Papers and Originals

Duration of Last Attack in 998 Fatal Cases of Coronary Artery Disease and its Relation to Possible Cardiac Resuscitation

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Summary: All the deaths attributed to coronary artery disease and occurring in Belfast during one year were studied.

The frequency distributions of the cases by interval of time between onset of the last attack and death are given for those not admitted to hospital, for those admitted to hospital, and for those already in hospital for some other cause of illness.

Sixty per cent. of all the deaths occurred outside hospital. This indicates that the problem of cardiac resuscitation in coronary artery disease is to a considerable extent an extra-hospital one.

Twenty-seven per cent. of the men and 22% of the women died within 15 minutes, but the median period of survival was 3 hours 30 minutes for men and 6 hours 18 minutes for women.

The median time interval from the onset of the attack to sending for medical aid was 1 hour 17 minutes for men and 1 hour 6 minutes for women, and from summoning medical aid to sending for the ambulance 59 minutes for men and 1 hour 26 minutes for women. Ninety-six per cent. of the ambulance journeys to the patient were accomplished in less than 20 minutes.

It was found among men, but not among women, that the duration of survival tended to be longer in older patients and in second or subsequent attacks.

Of the 596 who did not gain admission to hospital 229 (23% of all the 998 patients) were known to have survived for more than half an hour after the onset of the fatal attack; 182 (18%) survived for more than one hour; and 143 (14%) survived for more than two hours. It is among these that there would appear to be special scope for the cardiac ambulance, providing that medical aid is sought and the ambulance is summoned without delay.

There have been numerous reports in recent years of the successful resuscitation of patients developing cardiac arrest in hospital, and Pantridge and Geddes (1966), Restieaux *et al.* (1967), and Lawrie *et al.* (1967), working in coronary care units, have reported that resuscitation after cardiac arrest occurring in hospital was successful in more than 50% of cases.

There have been a few reports of organized attempts to resuscitate patients developing cardiac arrest outside hospital, however, though it seems that for some years specially equipped and staffed ambulances have been used in the U.S.S.R. for this purpose (Moiseev, 1962; Czazov, 1967). These ambulances

have been used mainly as second-call ambulances and are summoned by the doctor in charge of the ordinary ambulance, which first arrives on the scene, when he thinks the patient requires or may require cardiac resuscitation.

Pantridge and Geddes (1966, 1967) have described the use in Belfast of a specially equipped and staffed cardiac ambulance used as a "first-call" ambulance going out when summoned by the general practitioner, and they have reported some striking successes in the resuscitation of patients outside hospital.

Aims of Present Study

The present investigation was undertaken (a) to study the distribution of the time intervals between the onset of the fatal attack and death, (b) to estimate the proportion of patients dying from coronary thrombosis who died before admission to hospital had been sought or achieved, and (c) to consider in the light of these findings the possible scope for a cardiac ambulance in a large city. The promptness in sending for medical aid and for the ambulance and the time taken to dispatch the ambulance and for it to get to the patient are clearly of vital importance in this procedure, and a knowledge of the distributions of these times is necessary in order to assess the possibilities of successful resuscitation. It is also important to ascertain if any biological or social factors affect survival time, because knowledge of these may help to decide the most effective use of a cardiac ambulance. The associations between survival times and age, sex, rank of attack, civil state, and social class were therefore examined.

Population Studied

A study was made of all the deaths occurring in Belfast during the year ending 31 July 1966 in which arteriosclerotic heart disease (*I.C.D.*¹ 420.0) or heart disease specified as involving coronary arteries (*I.C.D.* 420.1) was entered anywhere on Part 1 of the medical certificate of the cause of death. Deaths ascribed to "angina pectoris" without mention of coronary artery disease (*I.C.D.* 420.2) were omitted because these might have included some diseases not due to arteriosclerotic heart disease. This exclusion is unlikely to affect the conclusions, because in Northern Ireland in 1965 this cause accounted for only 0.14% of all deaths classified under *I.C.D.* 420.

There were 1,017 deaths attributed to *I.C.D.* 420.0 and 420.1 (subsequently referred to as coronary artery disease) in the year

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¹ *International Classification of Disease*, 7th revision, 1955.

under review. Nineteen of these were excluded for the following reasons:

Necropsy did not confirm the medical certificate of cause of death (297 necropsies were carried out in this series) ...	8
Among those on whom necropsy was not carried out the consultant in charge said the wrong diagnosis had been recorded on the medical certificate of cause of death ...	1
Diagnosis considered incorrect after scrutiny of hospital records ...	10

Therefore 998 cases were available for study.

Only fatal cases of coronary artery disease were included, because the intention was to try to assess the scope for a mobile cardiac resuscitation unit in the treatment of cases of cardiac arrest. Fatal attacks, however, represent only a minority of all attacks of the disease. Belfast hospital records showed that during the same year about 1,600 non-fatal cases were admitted to hospital; in addition, there must have been other patients, of whom we have no knowledge, who developed the disease and recovered but who were not admitted to hospital.

Methods

Information was collected from the following sources: the central office of the Registrar of Deaths in Belfast, the patients' general practitioners, hospital records, the coroner's records, ambulance service records, and relatives of the patients.

While information recorded on the medical certificate of the cause of death—for example, age and sex—was available for all cases, other information was available only for some. The time interval between onset of the fatal attack and death could be determined in only 871 (87%) of the 998 cases. Not infrequently patients were found dead or did not live long enough for some of the events which were studied, such as those involving the ambulance service, to take place.

The data relating to the time intervals in the period from onset of the fatal attack to death were analysed as frequency distributions of patients by time interval. Medians of these distributions are given as the most appropriate single measurement because the distributions are highly skewed.

Results

Place and Circumstances of Death.—Of the 998 subjects 98 (9.8%) were found dead, 389 (38.9%) died before an ambulance was sent for or before it arrived, 109 (10.9%) were dead on arrival in the ambulance at hospital (an unknown number of this group were dead on being placed in the ambulance because it is a rule in the Northern Ireland ambulance service that the patient must be taken to hospital unless a doctor has certified him as dead), 305 (30.5%) were admitted to hospital, where they later died, and 97 (9.7%) died in hospital, having been admitted with some other condition. Many of this last group were geriatric cases. It is with those in the first three categories—that is, the 596 (60%) of the total who did not reach hospital—that we are concerned in relation to the possibility of extending the means of cardiac resuscitation to patients outside hospital.

TABLE I.—Distribution of all Cases by Age and Sex

Sex	Age (Years)												Total
	0-49		50-		60-		70-		80-		90 +		
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	
Male	64	9.9	124	19.3	232	36.0	159	24.7	61	9.5	4	0.6	644
Female	11	3.1	31	8.8	90	25.4	150	42.4	69	19.5	3	0.9	354
Total	75	7.5	155	15.5	322	32.3	309	31.0	130	13.0	7	0.7	998

Duration of Survival from Onset of Attack to Death

Age and Sex.—Table I shows the distribution of the 998 cases by age and sex. Among men the largest number of deaths occurred in the decade 60-69, among women a decade later. Nearly a third of the deaths among men occurred under 60 and one-tenth under 50.

The Chart shows the percentage of men and women surviving for different intervals of time for the 871 cases in which this time interval could be determined. Twenty-five per cent. died within 15 minutes and 38% within an hour. The median values show that 50% of the male deaths occurred within 3 hours 30 minutes and 50% of the female deaths within 6 hours 18 minutes. Table II shows the frequency distribution of the survival times in the three categories: not admitted to hospital, admitted to hospital, and dying in hospital from coronary artery disease but admitted for another condition.

As would be expected, a much higher proportion of those not admitted to hospital died within a short time of the onset than of those who gained admission. The proportion of very early deaths in those not admitted is probably even higher than shown, because included among the 117 cases not admitted in which this time interval was unknown are most of those who were found dead, and it is probable that many of these died too quickly to be able to summon help.

In considering ways in which delay in making cardiac resuscitation available to patients by the use of a cardiac ambulance might be reduced the time interval from onset to death may be divided into four operational periods: (a) onset of symptoms to sending for medical aid, (b) sending for medical aid to sending for ambulance, (c) receipt of message at ambulance station to dispatch of ambulance, and (d) dispatch of ambulance to arrival at patient. Where there is no cardiac ambulance available the time taken to get the patient into a hospital ward is of greatest importance.

Survival times of 871 fatal cases of coronary artery disease.

Onset of Attack to Sending for Medical Aid.—This interval was from the time of onset of the symptoms to the time the patient or someone else sent for the doctor. The median times for the 376 men and 226 women for whom this information was available were 1 hour 17 minutes and 1 hour 6 minutes respectively. Medical aid was not sought for more than six hours after the onset of symptoms in 20.5% of the male cases and in 23.9% of the female cases.

Time Interval between Sending for Medical Aid and Sending for Ambulance.—This time interval was the time between the patient, or someone on his behalf, sending for the doctor and the time the ambulance was sent for. The median times for the 164 men and 92 women for whom these times were known were 59 minutes for men and 1 hour 26 minutes for women. Of these 256 patients 32 died before they reached hospital.

TABLE II.—Distribution of Cases by Time Intervals from Onset of Last Attack to Death

Time Interval	Males								Females							
	Not Admitted to Hospital		Admitted to Hospital		Dying in Hospital*		All Males		Not Admitted to Hospital		Admitted to Hospital		Dying in Hospital*		All Females	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
<15 minutes ..	137	43.4	—	—	12	23.0	149	26.6	62	38.0	—	—	7	17.1	69	22.2
15–29 minutes ..	30	9.5	—	—	3	5.8	33	5.9	21	12.9	—	—	8	19.5	29	9.3
30–59 minutes ..	32	10.1	—	—	3	5.8	35	6.3	15	9.2	—	—	2	4.9	17	5.4
60–119 minutes ..	30	9.5	1	0.5	3	5.8	34	6.1	9	5.5	1	0.9	—	—	10	3.2
120–179 minutes ..	15	4.8	5	2.6	3	5.8	23	4.1	10	6.2	1	0.9	—	—	11	3.5
180–359 minutes ..	19	6.0	14	7.3	1	1.9	34	6.1	9	5.5	6	5.6	4	9.8	19	6.1
360–719 minutes ..	20	6.3	13	6.8	8	15.4	41	7.3	12	7.4	5	4.6	4	9.8	21	6.7
12–23 hours ..	9	2.8	17	8.9	4	7.7	30	5.4	5	3.1	9	8.3	3	7.3	17	5.4
24–47 hours ..	4	1.3	14	7.3	—	—	18	3.2	3	1.8	7	6.5	1	2.4	11	3.5
48–167 hours ..	10	3.2	32	16.8	4	7.7	46	8.2	7	4.3	30	27.8	1	2.4	38	12.2
1–2 weeks ..	2	0.6	45	23.6	1	1.9	48	8.6	2	1.2	11	10.2	3	7.3	16	5.1
2–3 weeks ..	2	0.6	22	11.5	4	7.7	28	5.0	3	1.8	10	9.2	1	2.4	14	4.5
3–4 weeks ..	2	0.6	8	4.2	4	7.7	14	2.5	1	0.6	11	10.2	1	2.4	13	4.2
4 weeks + ..	4	1.3	20	10.5	2	3.8	26	4.7	4	2.5	17	15.7	6	14.5	27	8.7
Total known ..	316	100	191	100	52	100	559	100	163	100	108	100	41	100	312	100
Not known ..	79		2		4		85		38		4		—		42	
Grand total ..	395		193		56		644		201		112		41		354	
Median ..	25 min.		165 hr. 38 min.		6 hr. 42 min.		3 hr. 30 min.		28 min.		147 hr. 30 min.		5 hr. 36 min.		6 hr. 18 min.	

* Coronary artery disease not reason for admission to hospital.

Time Interval between Summoning Ambulance and Admission to Ward.—This was known for 166 males and 105 females. The median times were 74 minutes for males and 88 minutes for females.

Time Interval between Summoning the Ambulance and its Dispatch.—Accurate records of the time an ambulance is summoned and the time it is dispatched are maintained at the ambulance station. The interval depends on the availability of an ambulance and on the degree of urgency as stated by the caller. These time intervals were known for 256 men and 124 women, the medians being 3 minutes for men and 8.5 minutes for women. The distributions of these time intervals for the two sexes were examined and there was a significant difference between them ($0.01 > P > 0.001$). The reasons for this unexpected finding are not entirely clear. On further examination of the data (McNeilly, 1967) it was found that a higher proportion of the onsets in women were insidious, and it was concluded that because of this the doctor was less likely to stress urgency in the case of a woman than in the case of a man.

Time Interval between Dispatch of Ambulance and Arrival at Patient.—Information about this time interval was available only in those cases where the ambulance was summoned by someone other than the general practitioner, usually for a person who had collapsed at work or in the street. For these cases the median was 8 minutes for 73 men and 8.3 minutes for 14 women; 96% of the journeys were accomplished in less than 20 minutes. The cardiac ambulance service in Belfast was started on an experimental basis while this study was in progress. This did not, however, materially bias our results, because approximately 97% of fatal cases of coronary artery disease for whom an ambulance was summoned in Belfast were conveyed in the ordinary ambulance over the relevant period of time.

Time Interval between Onset of Attack and Admission to Hospital Ward.—In the absence of a cardiac ambulance the time interval between onset of the attack and admission to the hospital ward is the important interval from the point of view of making the means of cardiac resuscitation fully available. In this series the median times for this interval were 7 hours 52 minutes for the 186 men and 8 hours 40 minutes for the 106 women for whom this time interval was known.

Biological and Social Factors

For this part of the analysis cases were grouped as follows for age: 0–59, 60–69, and 70 years and over. The rank of the fatal attack was taken as the number of previous attacks of coronary artery disease which had been confirmed by electro-

cardiographic examination plus the fatal attack, and cases were divided into two groups: (a) first attack and (b) second and subsequent attacks. For civil state cases were grouped as single (in which were included widowed persons and divorcees) or married. Four social class groups were distinguished—I and II non-manual, II manual and III manual, III non-manual and IV non-manual, IV manual and V—the occupation of the deceased being used to classify men and single women, and of the husband to classify married women. Data for each sex were dealt with separately throughout. In examining the relation between each of these five factors and the survival time, standardization for the factors other than the one under consideration was carried out by the method used, for example, by Elwood, Pemberton, Merrett, Carey, and McAulay (1965). Data were available for all the above factors for 553 men and 300 women.

Of the characteristics examined only age in men and rank of attack in men were significantly associated with the duration of time from onset to death. Older men and men in their second or subsequent attack tended to survive longer (Tables III and IV). Among the women there was a similar but non-significant trend with regard to age ($0.10 > P > 0.05$), but no trend, significant or otherwise, with any of the other characteristics.

TABLE III.—Comparison of Observed Distributions of Males by Time from Onset of Last Attack to Death and Age and that Expected on the Null Hypothesis after Standardizing for Civil State, Rank of Fatal Attack, and Social Class

Age at Death (Years)	Duration from Onset of Last Attack to Death						
	0-		15 Minutes-		12 Hours +		Total Observed
	Observed	Expected	Observed	Expected	Observed	Expected	
0-	55	48.00	69	62.55	51	64.48	175
60-	49	51.80	78	71.44	68	71.74	195
70 +	45	49.20	52	65.01	86	68.78	183
Total	149	149	199	199	205	205	553

 $\chi^2 = 12.7265$. D.F. = 4. $0.02 > P > 0.01$.

TABLE IV.—Comparison of Observed Distributions of Males by Time from Onset of Last Attack to Death and Rank of Attack and that Expected on the Basis of the Null Hypothesis after Standardizing for Age, Civil State, and Social Class

Rank of Fatal Attack	Duration from Onset of Last Attack to Death						Total Observed
	0-		15 Minutes-		12 Hours +		
	Observed	Expected	Observed	Expected	Observed	Expected	
I	107	98.13	134	128.29	124	138.59	365
II +	42	50.87	65	70.70	81	66.41	188
Total	149	149	199	199	205	205	553

 $\chi^2 = 7.8039$. D.F. = 2. $0.05 > P > 0.02$.

Discussion

This study indicates that the majority of deaths ascribed to coronary artery disease occur outside hospital. Those who are admitted to hospital represent, in fact, the survivors of a storm which has already taken its main toll. Fry and Dillane (1967) in their practice also found that in a series of 97 deaths from myocardial infarction, occurring within 24 hours of onset, 85% occurred outside hospital. Yater, Traum, Brown, Fitzgerald, Geisler, and Wilcox (1948) found in a group of U.S. Servicemen aged 18–39 who died from coronary artery disease that 49.6% died within 16 minutes of onset.

The rapidity with which so many deaths occur indicates that most of them are due to cardiac arrest. Most of the patients developing primary ventricular fibrillation—that is, not complicating congestive cardiac failure, etc.—do so during the first five hours after the onset of symptoms (Lawrie *et al.*, 1967), and therefore it is to this period that attention needs to be directed.

Recent reports dealing with hospital cases and cited above indicate that about 50% of patients developing cardiac arrest while in intensive coronary care units can be successfully resuscitated. The question which arises is whether, if communications were improved, more of the patients who at present die outside hospital could be successfully resuscitated, either by more rapid admission to hospital or by using a specially equipped and staffed cardiac ambulance to take the means of resuscitation to them. It would seem unlikely, however good the communication, that anything effective could be achieved for those who die outside hospital within 15 minutes of onset of symptoms; indeed, in most cases it would be difficult to bring resuscitation to those who die outside hospital within an hour of the onset. However, among those not admitted to hospital in this series 117 men and 65 women lived for more than one hour. If the means of cardiac resuscitation had been available for these patients and if the same sort of success had been obtained as in the hospital series cited above—that is, 50% successfully resuscitated—then some 58 men and 32 women—that is, 9% of the total number of patients in this study—might have survived.

This estimate must be regarded as extremely tentative, as it is based on certain assumptions which may not in fact be justified. Firstly, that the patient or a relative sends for the doctor very soon after an attack develops; secondly, that the doctor sends for the cardiac ambulance promptly; and, thirdly, that the proportion of otherwise fatal cases in which cardiac resuscitation is likely to be successful is about the same in patients outside hospital as in those in coronary care units.

A good deal of the delay between the onset of symptoms of an attack of coronary thrombosis and making cardiac resuscitation available is due to the patient or his relatives not sending for the doctor immediately. The symptoms may not be severe at first or they may occur at night when the patient may be unwilling to have his doctor summoned. We found in this series that more than a fifth of the patients delayed sending for the doctor for more than six hours. Perhaps if the public

were better informed about the significance of an attack of severe pain in the chest in middle-aged or elderly people this time interval might be shortened. Selected patients who have survived one attack of infarction might be given the telephone number of the ambulance service, and they or a relative be allowed to send for the ambulance should another attack occur.

If there is an efficient ambulance service there does not seem much scope for shortening the ambulance time. It would seem desirable, however, that all ambulance men should be taught to recognize cardiac arrest and be trained in methods of cardio-respiratory resuscitation as described by Wilder, Jude, Kouwenhoven, and McMahon (1964), as they are likely to be early on the scene in many cases.

The introduction of a cardiac ambulance service in Belfast (Pantridge and Geddes, 1967) has shown one way in which the interval between the onset of myocardial infarction and making the means of cardiac resuscitation available may be shortened. They have shown that patients who develop cardiac arrest outside hospital can sometimes be resuscitated before admission by using staff and equipment usually available only in hospital. Five out of 10 patients with cardiac arrest on whom resuscitation was attempted recovered. This suggests that patients developing cardiac arrest outside hospital are not greatly different clinically from those who develop it after admission to hospital.

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REFERENCES

- Czazov, E. J. (1967). *Myocardial Infarction*. Moscow.
 Elwood, P. C., Pemberton, J., Merrett, J. D., Carey, G. C. R., and McAulay, I. R. (1965). *Brit. J. industr. Med.*, 22, 27.
 Fry, J., and Dillane, J. B. (1967). *J. roy. Coll. gen. Practit.*, 14, 44.
 Geddes, J. S., Adgey, A. A. J., and Pantridge, J. F. (1967). *Lancet*, 2, 273.
 Lawrie, D. M., *et al.* (1967). *Lancet*, 2, 109.
 McNeilly, R. H. (1967). A Study of the Epidemiology of 998 Cases of Coronary Artery Disease in Belfast and the Relationship of some Biological and Social Factors to the Duration of the Last Attack. M.D. Thesis, Queen's University, Belfast.
 Moiseev, S. G. (1962). *Sovetsk. Med.*, 26, No. 6, p. 30.
 Pantridge, J. F., and Geddes, J. S. (1966). *Lancet*, 1, 807.
 Pantridge, J. F., and Geddes, J. S. (1967). *Lancet*, 2, 271.
 Restieaux, N., *et al.* (1967). *Lancet*, 1, 1285.
 Wilder, R. J., Jude, J. R., Kouwenhoven, W. B., and McMahon, M. C. (1964). *J. Amer. med. Ass.*, 190, 531.
 Yater, W. M., Traum, A. H., Brown, W. G., Fitzgerald, R. P., Geisler, M. A., and Wilcox, B. B. (1948). *Amer. Heart J.*, 36, 334, 481, 683.