Hospital Mortality in Acute Myocardial Infarction

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Summary: All 757 patients with acute myocardial infarction admitted to the three public hospitals in Auckland during one year were studied. About 7% died from cardiac arrhythmia four days or more after the onset of infarction. These patients had severe infarcts with circulatory failure on or shortly after admission to hospital. Late death from arrhythmia in patients recovering from circulatory failure may in many cases be preventable with anti-arrhythmic drugs.

Introduction

Previous mortality studies in acute myocardial infarction (Honey and Truelove, 1957; Beard *et al.*, 1960; Killip, 1966) have shown that hospital mortality is greatest during the first day of admission and that 50 to 60% of deaths occur during the first three days and 60 to 70% during the first week after admission to hospital. Studies in which the time of death has been related to the mode of dying have shown a similar temporal distribution of arrhythmic deaths to total deaths (Ball *et al.*, 1955), and a greater tendency for deaths from heart failure to occur late in the illness (Mower *et al.*, 1964). The present prospective study was undertaken in conjunction with a previously reported trial of propranolol (Norris *et al.*, 1968) in order to determine the natural pattern of hospital mortality and to define factors associated with prognosis.

Continuous electrocardiographic (E.C.G.) monitoring was not available in Auckland at the time of this study. Though this to some extent limited the amount of information available, it was thought that this disadvantage was outweighed by the opportunity of studying the natural history of death from infarction without the modifying factor of modern anti-arrhythmic treatment (Lown *et al.*, 1967). The patients reported here received no routine antiarrhythmic drugs apart from propranolol, which was shown to be ineffective in preventing sudden death. Information from this study has been applied to the management of patients in a coronary care unit which has been established at one hospital since the investigation was completed.

Patients and Methods

All 757 patients with myocardial infarction admitted to the three public hospitals in Auckland during one year were studied; 454 were included in the drug trial (Norris *et al.*, 1968), while 303 were excluded, mainly because of conditions such as heart failure, shock, and bradycardia, which might have been exacerbated by the drug under test.

As in the drug trial, myocardial infarction was presumed to have occurred if two of the following three criteria were satisfied: (1) characteristic clinical presentation; (2) pathological Q waves, ST elevation, or T-wave inversion with evolutionary changes; and (3) rise in serum aspartate aminotransferase (AsT) to over 40 units/ml. Necropsies were performed on 50% of

the patients who died, and the presence of a recent infarction was confirmed in all.

On admission to hospital patients had a chart completed on which personal details, previous ischaemic history, previous heart failure, other disease, time of onset of the most severe pain, and condition on admission, as judged by blood pressure, jugular venous pressure, and basal crepitations, were recorded in numerical form. In addition, heart size and lung fields were assessed by one radiologist from a chest x-ray film taken within 24 hours of admission, and serum AsT was measured daily for four days. Progress and complications were recorded thrice weekly until discharge, patients being treated according to conventional methods without E.C.G. monitoring or routine anti-arrhythmic treatment apart from propranolol. All information was recorded in numerical form and was subsequently transferred to I.B.M. punch cards.

Death was recorded as being due to arrhythmia, cardiogenic shock, heart failure, cardiac rupture, pulmonary embolus, or other cause; cardiac rupture and pulmonary embolus were in all cases verified at necropsy. For our purpose death was attributed to arrhythmia if it was sudden and unexpected; patients were either free of complications at the time of death or, if heart failure or shock was present, they were responding to treatment. In 33 of the 98 arrhythmic deaths (34%) the terminal rhythm was identified during attempts at resuscitation, while a further seven patients who were successfully resuscitated from ventricular fibrillation were considered as cases of death from arrhythmia. Death from shock was defined as an irreversible lowering of blood pressure, while heart failure implied acute pulmonary oedema or congestive cardiac failure.

In all cases the time of death after the onset of the most severe chest pain or initial symptom, and after admission to hospital, was recorded separately on the punch cards. In an attempt to assess factors which influenced prognosis or which might determine the mode of dying, details of past history, admission status, and progress were compared in survivors, arrhythmia deaths, shock deaths, heart-failure deaths, and deaths from arrhythmia occurring more than three days after the onset of infarction. As a check on the findings, and in view of the possible uncertainty about the mode of death in patients who did not have E.C.G. monitoring, a further series of 211 patients monitored in a coronary care unit, which was opened after this study was completed (Norris, 1968), were studied to ascertain the temporal distribution of deaths from arrhythmia.

Results

Of the 757 patients 195 died—a total hospital mortality of 26%. Seven were discharged from hospital after successful treatment of ventricular fibrillation, and are included in the analysis of deaths. The number and proportion of patients dying in the various ways are given in Table I, which shows that 52% of patients died of arrhythmia, 27% of shock, 14% of heart failure, and 7% of other causes. The time of death for all cases after admission to hospital, together with two other series (Killip, 1966; Honey and Truelove, 1957), is shown in the Chart, while the time of death after onset of the most

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TABLE I.—Mode of Dying of 195 Patients

Mode of Dying	No.	%
Arrhythmia	98+7*	52
Shock	54	27
Heart failure	29	14
Arrhythmia causing heart failure	3	1.5
Cardiac rupture	3	1.5
Pulmonary embolus	2	1
Other causes	6	3
Total	202	100

* Hospital survivors from ventricular fibrillation.

severe pain or initial symptom in patients dying of arrhythmia, heart failure, or shock is given in Table II.

TABLE II.—Time of Death Related to Mode of Dying

Mode of Dying	Time of Death in Days After Onset of Pain or Initial Symptom							Total
	0-1	2	3	4-7	8-14	15-21	22+	
Arrhythmia	23	6	6	21	30	9	10	105
Shock	33	3	2	4	8	0	4	54
Heart failure	5	2	0	3	8	5	6	29
All other causes	1	2	2	0	2	2	5	14
Total	62	13	10	28	48	16	25	202

It is seen from Table II that the distribution of deaths from arrhythmia and heart failure is different from that of shock, there being a greater number of deaths from arrhythmia and heart failure from the fourth day onwards after the onset of infarction. Of these dying of arrhythmia 70 (67%) died from the fourth day onwards (late arrhythmic deaths), while 16 (30%) shock deaths and 22 (76%) heart-failure deaths occurred four days or more after onset of the pain. Further analysis of the arrhythmia deaths, however, showed that the proportion of early to late arrhythmic deaths was very dependent on the

same in all those admitted within 24 hours of the onset (7%), the incidence of late arrhythmic death rising to 13% in patients admitted from one to seven days after the onset.

Twenty-six of the 211 patients who have since been monitored in a coronary care unit in one of the three hospitals involved in this survey died suddenly from arrhythmia or were resuscitated from ventricular fibrillation, and in 14 of these the arrhythmia occurred four days or more after the onset of chest pain. In all but one case the patient was being monitored or was under observation at the moment of death. This confirms an incidence of late arrhythmic death of approximately 7%.

Possible factors associated with death in hospital are given according to the mode of dying in Tables IV to VII. Though the average age of patients who died (67.4 years) was significantly greater than that of the survivors (60.5 years; $P < 0.01$), there was no difference in age in the three modes of dying (shock death 68.9 years, heart failure 68.7 years, arrhythmia 66.5 years, late arrhythmia 65.3 years). When sex is considered (Table V) it is seen that in women 43% of shock deaths occurred, compared with 24% of heart-failure deaths, 28% of arrhythmic deaths, and 27% of late arrhythmic deaths; this increased incidence of death from shock was of borderline significance ($P < 0.10$).

TABLE IV.—Mean Ages

Survivors	60.5 years	Heart-failure deaths	68.7 years
All deaths	67.4 "	Arrhythmia deaths	66.5 "
Shock deaths	68.9 "	Late arrhythmia	65.3 "

TABLE V.—Proportion of Males to Females

	Males	Females		Males	Females
Survivors	69%	31%	Heart failure deaths	76%	24%
All deaths	67%	33%	Arrhythmia deaths	72%	28%
Shock deaths	57%	43%	Late arrhythmia	73%	27%

TABLE VI.—Factors in Past Medical History Associated with Hospital Mortality

Factor	Survivors (555)	All Deaths (202)	Shock Deaths (54)	Failure Deaths (29)	Arrhythmic Deaths (105)	Late Arrhythmic Deaths (70)
Percentage of Patients Having the Factor						
Angina of 3 months' duration; no infarct	23	31*	28	35	32	23
One previous infarct	23	22	19	24	25	26
More than one previous infarct	6	7	11	7	5	5
Previous ischaemia (total of above)	52	61*	58	66	62	54
Dyspnoea not associated with lung disease	23	31*	24	31	33	31
Heart failure necessitating treatment in bed	5	11*	7	24*	8	11
Diabetes	10	10	6	17	11	9
Hypertension	19	19	7*†	14	27	26

* Incidence significantly different from survivors ($P < 0.02$).† Incidence significantly different from total deaths ($P < 0.02$).

Percentage of total hospital deaths from acute myocardial infarction according to the day after admission to hospital in the present and two previously reported series.

time of admission to hospital, patients admitted within six hours of onset of the most severe chest pain being more liable to early death (Table III). The proportion of patients dying from arrhythmia four days or more after infarction was the

TABLE III.—Time of Occurrence of Arrhythmic Death Related to Time of Admission to Hospital

Time of Admission After Onset of Pain	No. of Patients	Time of Death After Onset of Pain			
		0-3 Days		4 Days or More	
		No.	% of Patients	No.	% of Patients
0-6 hours	262	23	9	19	7
6-24 hours	239	5	2	17	7
1-7 days	174	3	2	23	13
Total	675*	31	5	59	9

* Eighty-two patients, including 15 arrhythmic deaths, are excluded because of uncertainty over the precise time of onset of infarction, or admission after one week.

Table VI shows factors in the past history, with their occurrence in all patients and in patients who died of shock, heart failure, arrhythmia, or late arrhythmia. Surprisingly, neither a history of hypertension nor of diabetes was associated more commonly with death than survival. A past history of ischaemic heart disease was associated more often with death (61%) than with survival (52%), though in the three groups of angina without infarction, one previous infarct, or more than one previous infarct the increased likelihood of death was significantly greater only in angina (present in 31% of deaths and 23% of survivors). No factor was of statistical significance in predicting the mode of dying except that previous hypertension seemed to protect against death from shock. Only 7% of shock deaths compared with 19% of all patients dying had a history of hypertension.

Admission status (Table VI) was of much greater value than past history in predicting survival. Right or left heart failure as evidenced on admission by a raised jugular venous pressure

or basal crepitations, a systolic blood pressure below 110 mm. Hg, full-thickness infarction, and the x-ray appearance of interstitial or pulmonary oedema were all associated with a significantly greater total mortality. However, none of these complications had any predictive value in determining the mode of dying, except that moderate or marked basal crepitations were more often associated with death from heart failure, and a systolic B.P. of less than 110 mm. Hg with death from shock.

TABLE VII.—Factors in Initial Clinical Examination Associated with Hospital Mortality

Factor	Survivors (555)	All Deaths (202)	Shock Deaths (54)	Failure Deaths (29)	Arrhythmic Deaths (105)	Late Arrhythmic Deaths (70)
Percentage of Patients Having the Factor						
Raised jugular venous pressure ..	23	48*	43*	59*	48*	52*
Basal crepitations ..	43	66*	59*	76*	68*	74*
Basal crepitations moderate or marked ..	22	49*	46*	69*†	45*	48*
Systolic B.P. below 110 mm. Hg ..	10	37*	67*†	28*	28*	22*
Transmural infarction ..	56	72*	69	69	72*	68*
Anterior transmural infarction ..	28	44*	35	38	48*	43*
X-ray evidence of interstitial or pulmonary oedema ..	20	54*	52*	66*	51*	53*

* Incidence significantly different from survivors ($P < 0.02$).

† Incidence significantly different from total deaths (< 0.02).

Discussion

Numerous retrospective studies have been made of hospital mortality in myocardial infarction (Rosenbaum and Levine, 1941; Mintz and Katz, 1947; Billings *et al.*, 1949; Doscher and Poindexter, 1950; Honey and Truelove, 1957; Killip, 1966), and the wide range of mortality between approximately 15 and 40% is almost certainly due to selection of cases rather than to differences in standard of treatment. Nevertheless, there is general agreement on the temporal distribution of deaths (see Chart). There is, however, no prospective study describing the pattern of death according to the mode of dying defined by prearranged criteria, previous reports being concerned with groups of cases studied retrospectively from the case notes (Ball *et al.*, 1955; Mower *et al.*, 1964; Grendahl, 1967).

Ball *et al.* (1955) found a similar distribution of arrhythmic deaths to total deaths in a group of 342 patients, with a 26% mortality one month after infarction. Of these deaths 23% occurred on the first day, 50% during the rest of the first week, and 27% during the rest of the first month. Ventricular fibrillation was presumed to be the cause of death in 65% of cases; 29% of these occurred on the first day, 42% during the rest of the first week, and 29% during the rest of the first month. Mower *et al.* (1964), however, found that deaths from heart failure were more likely to occur late in the illness (mean 10.4 days after onset) than deaths from hypotension (mean 5.3 days) or arrhythmia (5.0 days). Grendahl (1967) does not comment in detail on the temporal distribution of deaths according to the mode of dying, but analysis of the figures given indicates that 50% of acute arrhythmic deaths occurred more than three days after admission to hospital compared with 30% of deaths from all other causes. The relevance of this to the present study is uncertain, however, as only 26% of the deaths described by Grendahl were considered to be due to acute arrhythmia.

A possible objection to the present definition of arrhythmic death is that the patients did not have E.C.G. monitoring, were often not under observation at the moment of death, and in two-thirds of cases the terminal rhythm was not identified. Sudden death after myocardial infarction may be due to cardiac rupture or pulmonary embolus, cardiac rupture being found at necropsy in 4.7% of patients with infarction (London and London, 1965), while pulmonary embolus occurs in 28% of necropsies, but probably is the cause of death in only 4% of

cases, this figure being reduced to 1.4% by anticoagulant treatment (Hilden *et al.*, 1961). As necropsy was performed in only half the patients who died in this series, and as cardiac rupture and pulmonary embolus were not diagnosed without necropsy, it is probable that a further five patients died from these causes in addition to the five recorded in Table I as having done so. Death from heart failure and shock may also occur rapidly, but in our experience it is rare for this to occur in less than about 30 minutes. With relatively close nursing observation, usually in open wards, it is thought to be unlikely that more than a small proportion of deaths in the present series attributed to arrhythmia were actually due to cardiac failure or shock. In addition, the total proportion of arrhythmic deaths (52%) is not greater than that reported from the other series (Mower *et al.*, 1964), while a similar experience with late arrhythmias in patients subsequently monitored in a coronary care unit is also in agreement. For these reasons it is concluded that the diagnosis of arrhythmia as a mode of dying was correct in all but a few cases, and these would not alter the general conclusions drawn from this survey.

It is evident that the relatively low mortality from arrhythmia during the first three days in this study is a reflection of late admission to hospital. The findings in community studies (Bainton and Peterson, 1963; Pell and D'Alonzo, 1964) that approximately 85% of deaths from infarction occur within the first 24 hours, together with those of Pemberton and McNeilly (1967) that of 901 fatal coronary attacks in Belfast during a one-year period only 414 patients reached hospital, while 102 were dead on arrival, suggest that the present report may deal with only 20 to 35% of coronary deaths in our community. This rests on the assumption that the Auckland community does not differ significantly from the communities in the previous reports. The provision of a mobile intensive care unit in Belfast now ensures that two-thirds of admitted patients come under intensive care within four hours of onset, with a consequent 9% incidence of ventricular fibrillation in patients seen within four hours (Pantridge and Geddes, 1967). This is comparable with our own incidence of 9% of arrhythmic deaths in patients admitted within six hours, and emphasizes that the present results are not in conflict with those of other workers. Nevertheless, the 7% mortality from late arrhythmia found in patients admitted up to six hours or six to 24 hours after the onset suggests that the proportion of late arrhythmic deaths is not influenced by the time of hospital admission up to 24 hours after infarction. The 13% mortality from late arrhythmia in patients admitted between one and seven days after infarction is probably due to selection of more seriously ill patients.

The information in Tables VI and VII is an attempt to identify factors which may be of importance in predicting the likelihood and mode of dying. The main facts that emerge are that the past history is a poor guide to prognosis, but that the patient's condition on admission is of great importance. Though the negative prognostic value of the past history, particularly with regard to previous myocardial infarction, is surprising, the same observation was made by Honey and Truelove (1957); a possible explanation is that patients with second or third infarcts are more likely to die before reaching hospital (Bainton and Peterson, 1963). Most reports agree that there is no adverse effect of hypertension on early survival (Billings *et al.*, 1949; Honey and Truelove, 1957; Beard *et al.*, 1960), though earlier workers have found an adverse effect of diabetes (Billings *et al.*, 1949; Honey and Truelove, 1957). Inaccurate reporting and varying criteria for diagnosis are obvious factors limiting the reliability of historical information. In the present study the information gained in accuracy by being obtained prospectively, but it was not possible to enforce strict criteria for the diagnosis of previous infarction, hypertension, or diabetes.

Though the condition on admission gave useful prognostic information, it was still a poor guide to the likely mode of

dying, heart failure on admission, as determined clinically and radiologically, being nearly as likely to result in death from arrhythmia as in death from failure. Patients suffering late arrhythmic death were, however, much more ill than the survivors, having a greatly increased incidence of shock and heart failure, and a greater incidence of transmural infarction, particularly involving the anterior part of the heart. A detailed analysis of our 70 cases of late arrhythmic death showed that, excluding a few who had clearly diagnosable reinfarction, all but four had radiological evidence of interstitial or pulmonary oedema on admission, or heart failure, hypotension, or a major arrhythmia during the first few days after admission.

It is doubtful whether long-term E.C.G. monitoring of all patients at risk of late arrhythmic death is economically feasible or psychologically desirable, and it is probable that the yield in lives saved will be considerably less than by the institution of early intensive care as practised by Pantridge and his colleagues. It is also true that ventricular fibrillation complicating heart failure or shock has a poor prognosis in spite of monitoring and resuscitation (Robinson, 1965). Nevertheless, it is thought that arrhythmic death in patients who are recovering from circulatory failure is in many cases preventable with anti-arrhythmic drugs, and the logical use of E.C.G. telemetry (Cercek *et al.*, 1965) is in this group of patients.

It is now our practice, in a four-bedded coronary care unit which has opened at Green Lane Hospital since this study was completed, to readmit patients who have had heart failure or major arrhythmia during their three to seven days of initial monitoring from the ward to the unit if their condition deteriorates. Warning signs of impending death from ventricular fibrillation are taken to be further chest pain not quickly relieved by trinitrin, a fall in blood pressure, or irregularity in the pulse which was not present before. Nurses are instructed to feel the pulse at the wrist of all coronary patients for a full minute and to report irregularities and ectopic beats. As late arrhythmic death occurs so seldom in uncomplicated cases, it can be argued that it is unnecessary to keep these

patients in hospital for more than a week, and that mobilization and rehabilitation may be correspondingly accelerated.

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Organochlorine Pesticide Residues in Human Fat in Great Britain

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Summary : In order to assess the trend in the body load of organochlorine pesticide residues in Great Britain, between July 1965 and June 1967 samples of fat were taken during routine necropsies on 247 subjects over 3 years old and on 44 stillborn or premature babies and infants below the age of 3. The levels of the three main pesticides, B.H.C., dieldrin, and D.D.T., were lower than those found in an earlier survey carried out in 1963 and 1964. No marked differences were observed in levels throughout Britain, but the levels in man were higher than those in women. Britain compares favourably with other countries in which similar surveys have been done.

Introduction

The presence of organochlorine pesticide residues in human body tissues continues to attract considerable attention. Originally a matter of curiosity and concern, the determination of national mean concentration levels of these pesticides in

human fat has now come to be regarded more as a method of measuring the degree of exposure to which a population is subjected. Useful information can be derived from each set of results and also from any trends that may become apparent from year to year. The effects of the general withdrawal from use of certain pesticides, or the introduction of new compounds into agricultural and veterinary practice, can be followed by such studies.

Between 1965 and 1967 at least 15 publications have appeared giving results of analyses of samples of human fat from such widespread sources as, for example, India (Dale *et al.*, 1965), Israel (Wassermann *et al.*, 1965), Denmark (Wiehe, 1966), New Zealand (Brewerton and McGrath, 1967), and New Orleans (Hayes *et al.*, 1965). All of these papers tell much the same story ; that these organochlorine pesticide residues are omnipresent. The papers differ, however, in reporting mean concentration levels, varying sometimes by orders of magnitude according to country.

In Britain an early study in 1961 was confined to South-east England (Hunter *et al.*, 1963). In 1963 and 1964 a further study, instigated by the Advisory Committee on Pesticides and Other Toxic Chemicals, was carried out jointly by

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