Mortality within hospital after resuscitation from ventricular fibrillation outside hospital

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Abstract

Objective—To determine factors related to mortality within hospital after successful resuscitation from ventricular fibrillation outside hospital by a mobile coronary care unit manned by a physician.

Design—Retrospective review of records of patients resuscitated and admitted to hospital between 1 January 1966 and 31 December 1987.

Setting—Mobile coronary care unit, coronary care unit, and cardiology department.

Patients—281 patients (227 male), aged 14–82 (mean 58) successfully resuscitated from ventricular fibrillation outside hospital of whom 182 (65%) developed ventricular fibrillation before the arrival of the mobile coronary care unit. The aetiology of ventricular fibrillation was acute myocardial infarction in 194 patients (69%), ischaemic heart disease without infarction in 71 (25%), and other or unknown in 16 (6%).

Main outcome measures—Death within hospital.

Results—There were 91 deaths in hospital (32%). Factors on univariate analysis significantly associated with increased mortality were patient age ≥ 60 years, previous myocardial infarction or cerebrovascular disease, prior digoxin or diuretic treatment, collapse without prior chest pain or with pain lasting 30 minutes or less, defibrillation delayed by ≥ 5 min, ≥ 4 shocks required to correct ventricular fibrillation, left ventricular failure or pulmonary oedema and cardiogenic shock after successful defibrillation, and coma on admission to hospital. On multivariate analysis the most important factors (in rank order) were cardiogenic shock after defibrillation, coma on admission to hospital, age ≥ 60 years and the requirement for four or more shocks to correct ventricular fibrillation.

Conclusions—The in-hospital mortality of patients resuscitated from ventricular fibrillation outside hospital was related to patient characteristics before the cardiac arrest and to the immediate haemodynamic and neurological status after correction of ventricular fibrillation

as well as to factors at the resuscitation itself. The in-hospital mortality of this study compares favourably with the results obtained by units staffed by paramedical workers and emergency medical technicians, although 35% (99/281) of the patients had ventricular fibrillation after the arrival of the mobile unit and defibrillation was thus rapid.

Since the feasibility of resuscitation from ventricular fibrillation outside hospital was first demonstrated in Belfast in 1966,¹ many mobile coronary care schemes have been established. In the United States there are now more than 300 prehospital coronary care programmes.² Of the many published studies of outcome after prehospital cardiac arrest, most have concentrated on the relation between resuscitation-related factors (such as availability of bystander cardiopulmonary resuscitation and delay in defibrillation) and survival rather than patient characteristics before the arrest or haemodynamic status after correction of ventricular fibrillation. Furthermore, few studies have considered factors specifically related to death within hospital for patients who survive to be admitted. We describe 281 patients resuscitated from ventricular fibrillation outside hospital by the Royal Victoria Hospital's mobile coronary care unit and we assess factors related to in-hospital mortality.

Patients and methods

PATIENTS

We studied patients who were resuscitated outside hospital after ventricular fibrillation developed and who were admitted to hospital by the Royal Victoria Hospital mobile coronary care unit between 1 January 1966 and 31 December 1987. Patients developed ventricular fibrillation before or after the arrival of the mobile unit. When ventricular fibrillation developed after the mobile unit's arrival, patients received immediate defibrillation. Patients were not included in the study if ventricular fibrillation was iatrogenic—that is, if it occurred during treatment of ventricular tachycardia or asystole.

COLLECTION OF DATA

Since the mobile unit started operation, patient characteristics, circumstances of arrest, resus-

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citation details, and condition after successful resuscitation have been recorded on standardised forms. The following factors were studied to determine their relevance to outcome:

Patient characteristics—sex, age, previous history of myocardial infarction, previous stable angina or chronic cardiac dyspnoea (New York Heart Association grade II or greater), previous hypertension, diabetes mellitus or cerebrovascular event (stroke or transient ischaemic attack), previous drug treatment (digoxin, diuretics, β blocking and antiarrhythmic agents), smoking history.

Aetiology and circumstances of arrest—aetiology, site of infarction if present, year, time, place, ventricular fibrillation before or after the arrival of the mobile unit, presence or absence of chest pain and its duration before ventricular fibrillation.

Resuscitation details—presence or absence of cardiopulmonary resuscitation before defibrillation, cardiopulmonary resuscitation operator, delay in starting cardiopulmonary resuscitation after collapse where given, delay in defibrillation, number of shocks required to correct ventricular fibrillation (defined as the total number of shocks administered at the time of the initial arrest outside hospital before a stable rhythm was achieved and maintained even if ventricular fibrillation recurred after the initial resuscitation at the time of the initial arrest).

Condition after successful defibrillation—left ventricular failure or pulmonary oedema, cardiogenic shock (systolic blood pressure < 80 mm Hg with peripheral circulatory shut-down), coma on admission to hospital.

Statistical analysis was performed with the *Statistical Package for the Social Sciences-II* program on a Digital Professional 350 microcomputer. To test single factors for significance in influencing in-hospital mortality we used a χ^2 test with Yates's correction on 2×2 contingency tables. We used the multiple regression program of *Statistical Package for the Social Sciences-II* for multivariate analysis in order to determine the most significant factors and rank them in order.

Results

PATIENTS

Between 1 January 1966 and 31 December 1987, 281 patients (227 male; age range 14–82; mean (1 SD) 58 (12) years) in whom ventricular fibrillation developed outside hospital were successfully resuscitated by the Royal Victoria Hospital mobile coronary care unit and were admitted to hospital. The cardiac arrest was witnessed in all except one patient. One hundred and eighty two (65%) patients developed ventricular fibrillation before the arrival of the mobile unit.

AETIOLOGY

The aetiology of ventricular fibrillation was identified as acute myocardial infarction on the basis of electrocardiograph and/or serial cardiac enzyme changes in 194 (69%) patients. The site of infarction was inferior or posterior in 66 patients (34%), anterior in 121 (62%), and was unknown in seven (4%). Seventy one (25%) of the 281 patients had ischaemic heart disease but no evidence of acute myocardial infarction at the time of ventricular fibrillation. Thus coronary artery disease, with or without acute myocardial infarction, caused ventricular fibrillation in 265 (94%) of the patients seen. The aetiology was not related to coronary artery disease in 13 patients and was unknown in three.

IN-HOSPITAL MORTALITY

Of the 281 patients, 91 (32%) died in hospital; thus 190 patients (68%) survived to be discharged. Of the 91 in-hospital deaths, 41 (45%) occurred within 48 hours of the initial arrest and 50 (55%) occurred ≥ 48 hours later. Death was due to intractable ventricular fibrillation (23 patients), cerebral anoxia (24), cardiogenic shock (nine), respiratory failure (13), cardiac failure (17), and bradycardia (five).

FACTORS RELATED TO IN-HOSPITAL MORTALITY AND SURVIVAL TO DISCHARGE

Patient characteristics

Patients who survived to leave hospital were significantly younger (56.0 (12)) than those who died before discharge (60.8 (11)) ($p < 0.01$).

Table 1 Patient characteristics significantly associated with in-hospital mortality (univariate analysis) (%)

Factor	Survived	Died	χ^2	DF	Significance
Age:					
< 40	11 (85)	2 (15)	11.46	2	0.01 > p > 0.001
≥ 40 –< 60	104 (76)	32 (24)			
≥ 60	75 (57)	57 (43)			
Previous MI*:					
Yes	73 (61)	47 (39)	4.20	1	0.05 > p > 0.01
No	117 (73)	43 (27)			
Previous cerebrovascular event†:					
Yes	5 (33)	10 (67)	7.44	1	0.01 > p > 0.001
No	184 (70)	77 (30)			
Prior digoxin therapy‡:					
Yes	20 (53)	18 (47)	3.99	1	0.05 > p > 0.01
No	169 (70)	71 (30)			
Prior diuretic therapy‡:					
Yes	38 (55)	31 (45)	6.26	1	0.05 > p > 0.01
No	151 (72)	58 (28)			

DF, degrees of freedom, MI, myocardial infarction.

*One missing observation, †five missing observations, ‡three missing observations.

Table 2 Factors related to the cardiac arrest that were significantly associated with in-hospital mortality (univariate analysis) (%)

Factor	Survived	Died	χ^2	DF	Significance
VF before arrival of mobile unit:					
Yes	112 (62)	70 (38)	7.94	1	0.01 > p > 0.001
No	78 (79)	21 (21)			
Chest pain before VF:					
Yes	136 (72)	53 (28)	4.38	1	0.05 > p > 0.01
No	54 (59)	38 (41)			
Duration of chest pain before VF:					
≤ 30 min	16 (53)	14 (47)	6.47	2	0.05 > p > 0.01
> 30 min < 4 h	106 (76)	33 (24)			
≥ 4 h	14 (70)	6 (30)			
Delay in defibrillation*:					
< 5 min	106 (75)	36 (25)	6.00	2	0.05 > p > 0.01
5–9 min	38 (62)	23 (38)			
≥ 10 min	45 (60)	30 (40)			
Shocks to correct VF(n)*:					
< 4	138 (72)	53 (28)	5.31	1	0.05 > p > 0.01
≥ 4	50 (57)	37 (43)			

DF, degrees of freedom; VF, ventricular fibrillation.

*Three missing observations.

The influence of patient age on survival to leave hospital was confirmed by χ^2 testing (table 1). Single-factor analysis showed that the following patient characteristics were also significantly ($p < 0.05$) associated with in-hospital mortality: previous myocardial infarction, previous cerebrovascular event, prior digoxin therapy, and prior diuretic therapy.

Aetiology and circumstances of arrest

Single factor analysis showed that the following circumstances of the cardiac arrest were significantly associated with death in hospital (table 2): ventricular fibrillation developing before the arrival of the mobile unit, collapse without preceding chest pain, pain lasting ≤ 30 minutes before collapse for patients who had chest pain, delay in defibrillation ≥ 5 minutes after collapse, and the requirement for four or more shocks to correct ventricular fibrillation at the initial arrest and to allow a stable rhythm to be maintained.

Condition after successful defibrillation

The presence of the following features after successful defibrillation was significantly related to in-hospital mortality on single factor analysis (table 3): left ventricular failure or pulmonary oedema, cardiogenic shock, and failure to recover consciousness by the time of admission to hospital.

Factors not related to outcome

These were sex, previous stable angina, previous chronic cardiac dyspnoea, history of hypertension, diabetes mellitus, prior treatment with β blockers or antiarrhythmic agents, a history of smoking, aetiology of ventricular fibrillation, site of infarct if ventricular fibrillation was caused by acute myocardial infarction, year, time and place of ventricular fibrillation, presence or absence of cardiopulmonary resuscitation before defibrillation if patients had ventricular fibrillation before the arrival of the mobile unit, and for patients who received cardiopulmonary resuscitation, the delay to resuscitation and type of operator.

Multivariate analysis

Factors shown to be significantly related to in-hospital mortality on univariate analysis were also analysed by a stepwise forward algorithm with factors entered as binary variables.

Factors of greatest significance in predicting in-hospital mortality were cardiogenic shock after successful defibrillation, coma on admission to hospital, age ≥ 60 years, and the need for four or more shocks to correct ventricular fibrillation (table 4).

Discussion

The initial experience with the Royal Victoria

Table 3 Factors after successful defibrillation significantly associated with in-hospital mortality (univariate analysis) (%)

Factor	Survived	Died	χ^2	DF	Significance
Cardiac failure*:					
No	127 (73)	48 (27)	11.33	2	0.01 > p > 0.001
Mild/moderate	52 (65)	28 (35)			
Pulmonary oedema	10 (40)	15 (60)			
Cardiogenic shock:					
Yes	1 (4)	24 (96)	47.58	1	p < 0.001
No	189 (74)	67 (26)			
Coma on hospital admission:					
Yes	65 (56)	51 (44)	11.22	1	p < 0.001
No	125 (76)	40 (24)			

*One missing observation. DF, degrees of freedom.

Table 4 Factors significantly ($p < 0.05$) related to in-hospital mortality on stepwise multiple regression analysis

Step	Factor	Standardised Coefficient	F value
1	Cardiogenic shock after defibrillation	0.443	70.62
2	Coma on hospital admission	0.181	10.73
3	Age ≥ 60	0.138	6.88
4	≥ 4 shocks to correct VF	0.112	4.16

VF, ventricular fibrillation.

Hospital mobile coronary care unit³ confirmed that ventricular fibrillation was the usual rhythm of cardiac arrest in patients who were seen soon after collapse and that successful resuscitation and survival to leave hospital were practical propositions for patients who had ventricular fibrillation outside hospital.

Although there have been many subsequent reported studies of survival after pre-hospital cardiac arrest most have considered pre-hospital and in-hospital mortality together and few have specifically assessed deaths after hospital admission. Furthermore, most have concentrated on resuscitation details rather than on patient characteristics and haemodynamic status after correction of ventricular fibrillation.

PATIENTS STUDIED

The patients studied here differ in two major respects from those resuscitated out of hospital from ventricular fibrillation and cardiac arrest irrespective of rhythm by paramedical and emergency medical technician-based units. Firstly, 69% of all patients and 73% of patients with coronary artery disease were identified as having had acute myocardial infarction at the time of ventricular fibrillation. In comparison, other studies have suggested that acute myocardial infarction or acute transmural myocardial infarction accounts for a minority of cases of cardiac arrest out of hospital, with figures of 17–40% for patients surviving to reach hospital^{4–6} and in some cases to be discharged home.⁴ Secondly, a higher proportion of patients (35%) developed cardiac arrest after the arrival of the mobile unit than in other studies (11–16%).^{4,6,7} These features may reflect differences in the use of our unit, which was established to provide physician-based care not only in cases of sudden death but also to manage patients in the early phase of acute myocardial infarction.⁸ Three quarters of patients resuscitated from cardiac arrest out of hospital by another physician-manned mobile unit based in Reykjavik had acute infarction.⁹

In our study the in-hospital mortalities of 32% for all patients and of 38% for patients who had ventricular fibrillation before the arrival of the unit compare favourably with results of 41–52% reported by units manned by paramedical staff and emergency medical technicians.^{10–14} We showed no significant relation between in-hospital mortality and the aetiology of ventricular fibrillation.

FACTORS RELATED TO IN-HOSPITAL MORTALITY

Patient characteristics

The importance of age in relation to death

within hospital was confirmed both on univariate and on multivariate analysis, where on stepwise analysis it appeared after cardiogenic shock and coma following defibrillation. Other studies have confirmed the association of patient age and outcome within hospital after resuscitation from out-of-hospital ventricular fibrillation and other cardiac arrest rhythms.^{15–17}

Of other patient characteristics, previous history of myocardial infarction, cerebrovascular event, and prior digoxin or diuretic therapy were associated with increased in-hospital mortality. Few studies have assessed any of these factors. Weaver *et al* did not find prior digoxin or diuretic therapy to be significantly related to in-hospital mortality after resuscitation from ventricular fibrillation out of hospital.¹⁸ The increased in-hospital mortality associated with digoxin and diuretic therapy in the present study may reflect an increased likelihood of collapse without warning chest pain and hence delayed defibrillation. Alternatively, these drugs may be indicators of poor cardiac function. An increased in-hospital mortality for patients resuscitated from out of hospital ventricular fibrillation with a previous history of cardiac failure has been reported.¹⁶

Circumstances of cardiac arrest

Ventricular fibrillation occurring before the arrival of the mobile unit and defibrillation delayed by ≥ 5 minutes were significantly associated with increased in-hospital mortality and confirm the importance of early defibrillation.¹⁹ Further support is provided by the increased mortality in patients who collapsed without warning chest pain (and in whom, therefore, defibrillation must have been delayed) and in patients who had pain lasting ≤ 30 minutes who because of delays in summoning help were more likely to have collapsed before the arrival of the mobile unit. The association between the number of shocks required to correct ventricular fibrillation and outcome was confirmed both on univariate and multivariate analysis. Dunn *et al* confirmed an increased in-hospital mortality for patients who require ≥ 4 shocks to terminate in-hospital or out-of-hospital ventricular fibrillation,²⁰ and Hargarten *et al* showed a linear decrease in survival with each shock delivered (up to five) for patients receiving treatment for ventricular fibrillation outside hospital.⁷

Condition after successful defibrillation

Univariate analysis showed that left ventricular failure and cardiogenic shock after successful defibrillation were significant predictors of in-hospital mortality; and multivariate analysis showed cardiogenic shock to be the most important predictor of death in hospital. Few studies of patients resuscitated from ventricular fibrillation out of hospital have considered the influence of haemodynamic status after resuscitation on survival. Liberthson *et al* reported an in-hospital mortality of 92% for patients who had cardiogenic shock after resuscitation from ventricular fibrillation out of hospital and of 64% for patients with conges-

tive heart failure compared with 58% for all patients.⁵ Studies of ventricular fibrillation in hospital confirm the adverse influence of cardiac failure and cardiogenic shock at the time of ventricular fibrillation on in-hospital mortality.²¹⁻²²

Unconsciousness on admission to hospital was a significant predictor of in-hospital mortality both on univariate and multivariate analysis. Again, the importance of early defibrillation in speeding neurological recovery and hence survival has been confirmed elsewhere.²³⁻²⁴

In conclusion, our results show that a favourable outcome for discharge from hospital after resuscitation from ventricular fibrillation out of hospital is more likely in young patients with no prior cardiac history who have immediate or early defibrillation, no haemodynamic abnormality, and who recover consciousness rapidly after correction of ventricular fibrillation. Wider availability of early defibrillation outside hospital particularly in the home, at work, and in public places by automatic, semi-automatic, and trans-telephonic defibrillators will increase the likelihood of survival after the onset of ventricular fibrillation outside hospital.

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