 (95% CI 0.74 to 0.95). Results were similar when patients residing in nursing homes were excluded from the analysis (OR 0.83, 95% CI 0.72 to 0.94), or when nursing home status was not allocated a point (OR 0.83, 95% CI 0.72 to 0.94).

There was no evidence of a difference in the relationship between chronic condition count and survival in subgroups defined by age or gender. However, the interaction term between chronic condition count and EMS response interval approached significance ($p = 0.07$), suggesting that the relationship between chronic condition count and survival was modified by response interval. The chronic condition–outcome association tended to be more prominent among those with longer EMS response intervals. For example, the OR of survival was 0.72 (95% CI 0.59 to 0.88) for each additional chronic condition when the EMS response interval was 8 min compared with an OR of 0.95 (95% CI 0.79 to 1.14) when the EMS response interval was 3 min.

DISCUSSION

In this cohort study of out-of-hospital VF cardiac arrest, the increasing count of chronic conditions as assessed from the EMS report was associated with a decreased likelihood of survival, a relationship that persisted after adjustment for traditional predictors of survival. This relationship was especially apparent among those with longer EMS response intervals.

Table 1 Distribution of pre-existing chronic conditions

Chronic condition	n	(%)
Any chronic condition	778	(74.6)
Heart disease	529	(50.7)
Congestive heart failure	159	(15.2)
Myocardial infarction	172	(16.5)
Hypertension	203	(19.5)
Diabetes	167	(16.0)
Stroke	61	(5.9)
Lung disease	75	(7.2)
Cancer	42	(4.0)
Gastrointestinal disease	37	(3.6)
Kidney disease	42	(4.0)
Psychiatric disorder/substance misuse	36	(3.5)
Other conditions	152	(14.6)

n = 1043.

Table 2 Characteristics according to number of chronic conditions

Characteristic	Number of chronic conditions None (n = 286)	1 (n = 323)	2 (n = 211)	3 (n = 125)	4–8 (n = 98)
Mean (SD) age (years)*	58.4 (15.2)	64.5 (13.6)	66.6 (14.3)	68.9 (14.0)	72.8 (12.2)
Men, % (n)*	79.0 (226)	80.8 (261)	73.0 (154)	68.0 (85)	62.2 (61)
Arrest before arrival, % (n)	88.5 (253)	87.9 (284)	89.6 (189)	92.8 (116)	87.8 (86)
Witnessed, % (n)*	82.5 (236)	78.3 (253)	78.2 (165)	77.6 (97)	70.4 (69)
Location, % (n)*					
Residential	45.1 (129)	64.1 (207)	72.5 (153)	72.0 (90)	53.1 (52)
Public	54.9 (157)	34.1 (110)	19.4 (41)	20.0 (25)	9.2 (9)
Nursing home	0 (0)	1.8 (6)	8.1 (17)	8.0 (10)	37.7 (37)
Citizen CPR, % (n)	60.8 (174)	56.4 (182)	47.9 (101)	48.0 (60)	64.3 (63)
Mean (SD) BLS interval (min)	5.8 (3.4)	5.6 (2.0)	5.6 (2.6)	5.4 (2.2)	5.4 (1.6)
Mean (SD) ALS interval (min)	10.2 (5.6)	9.9 (5.4)	9.5 (4.8)	10.0 (4.9)	9.9 (4.7)

ALS, advanced life support; BLS, basic life support; CPR, cardiopulmonary resuscitation.
*p Value <0.05 for test of trend between specific characteristic and number of chronic conditions.

In an investigation by Hallstrom *et al*,[6] increasing comorbidity was inversely and strongly related to odds of survival. However, in that study, ascertainment of comorbidity required interviews of bystanders and family members during the weeks and months after the arrest. Although the interview process may provide more reliable information, the resources to routinely undertake and complete such a process are considerable, especially when compared with the method of ascertainment used in this study. On the basis of this review of existing EMS records, the prevalence of chronic conditions tended to be slightly less than more resource-intensive approaches.[6 8] Information about chronic health conditions included in EMS reports typically derives from lay bystanders during a pressured and limited period. Given these circumstances, a measure of under-ascertainment might be expected.

The increasing burden of comorbidity as measured by chronic condition count was associated with other traditional predictors of outcome (older age, unwitnessed arrest, non-public location) and, in turn, may provide an understanding of how these characteristics influence prognosis. However, increasing chronic condition count remained independently associated with a lower odds of survival after accounting for traditional predictors, especially as EMS response intervals increased. Additional comorbidity may hasten electrical, haemodynamic and metabolic decline. Taken together, one potential interpretation is that patients with VF with excess chronic conditions may be a group who would especially benefit from treatments designed to effectively treat the pathophysiology of the haemodynamic and metabolic phases that predominate with longer EMS response.[7] Animal models that simulate such chronic conditions may be useful as we try to understand how clinical comorbidity affects arrest pathophysiology and, in turn, may guide treatment.[13]

This study has limitations. Most notably, we relied solely on EMS reports to assess chronic conditions. This approach, though efficient, undoubtedly produced some misclassification most likely by under-ascertainment of chronic conditions. Such misclassification would tend to attenuate the comorbidity–survival relationship, suggesting that the true magnitude of the relationship may be even greater than observed in this study. We did not attempt to grade the severity of specific conditions, but rather we strove for a more straightforward and practical dichotomous approach. We also did not attempt to evaluate the independent survival association of individual chronic conditions; individual chronic conditions may differentially influence survival in terms of both the magnitude and the mechanism of the effect. The study took place in a community with a mature EMS system where providers routinely record some measure of chronic health history. These are considerations when judging the generalisability of the findings.

In this cohort, an increasing burden of clinical comorbidity based on a review of EMS reports was associated with a lower odds of survival after VF cardiac arrest. Such information could be used to explain or refine estimates of the effects of interventions or other characteristics of interest. Moreover, the finding suggests that chronic conditions influence arrest pathophysiology and in turn could help guide resuscitation care. Future work should explore the mechanisms by which clinical comorbidity influences outcome. A better understanding of the role of clinical comorbidity coupled with other tools to assess the underlying substrate such as VF waveform processing techniques may provide for improved approaches to resuscitation.[14]

Table 3 OR of survival to hospital discharge according to number of chronic conditions

	Number of chronic conditions None (n = 286)	1 (n = 323)	2 (n = 211)	3 (n = 125)	4–8 (n = 98)	Trend
Survival, %, (n)	43.4 (124)	35.0 (113)	32.7 (69)	24.0 (30)	18.4 (18)	
Model 1	1	0.70 (0.51 to 0.97)	0.63 (0.44 to 0.92)	0.41 (0.26 to 0.66)	0.29 (0.17 to 0.52)	0.75 (0.68 to 0.84)
Model 2	1	0.80 (0.57 to 1.11)	0.72 (0.49 to 1.06)	0.48 (0.29 to 0.77)	0.36 (0.20 to 0.64)	0.79 (0.70 to 0.88)
Model 3	1	0.86 (0.60 to 1.23)	0.83 (0.55 to 1.26)	0.56 (0.33 to 0.95)	0.46 (0.24 to 0.88)	0.84 (0.74 to 0.95)

Figures are OR with 95% CI, unless otherwise specified.
None is the referent group.
Model 1 is unadjusted.
Model 2 is adjusted for age and gender.
Model 3 is adjusted for age, gender, witness status, citizen cardiopulmonary resuscitation, location, whether the arrest took place before emergency medical services arrival, and basic life support and advanced life support response intervals.

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IMAGES IN CARDIOLOGY

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The ''winking'' coronary sinus

A 79-year-old woman presented with increasing dyspnoea over 1 year. She had a history of chronic atrial fibrillation and examination showed the presence of a systolic and diastolic murmur. A dilated coronary sinus (CS) was seen on transthoracic echocardiography (panels A and B). In the parasternal short axis view, the coronary sinus could be seen ''winking'' in the right atrium (supplementary movie file available online at http://heart.bmj.com/supplemental). This was probably due to the dilated circular end of the CS moving in and out of the echocardiographic plane during the cardiac cycle. On coronary angiography, there was a giant right coronary artery draining through a fistula into the coronary sinus and then into the right atrium. A right-heart study showed a rise in oxygen saturation from 55% in the inferior vena cava to 66% in the right ventricle. The Qp:Qs shunt ratio was 1:4.

This elderly patient had a congenital coronary artery fistula between the distal right coronary artery (arterial) and the coronary sinus (venous). Increased arteriovenous flow had resulted in marked dilatation of the right coronary artery and the right coronary sinus.

Treatment options include surgical ligation or use of a transcatheter closure device. The patient declined these treatment options and was managed conservatively.

Supplementary movie file available at http://heart.bmj.com/supplemental

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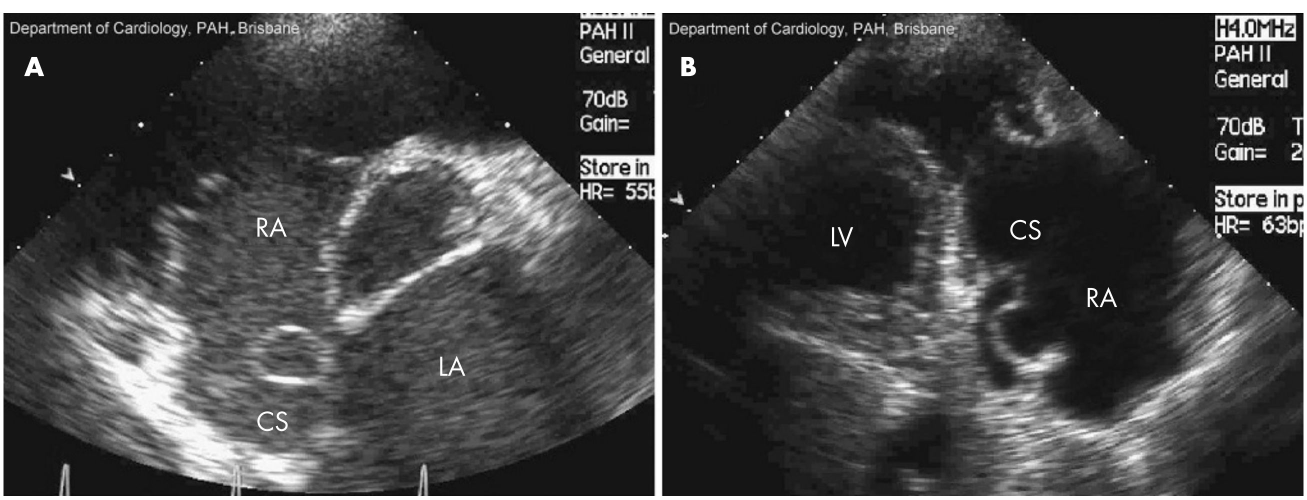

(A) Transthoracic echocardiogram in parasternal short axis view at the level of the left ventricular outflow tract just below the aortic valve. The circular contour of the dilated coronary sinus can be seen at this level during ventricular diastole. (B) Parasternal long axis view of the right ventricular inflow tract, showing the dilated coronary sinus. CS, dilated coronary sinus; LA, left atrium; LV = left ventricle; RA, right atrium.