THE EFFECTIVENESS OF A MOBILE CORONARY CARE UNIT

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CONTENTS

C O N T E N T S (contd.)

THE THESIS

It is proposed that a doctor-manned mobile coronary care unit is effective in reaching a significant proportion of the population at risk with ischaemic heart disease. It reduces the mortality of these patients significantly and gives information about patients it fails to reach. It provides an effective means of making decisions about home and hospital treatment for patients with ischaemic heart disease.

It is a cheap and effective adjunct to the hospital services for patients with ischaemic heart disease and has no adverse effects upon these patients.

CHAPTER 1

INTRODUCTION

Historical Aspects

Since the first descriptions of ischaemic heart disease at the beginning of this century the prevalence of the recognised disease has risen dramatically until it now accounts for the majority of deaths in all countries rich enough to keep accurate records (Rose, 1972).

In response to this epidemic treatment methods have shown a similar acceleration of change. Early methods of management of the disease were based on pathological evidence that the area of myocardial necrosis was completely unstable for a period of six weeks. This led to a regime of strict bed rest for that time (Mallory et al., 1939). As a result a growing proportion of cases were treated in hospital rather than at home. This tendency was increased in the 1950s by the vogue for anticoagulant treatment, which could be administered only in hospital.

Honey and Truelove (1957), working from hospital, catalogued the increasing number of admissions from ischaemic heart disease and at the same time demonstrated the importance of a new concept, the time after the onset of a patient's symptoms, as a factor in survival. They showed that a third of the patients who died of myocardial infarction within two months of admission to hospital did so within 24 hours.

Early results from a study of the general population in the town of Framingham, Massachusetts detected every person who developed ischaemic heart disease by regular clinical examinations. They showed (Kannel et al., 1961) that the trend for patients to die early after the onset of their symptoms was even more marked for the community as a whole. They made the startling finding that 56.1% of all deaths within 3 weeks of an attack of myocardial infarction occurred within an hour of the onset of symptoms, and that the hospital population

represented a group of patients who were survivors of the worst of the attack.

The basically depressing message of the early Framingham work was partially obscured by the development at that time of resuscitation methods for patients who had had a cardiac arrest. These methods of internal, later external, cardiac massage and defibrillation were particularly successful for patients with ischaemic heart disease and led to a hope that the mortality from that disease could be radically reduced.

Coronary care units were developed where these skills in resuscitation could be provided for patients as rapidly as possible. They admitted patients for the first 48 hours of their stay in hospital, the main danger period. Workers in these hospital coronary care units claimed that they reduced the overall mortality from myocardial infarction in hospital by one third (Lawrie et al., 1968). These claims were based on comparisons of the mortality rates in hospital before the use of coronary care units with that in the units themselves, and the commonsense attitude that if patients were resuscitated promptly from cardiac arrest they must have had a better survival rate than a group of patients without such facilities. No controlled trial was performed at this stage because of the feeling that to do so would be to expose the control group to unnecessary risk.

Studies in coronary care units also increased the amount of detailed knowledge about the causes of death in ischaemic heart disease (Lawrie et al., 1968) and showed that the patients often died with arrhythmias amenable to defibrillation. However about two-thirds of the patients who died in hospital developed signs of cardiogenic shock or left ventricular failure, and were generally untreatable. The units

also increased the available knowledge about arrhythmias which were
thought to be precursors of ventricular fibrillation (Sandöe et al.,
1970) but although many drugs were developed with the aim of preventing
such arrhythmias going on to cardiac arrest no completely effective
drug was found for routine prophylaxis.

While these developments were occurring several groups of workers,
bearing in mind the Framingham findings, examined the community prevalence
of ischaemic heart disease in this country. In particular they looked
at the relationship between deaths and the time after the onset of
symptoms (McNeilly and Pemberton, 1968; Armstrong et al., 1972).

The Edinburgh Community Study

Table 1 showed some of the information from the Edinburgh study
by Armstrong. It was used to show the average outcome for one hundred
people with myocardial infarction in Edinburgh over the four weeks after
the onset of their symptoms.

The most obvious feature of the figure was the 26% of patients
who died before medical aid arrived. This was due, in the main, to
the fact that their deaths were very soon after the onset of any
symptoms; many simply collapsed without any prior warning. General
practitioners opted to treat 20% at home so that only 54% of patients
actually reached hospital. About half of these were admitted to
intensive care units so that 28% of the patients from the community
were treated by hospital coronary care units.

The proportion of deaths for patients treated at home, in a
general medical ward and in the coronary care unit was 5%, 6% and 5%
of the community respectively. On the other hand, using the more
conventional way of describing the mortality from ischaemic heart

TABLE 1   Outcome for One Hundred People with Myocardial Infarction under 70 years in Edinburgh (based on Armstrong 1972)

100 People at Home ⟶ Dr. arrives ⟶ Hospital ⟶ CCU ⟶ Ward ⟶ Home
                         74   54   28   25   43

26 Unattended deaths

20 treated at home ⟶ 5 died

26 treated in General Ward ⟶ 6 died

3 died

2 died
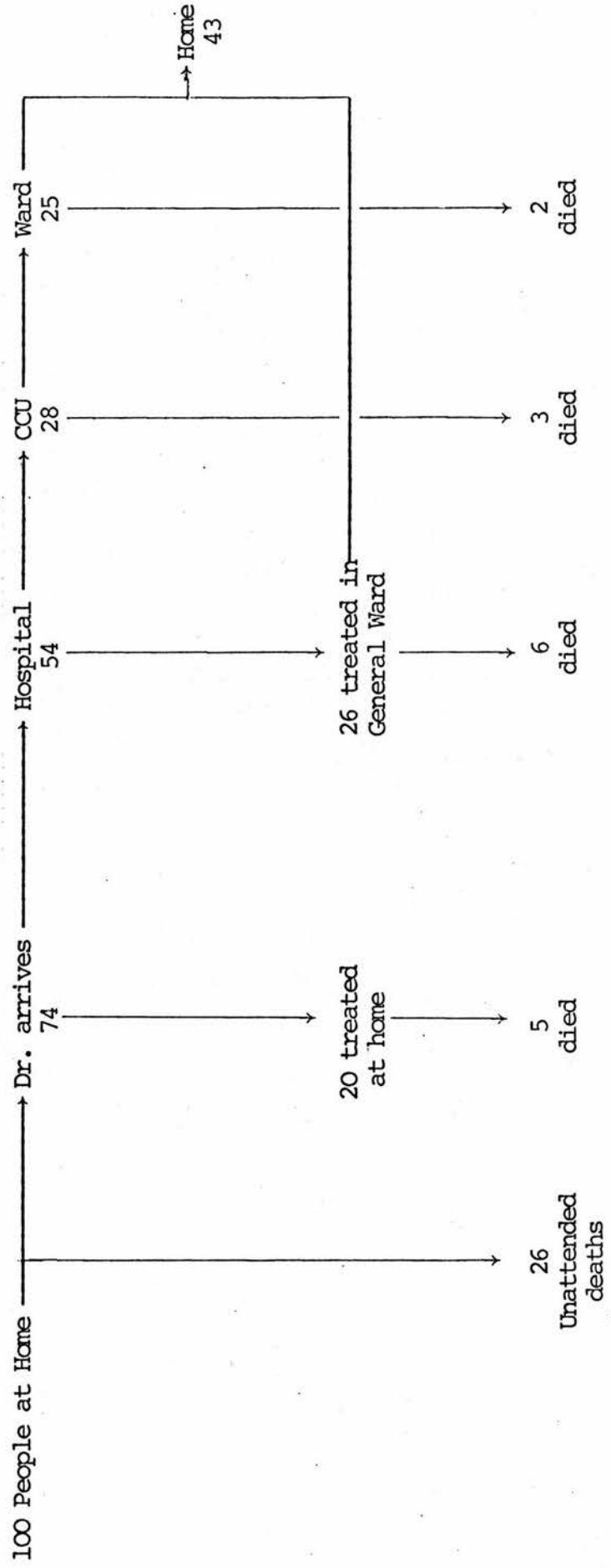
disease 5/20 (25%) died at home, 6/26 (23%) died in the general wards
and 5/28 (19%) died in the coronary care unit or after discharge to
the general ward.

This figure illustrated some of the difficulties of comparing
different methods of management of patients, particularly the difficulty
of demonstrating the benefits of coronary care units on a community
basis, for although the coronary care unit was more successful than
the hospital ward these figures became very diluted on a community
scale. More important than these factors was the difficulty of comparing
the severity of the disease for patients managed in the various ways.
No information was available on this point.

Figure 1, also derived from the Edinburgh community study showed
the cumulative mortality for patients with myocardial infarction over
the four weeks after the onset of symptoms. The semi-logarithmic scale
made it possible to construct a straight line to the data for all deaths.
This fitted the data precisely ($r = 0.997$, $p < 0.001$). The equation for
the line was $y = 19.07 + 8.09 Log_{10}x$, where y was the cumulative mortality
and x time after the onset of symptoms in hours.

The line at under one hour has been extrapolated, though no data
were available for these times. Other workers have found (Carlisle
and Lewis, 1976) that the cumulative mortality at under one hour fitted
a parallel line for similar data from Belfast. It was therefore
considered reasonable to extrapolate the line, to give the approximate
mortality at under one hour, for certain limited purposes.

The graph for arrhythmic deaths was drawn by eye and obtained
by subtracting deaths from low cardiac output at the times shown
(Sheidt et al., 1970) from the figures for total deaths. Less than
1% of deaths were due to causes other than primary arrhythmias or low

CUMULATIVE MORTALITY (%)

$y = 19.07 + 6.09 \, Log_{10}^x$

ALL DEATHS

DEATHS
(SHOCK
AND
FAILURE)

ARRHYTHMIC
DEATHS
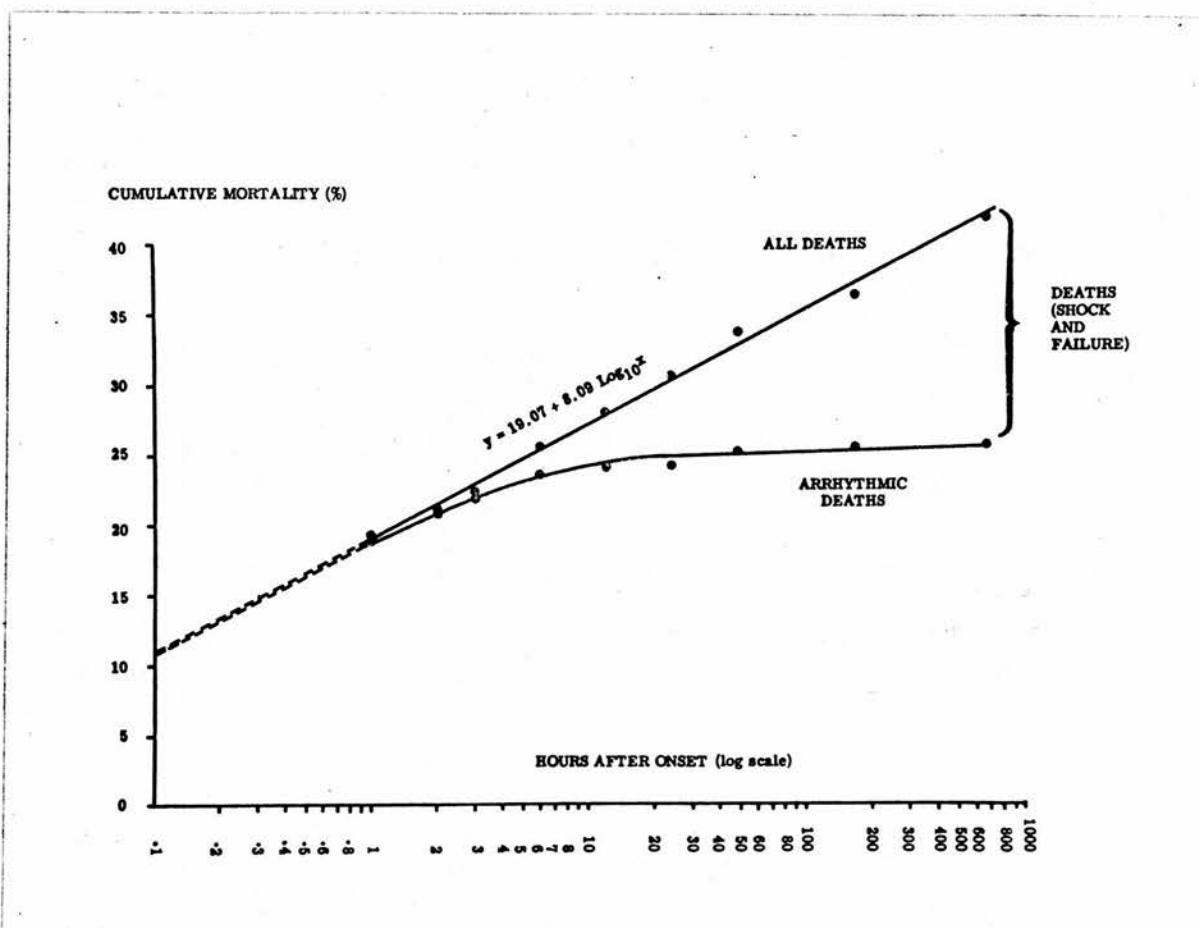
HOURS AFTER ONSET (log scale)

FIGURE 1   Cumulative mortality from ischaemic heart disease

for all deaths and arrhythmic deaths.

(from Armstrong et al., 1972;   Sheidt et al., 1970)

cardiac output, so the curved line approximated to the number of deaths due to arrhythmias.

This figure served, firstly to re-emphasise the large number of patients who died soon after the onset of their symptoms. Secondly, it showed the relative importance of the two major causes of death at different times. Thus in the first 2 hours 20.8% of patients in the community died of a primary arrhythmia but only 0.3% of low cardiac output, whereas between 48 hours and 4 weeks (672 hours), 0.4% of patients died of a primary arrhythmia compared to 7.8% who died of low cardiac output. As the methods of resuscitation available were effective only for patients who arrested with arrhythmias, any attempt to reduce the mortality from ischaemic heart disease had to aim at the group dying of such arrhythmias.

Hospital coronary care units, while successful in perfecting resuscitation methods for arrhythmias have been less successful in retrieving patients at a time when they were at a high risk from such arrhythmias. Thus the median time of arrival in the coronary care unit at the Royal Infirmary in Edinburgh was 4 hours 30 minutes after the onset of symptoms (Fulton, 1969). The figure showed that only 2.2% of the population at risk were liable to have an arrhythmic arrest between that time and the normal time of discharge from the unit, 48 hours later.

These figures could be described more graphically as the odds of seeing a patient develop ventricular fibrillation. These were 1 in 1,977 on average per hour of monitoring in the coronary care unit ($4\frac{1}{2}$ to 48 hours after the onset of symptoms), and 1 in 26,000 per hour for the average time in the ward (48 hours to 14 days). On the other hand the odds during the first hour were 1 in 5. Thus the earlier any resuscitation service could be provided the more effective was it likely

to be, in terms of lives saved.

Mobile Coronary Care Units

With this in mind several groups of workers, notably those in Belfast, set up mobile coronary care units, which took the specialised skills and equipment of the hospital coronary care unit to the patient's home. The Belfast unit was manned by physicians and normally called out by the general practitioner, though the general public could also call the unit in emergencies. The Belfast group showed that resuscitation of patients from cardiac arrest was possible in the home (Adgey et al., 1969). They reduced the median time from the onset of symptoms to the arrival of the mobile unit to 1 hour 40 minutes, a great saving on their median time for the arrival of patients in hospitals of over 8 hours.

The early doctor-manned mobile coronary care units were simply extensions of the hospital unit. They depended on the patient calling for help in response to symptoms suspicious of ischaemic heart disease, often with the general practitioner as intermediary. The Edinburgh community study (Fulton, 1969) showed that patients rarely called for help immediately; usually at least an hour elapsed after the onset of symptoms before they called for medical aid. Thus mobile coronary care units of this type were restricted in their effect upon patients at the commonest time for sudden cardiac deaths - within an hour of the onset of their symptoms.

Perhaps because of this inherant limitation mobile coronary care units have not developed in this country at the same rate as hospital units (Dewar, 1975). The inability of such units to reach the great mass of the early arrhythmic deaths has also led to some disillusion

with all intensive coronary care.

Two major responses have occurred to this disillusion. One, to try to reach patients even faster, using highly organised emergency resuscitation units, which are mainly concerned with getting to patients quickly and concentrating upon cases where the patient has already collapsed. These units are manned by non medical staff, often, in the United States by firemen (Cobb et al., 1975; Nagel et al., 1975). In this country workers in Brighton have developed an intermediate service, which responds to calls for the transportation of patients with suspected ischaemic heart disease but is mostly involved with emergency calls where the patient has had, or seems to be in great danger of, a cardiac arrest (White et al., 1973).

Another response to the problem of retrieving patients has been to doubt the usefulness of any form of intensive care when the majority of patients with treatable cardiac arrests appear to be out of reach of the facilities set up to help them. Thus the Bristol study (Mather et al., 1971, 1976) suggested that some of the groups of patients admitted to coronary care units would be as well treated at home. This study received a wide press and was generally interpreted as meaning that intensive care for patients with ischaemic heart disease did not reduce mortality.

The present study was performed against this background in order to measure the effectiveness of a mobile coronary care unit manned by physicians. It was hoped to do this without joining either of the two rapidly polarising groups; the one advocating yet more rapid provision of intensive care facilities, the other stating that all intensive care was a waste of expensive facilities compared to the returns.

CHAPTER 2

PREVIOUS STUDIES

Previous evaluation of coronary care services

There has been only one published comparison of hospital treatment of patients with ischaemic heart disease with home treatment (Mather et al., 1971, 1976). This study centred upon patients seen by 458 general practitioners in the West of England. Men under 70 years of age who were later proved to have had myocardial infarction within the previous 48 hours formed the study population. The decision as to whether one of these men should be entered into the randomised part of the trial was made by the general practitioner without being given, or being required to give, reasons for this decision.

Patients eligible for inclusion in the trial when seen by their general practitioners were divided into five groups. The first group, 'mandatory hospital' required admission to hospital for treatment of their attack of ischaemic heart disease for reasons 'which allowed (the general practitioner) no choice in the place of treatment'. This group comprised 24.1% of the total. Another two groups 'might have been randomly allocated to treatment either at home or in hospital, but the general practitioner was inhibited by various considerations'. These 'elective home' and 'elective hospital' patients comprised 8.0% and 44.2% of the total respectively. The remaining 450 patients (23.7%) were randomised into two sets, one for home treatment, the other for hospital including treatment in a hospital coronary care unit. The mortality in these two groups was similar up to 330 days after the original attack.

In a study where the definition of the study group was not made clear it would have been important to examine closely the non-randomised groups. Unfortunately this was not done in the full report though some detail was given in a preliminary paper (Mather et al., 1971). The

most interesting patients were those who the general practitioners decided required hospital and could not be entered into the trial, the 'mandatory hospital' and 'elective hospital' groups for they comprised 68.3% of the total and were considered by the general practitioners to be bad risks for home treatment. In the preliminary report 16.8% died. This was significantly higher than the other groups together but not higher than the 'random hospital' group. The 'mandatory hospital' patients were not separated from the 'elective hospital' group which was unfortunate as the mandatory group might have been expected to be the more severely ill.

Some data were available about the randomised groups themselves. Time after the onset of symptoms was known in 290 cases and was between 3 and 4 hours median time until the first receipt of medical aid. The trial could not commence until the 'random hospital' group had reached hospital, but this delay was not stated. In Edinburgh, a relatively compact area compared to the South West of England, patients took another hour and a half to reach a coronary care unit after their first contact with medical care (Fulton, 1969). The median time for patients to commence the study was therefore likely to have been over 5 hours after the onset of symptoms.

By that time a maximum of 2.8% of patients would be expected to have an arrhythmic cardiac arrest until 4 weeks after the onset of their symptoms, using the Edinburgh data (Fig. 1). This represented the figure for the community as a whole and was an underestimate, for some of the population had already died by the time the study commenced. Thus 25% of the patients in the community had died by five hours after the onset of symptoms increasing the proportion of patients likely to have a treatable cardiac arrest to 3.7%.

This was the maximum expected difference between those patients treated in hospital and those treated at home if the patients had been randomly selected from the whole population. As they were not so selected the difference might have been less. The study was set up to detect a minimum difference in mortality of 15% between home and hospital treatment so it was to be expected that no such difference was detected.

It is easier to be critical about a trial of medical care than to suggest a better method. A randomised controlled trial with stricter criteria for admission and exclusion may not be the full answer for using comparative mortalities as the outcome for patients being treated in different ways has ethical problems. Thus death in ischaemic heart disease is not a single entity, for some forms of cardiac arrest, due to primary arrhythmias, are treatable, others due to low cardiac output, untreatable. Any study which simply looks at deaths might select all the untreatable patients into hospital, leaving the treatable at home. Even after randomisation it would be important to compare the types of cardiac arrest in the treatment groups.

Another method, which avoided the ethical difficulties of using a control group, was to study the population with ischaemic heart disease in general by constructing a register of all cases, while at the same time studying the treatment facilities to estimate their impact upon the patients in the register. Such an approach could point out areas of neglect for improvement, not confined to specially selected study groups. Such an approach was used in North Karelia in Finland (Salonen et al., 1976). It was used to detect and register every case of ischaemic heart disease in the community and cross-refer each case to the type of treatment he or she received.

The major problem with such an approach was to estimate the

relative severity of illness affecting patients in the various treatment groups, the very problem that randomised controlled trials are designed to overcome. The Finnish workers have made a start in overcoming this difficulty by including factors about the patient's clinical state in their analysis. They used their ischaemic heart disease register to compare patients treated in small health centres with others treated in a central hospital. It showed that patients treated in the central hospital had a lower mortality rate than those in the health centres. By performing a linear multiple discriminant analysis on the patients in the register and including factors known to be related to severity, they showed that the place of treatment did not affect the outcome significantly i.e. the patients in the health centres had more severe illness, completely explaining the higher mortality.

Such an approach has not been tried to compare hospital treatment with home treatment as yet, nor has it been used in an area where a mobile coronary care unit was functioning, despite the fact that many such registers have been set up (World Health Organisation, 1976).

A third approach to the problem of where best to treat patients with ischaemic heart disease was to examine the individual characteristics of patients as early in the disease process as possible and to find the characteristics which were associated with a good or bad outcome. These characteristics could then be used to predict the outcome for other patients. The aim was to separate off a good risk group who could be treated safely at home from the bad risk patients who were liable to require the specialised facilities of a coronary care unit.

This approach had the benefit of assessing each patient individually before any decision had been made. It did not require a

control group as did the randomised controlled trial and it could be used on individual patients unlike the heart disease register approach. By continuously updating the system for patients misclassified it could provide the optimum facilities for each patient. If the number of patients shown to benefit from intensive care was seen to be very small it could be used as a method for assessing the usefulness of such facilities.

The drawback of this method was that it required a lot of detail about patients when they were first seen, in their own home. The only possible way to achieve this was in a mobile coronary care unit run by physicians. An attempt to set up such an analysis is described later in this thesis.

Previous evaluation of mobile coronary care units

A major problem of measuring the effectiveness of any service is to define the functions of that service. This is particularly important for mobile coronary care units for several types of unit have evolved and comments in the medical press have not always made clear the differences.

Table 2 listed the functions of a doctor-manned mobile coronary care unit in two ways. The first listing gave the functions of that unit in terms of urgency; those requiring life saving treatment at the top of the list. The second half of the table gave the same functions listed in order of prevalence, i.e. those required most frequently. These were most commonly administrative decisions about the disposal and diagnosis of the patient and explanations to him or her about the illness. The most commonly performed functions were those traditionally performed by a doctor rather than by a non-medical person. The more urgent functions were those which could be taken over by non-medical workers.

Thus a doctor-manned mobile coronary care unit had functions which could not be assumed by non-medical personnel. These functions, while not urgent were important for the proper integration of the unit into the general practice and hospital services and affected more patients than the purely lifesaving functions.

No previous study has attempted to assess any of the functions of a mobile coronary care unit by experiment in a controlled trial or by a survey of the population served and the impact of the unit upon it. Only one attempt has been made to relate, in any way, the results from a mobile coronary care unit with community statistics (Crampton et al., 1975).

This study described a doctor-manned mobile coronary care unit in

TABLE 2   Functions of a Doctor-Manned Mobile Coronary Care Unit in Order

Urgency

1. Treatment of cardiac arrest.

2. Treatment of 'pre-arrest' arrhythmias.

3. Treatment of poor clinical state, e.g. left ventricular failure.

4. Treatment of symptoms, particularly pain.

5. Reassurance of patients.

6. Decision about diagnosis.

7. Decision about place of treatment.

8. Training and learning from general practitioner.

9. Training and learning from ambulancemen.

10. Learning about and research into ischaemic heart disease.

Prevalence

1. Decision about diagnosis.

2. Decision about place of treatment.

3. Reassurance of patient.

4. Treatment of symptoms, particularly pain.

5. Training and learning from ambulancemen.

6. Training and learning from general practitioner.

7. Learning about and research into ischaemic heart disease.

8. Treatment of poor clinical state, e.g. left ventricular failure.

9. Treatment of 'pre-arrest' arrhythmias.

10. Treatment of cardiac arrest.

a community of 80,000 people. The mobile unit attended 71 patients with myocardial infarction in twenty two months, of whom 28 had had a pre-hospital cardiac arrest. Eight of these survived to leave hospital alive.

It was claimed that the setting up of the mobile unit reduced the community death rate from 2.64 per thousand to 2.19 per thousand. In a population of 80,000 this would correspond to 36 extra lives saved but there was no proof that any form of therapy contributed to preventing cardiac deaths except for the eight resuscitated. A quoted figure of 2.64 per thousand before the mobile unit was functioning was derived from an average of the 10 years up to the year during which the mobile unit started. It was then incorrectly compared with the single year figure of 2.19 per thousand when the mobile unit was running.

The mortality rate from ischaemic heart disease was falling rapidly until it stood at 2.3 per thousand the year before the inception of the mobile unit. This was not significantly different from the figure of 2.19 per thousand the year that the mobile unit was running. The association of reduced mortality with the starting of the mobile coronary care unit was therefore unlikely to be cause and effect, especially as the mortality had been falling steadily during four of the five years before the mobile unit was used.

The information coming out of other centres with mobile units has been disappointing. No measurement has been made of the effectiveness of units and the Belfast unit has been virtually alone in describing the problems of the pre-hospital management of patients with ischaemic heart disease, apart from cardiac arrest.

Treatment of cardiac arrest

In Belfast 27/61 (44.3%) of patients who had ventricular
fibrillation in the mobile unit left hospital alive (Adgey et al.,
1969). The incidence of ventricular fibrillation in patients seen
within the first hour after the onset of their symptoms was very high
at 9.5%, but this proportion was raised artificially, for the mobile
unit was selectively called for arrests at the earliest times after
onset. Thus 23 of the 28 patients had ventricular fibrillation before
the arrival of the unit. The difficulty with these data was that there
was no way of relating these patients to the population at risk - if they
represented the increased incidence of arrests in the community at this
time or whether the mobile unit could in some way be selecting out an
atypical group. This was important if the mobile unit was to be shown
not to be precipitating the very cardiac arrests which it was then
treating.

The Belfast mobile coronary care unit arrived at patients at a
median time of 1 hour 40 minutes after the onset of symptoms; in cases
of cardiac arrest much more quickly with a median time of 25 minutes
(Adgey et al., 1969). Despite this many patients were not reached soon
enough due to the large number of virtually instantaneous arrests. As
a response to this problem a new type of mobile coronary care unit was
developed in the United States (Cobb et al., 1975; Nagel et al., 1975).

These units were run by non-medical personnel and were designed
to act as general resuscitation units rather than as coronary care units.
They therefore concentrated more on the 'high urgency' functions of a
mobile coronary care unit rather than the 'high prevalence' ones. The
majority of calls were from patients' families for people who had already
arrested; their aim being to get to the patient within 4 minutes in

order to resuscitate him or her. Cobb and Nagel both used fire
department personnel for this purpose, based in several units throughout
the cities involved.

In Brighton an intermediate type of unit (White et al., 1973) was
developed, manned by ambulancemen and responding mainly to emergency
calls, but also taking some routine patients with ischaemic heart disease
into hospital.

The only figures published in sufficient detail to make a comparison
of these units were those on the treatment of cardiac arrest. Table 3
showed these data. In order to make the patient groups roughly comparable
in severity only those patients who were initially in ventricular
fibrillation, whether attempts at resuscitation had been made or not,
were included. These patients have been shown to have a reasonable
chance of survival compared to patients found in asystole (Adgey et al.,
1969).

The table showed that the non-medical resuscitation teams were
less successful than the Belfast group at resuscitating patients in
ventricular fibrillation. Several reasons may have accounted for this.
The groups concentrating on treating patients who had already arrested
may have been at a disadvantage to the Belfast unit for the latter may
have been on their way to some of the patients when the arrest occurred,
shortening the period of the arrest before resuscitation commenced. It
was unlikely that this would have accounted for such marked differences
in the resuscitation rates, particularly for the lower hospital mortality.

It was emphasised by the Seattle and Miami workers that they saw
one group of patients who had had a cardiac arrest as their initial
symptom and who, if resuscitated had no objective signs of myocardial
damage. These made up over 50% of the patients seen by these groups but

TABLE 3   Resuscitation of Patients in Ventricular Fibrillation in

Community

Place	Number of VFs	Died in MCCU	Died in Hospital	Survived (%)
SEATTLE (Cobb et al., 1975)	1106	640	273	193 (17.5)
MIAMI (Liberthson et al., 1974)	301	200	59	42 (14.0)
BRIGHTON (999 only) (White et al., 1973)	65	57	3	5 (7.7)
CHARLOTTESVILLE (Crampton et al., 1975)	23	9	9	5 (21.7)
BELFAST (Adgey et al., 1969)	61	22	12	27 (44.3)

VF = ventricular fibrillation
MCCU = mobile coronary care unit

were not described in the Belfast results. It was possible that this group of patients who had an increased tendency to re-arrest were the cause of the lower success rates in the Miami and Seattle units. On the other hand these workers did not claim that these patients were more difficult to resuscitate, simply that they were more likely to re-arrest.

Non-medical personnel were less successful at resuscitation during the first 2 years of the Seattle unit than during the latter two years suggesting that training improved their performance but these teams are now as skilled at resuscitation as any medical groups (De Leo, 1975).

Whatever the cause of their better resuscitation rate the Belfast workers did not arrive at patients as soon after the onset of symptoms as the other groups. Table 4 showed the median times from onset to arrival of the mobile coronary care units for patients in ventricular fibrillation. The importance of speed was that many more of the early arrhythmic cardiac arrests were potentially within the range of the faster units. Thus the Seattle unit with a median time of arrival of six minutes after the onset of symptoms could potentially treat the equivalent of all cases of ventricular fibrillation from six minutes after the onset of symptoms onwards. This represents almost 60% of the patients who died in ventricular fibrillation (Fig. 1). On the other hand the relatively slow Belfast unit arriving at a median time of 25 minutes could have expected to treat only 10% of the arrhythmic deaths.

The effect of these faster times could be seen in the number of patients retrieved by each of the units. The overall number of patients seen in ventricular fibrillation and the number resuscitated to leave hospital alive were included in Table 4. The figures were taken from Table 3 and expressed as the number of patients per annum for each 100,000 population served by the units in order to make the figures

TABLE 4   Comparison of the Results of Resuscitation for Mobile Coronary Care Units

Centre	Median Time Onset to Arrival (mins.)	Population Served (000s)	Study Period (Months)	Patients seen in VF/100,000 pop^n/year	Patients saved from VF/100,000 pop^n/year
SEATTLE	6	500	48	55.3	9.6
MIAMI	15	400	42	21.5	3.0
BRIGHTON (999 only)	20	350	12	18.6	1.4
CHARLOTTESVILLE	–	80	22	15.7	3.4
BELFAST	25	500	39	3.8	1.7

comparable.

As expected the faster units saw many more cases in a given time than the slower units. Thus, despite the relatively poor resuscitation rate in the Seattle unit the large number of patients seen in ventricular fibrillation resulted in a higher overall number of patients being resuscitated.

This demonstrated the relative importance of arriving at patients quickly and of being successful at resuscitating them. The Belfast unit was the most successful at resuscitating the patients it managed to arrive at, but because it was relatively slow it saw small numbers and was therefore unable to make as much overall impact as the faster units. It remains to be seen if the first aid units, concentrating on arriving at patients early, were so unsuccessful at resuscitation because of technique which can be improved, or because of a more severely affected group of patients.

These figures did not take into account any differences in the natural prevalence of the disease between the centres. A unit serving an area with a relatively high prevalence of ventricular fibrillation would be able to reach a greater number of patients with the same amount of effort as a unit in an area of low prevalence. No figures were available on this point.

Prevention of Extension of myocardial damage

The Belfast workers have claimed that early treatment of patients in the mobile coronary care unit restricted the ultimate mass of myocardial damage in patients with ischaemic heart disease. They based this claim on the low mortality and prevalence of cardiogenic shock in patients seen by the mobile unit (Pantridge, 1970).

Patients seen within an hour of the onset of their symptoms were less likely to have signs of shock with only 4.9% being affected and a mortality of 9.8% compared to an average for other groups of 14.8% with shock and a mortality of 22.6%. This was claimed to be due to careful treatment of sinus bradycardia, said to be responsible for unnecessary extension of the area of myocardial damage if not treated.

No other mobile units have reported similar reductions in the prevalence of cardiogenic shock so it is unlikely that more widely used forms of therapy; opiates for the treatment of pain and reversal of the more marked rhythm disorders could have been responsible for the lower mortality.

The Belfast workers later extended their interest in controlling heart rate (Webb et al., 1972) by giving atropine to patients with a sinus bradycardia of under 60 beats a minute and practolol to patients with sinus tachycardia (over 100 beats a minute). They claimed that this reduced the mortality of 72 patients, first seen within 30 minutes of the onset of their symptoms to 9.7%. However 88 patients were originally seen within 30 minutes of the onset of their symptoms but 13 were excluded from the trial because they had had ventricular fibrillation and one because of previous hypertension. Another two were originally entered in the trial but no information about their survival was given because they were over 70 years. If the 13 patients with initial ventricular fibrillation had a similar outcome to the general Belfast figures (Table 3) 55.7% of them would be expected to die in hospital, representing 7 or 8 of them. This would give an overall mortality of 14 or 15 out of 85 (16 to 18%), not a particularly low figure. Unfortunately, these data were not given in the study.

Patients seen in the original study (Pantridge, 1970) at more than

an hour after the onset of symptoms had relatively mild disease with 7.7% shocked and a mortality of 13.3% in hospital. Any effect of treatment upon ultimate infarct size would be unlikely to have an effect in patients seen this late after the onset of symptoms (Braunwald et al., 1974). It seemed likely that the patients seen by the Belfast group were less severely ill than those seen elsewhere. There has been a trend for less severely ill patients with ischaemic heart disease to be admitted to hospital for the last 10 years (Rose, 1975) and this trend might be expected to be more marked in an area where a great deal of public interest and involvement has been aroused in the management of patients with heart disease.

It is certainly theoretically possible to affect the ultimate size of a myocardial infarction by treatment early on in man (Maroko et al., 1975) but no treatment has yet reduced the mortality from or incidence of cardiogenic shock in practice. The work performed so far showed that drugs could affect indirect measures of myocardial damage, the degree of ST segment elevation in precordial chest leads (Maroko et al., 1972) or the activity of the cardiac enzyme creatine kinase estimated serially in the blood (Sobel, 1974). Both methods had grave limitations. ST mapping showed marked fluctuations with time, presumably due to changes not controlled by therapy within the patient. Other workers showed (Morris et. al., 1974) that although ST segment changes were related to the clinical severity of patients they gave no more information than a simple clinical examination when gauging the patients response to therapy.

On the other hand serum creatine kinase activity had to be measured over a period of 4 to 6 hours to obtain a base-line and was therefore limited for monitoring the effects of drugs. Other methods of imaging

of the heart have not proved to be accurate enough for quantitative measurements.

Thus although it was possible to alter measurements said to be related to myocardial damage there has been no convincing proof that these changes were related to the final outcome for patients. Similarly no form of treatment has yet been shown to have any effect upon the mortality from cardiogenic shock.

Dangers of Mobile Coronary Care Units

It was a measure of the uncritical approach generally held towards intensive coronary care that no evidence had been published on the dangers of mobile coronary care units. A paper from Belfast did discuss the possible adverse effects of transporting patients (Mulholland and Pantridge, 1974) but it was not aimed specifically at patients in mobile coronary units. The stated aim of the paper was 'to study what, if any changes in heart-rate were precipitated by movement and how such changes might be prevented'.

The paper claimed that an 'inappropriately rapid' heart rate could have an effect upon the ultimate size of myocardial damage and suggested that the ideal heart rate for patients with ischaemic heart disease was between 60 and 100 beats a minute. These both seemed reasonable figures in line with most definitions of sinus bradycardia as being below 60 beats a minute and sinus tachycardia at above 100 beats a minute (Sandöe et al., 1970).

The heart rate of a series of patients was examined by continuous tape recording of the electrocardiogram before the patients were moved and later while being transported to hospital. A general criticism of the paper was that the resting heart rate was not defined. However obtained it was a single measurement which was then incorrectly compared with the 'maximal deviation from the resting rate' to give the rate during movement of the patient. Mean rates before and during movement or the maximum or minimum rates at each time would have been more appropriate for if there was any deviation in heart rate at all during movement the most extreme change was recorded.

The heart rate of untreated patients was shown to be higher during transport to hospital than before movement in 24/31 (77.4%). In another

group of 31 patients who had received only analgesics before being transported, 25 (80.6%) showed an increase in rate. The Belfast workers claimed that such increases required therapy. This was to ignore their original definition of what was an 'inappropriate' heart rate for most of the increases in rate were minimal and unlikely to be damaging.

If the data were re-analysed and patients' heart rates of 100 beats a minute or over and 60 beats a minute or less were regarded as damaging a different picture emerged. Of the control group of 31 patients only 5 had a heart rate which was increased from below 100 a minute at rest to above during transport. None of the control group had a fall in heart rate from above to below 100 a minute during that time. This 5-0 split i.e. 5 patients changed category from appropriate to inappropriate and 0 changed in the opposite direction, was not statistically significant at the 5% level by the sign test (Appendix B). Thus transport was not associated with a significant number of patients acquiring a damaging tachycardia.

As for bradycardia 3 of the control patients had heart rates of 60 or less and increased their rates on transport to above that, whereas 2 patients with rates initially above 60 a minute dropped to below it during transport. Thus the overall effect of transport on the control group was to change the heart rate of 7 patients from being 'appropriate' (between 60 and 100 beats a minute), to being 'inappropriate', outside these limits and 3 patients changed categories in the opposite direction. This 7-3 split was not significant at a 5% level. Thus transport caused no inappropriate change in heart rate.

The Belfast workers defined heart rates of below 60 beats a minute or above 100 beats a minute as potentially damaging, but did not use these rates in their own analysis of the study. They did look in some

detail at the patients with very fast rates (over 110/min), but most of the patients with such rates during transport also had them at rest.

Curiously, if the criteria of over 100 beats a minute and under 60 beats a minute were applied to the 4 other patient groups in the study the patients who received analgesics only showed no significant differences in heart rate during transport compared to the resting state. On the other hand 3 groups who received drugs to prevent changes of heart rate with movement (atropine 0.6 mg and practolol 5 mg or atropine 0.6 mg and practolol 10 mg or atropine 0.6 mg with sotalol 10 mg) all showed a statistically significant increase in the number of patients with sinus tachycardia or sinus bradycardia after treatment to prevent them. All of the treatment groups also showed a significant increase in the incidence of sinus tachycardia alone. This was the direct opposite of the authors' claim that treatment reduced the incidence of inappropriate heart rates during movement.

This situation appears to have arisen because of a reluctance on the part of the authors to define what they meant by a damaging heart rate. No other evidence has been published on the possible harmful effects of mobile coronary care units.

Gaps in the Literature

No critical evaluation of the role of coronary services has yet been carried out. The Karelia project (Salonen et al., 1976) was a good attempt to give the full community background to coronary services and derive lessons from it but this study did not include a mobile coronary care unit. The only randomised controlled trial of any aspect of coronary care did not meet up to the basic problem of defining its study group and again did not involve a mobile unit (Mather et al., 1976).

It was important to make a study of coronary services against the background of community experience for there was no other reliable way of proving that the services were not harmful. Of the possible methods of evaluating services it is unlikely that an ethical randomised controlled trial can be devised due to the problem of arrhythmic deaths in the control group, for it is known that coronary care can treat such deaths. On the other hand a careful community survey with indices of severity developed during the study could give information about the relative merits of various methods of management and also highlight groups of patients not coming under medical care.

Basic questions, such as where to treat a patient, the likelihood of he or she having sustained myocardial damage and the probability of the patient having a cardiac arrest are of paramount importance to the general practitioner at the patients' home. Despite this new methods of treatment have served only to confuse general practitioners as to the best management of patients with ischaemic heart disease (Hampton et al., 1975). This thesis described a method of clarifying the approach to management.

No previous attempt has been made to form a cost-effectiveness equation for any of the coronary services. This the thesis also

attempted. Adverse effects of coronary services have also been largely
ignored. The possible adverse effect of a mobile coronary care unit upon
the incidence of arrhythmias and patient anxiety was therefore explored.

CHAPTER 3

METHOD

Patients

The study group consisted of 277 patients seen by the mobile unit.
The survivors were later admitted to a coronary care unit with symptoms
suggesting myocardial infarction. 195 patients were male and 82 female.
Their average age was 57.5 years with an upper limit of 70 years. The
final diagnosis of the patients, on leaving hospital was myocardial
infarction in 168 (60.6%), myocardial ischaemia in 62 (22.3%) and the
rest a series of other cardiac and non-cardiac diagnoses.

No specific interventions were made regarding therapy other than
those indicated by the therapeutic schedule for the coronary care unit
(Lawrie et. al., 1967; Appendix A). This often necessitated giving
analgesics; morphine 10 mg and cyclizine 50 mg., usually given slowly
intravenously until pain was substantially relieved. Atropine was given
for sinus bradycardia if the patient's blood pressure fell below 90 mm Hg
or breakthrough ectopic beats were seen. The only other drug frequently
given was lignocaine for close-coupled (R on T) ectopic beats or
ventricular tachycardia.

Diagnostic criteria

A final diagnosis of myocardial infarction was made if changes
were seen in the electrocardiogram sufficient to warrant allocation to
group 1A (a-e) of the W.H.O. classification (World Health Organisation,
1966) consisting of Q waves and ST, T wave elevation in anterior or
inferior leads showing transmural infarction in these areas and preferably
evolutionary changes with time. Alternatively the diagnosis was made by
changes in the electrocardiogram in group 1B (f-o); cases in which the
changes of myocardial infarction were present but more difficult to
interpret as in true posterior infarction. The diagnosis was also made

by an increase in serum creatine kinase and aspartate aminotransferase activities in the presence of bundle branch block on the electrocardiogram (Lawrie et al., 1967; Smith, 1967).

The diagnosis of myocardial ischaemia was made in patients having a history of typical myocardial pain in the chest and with possible radiation to the arms, without objective signs, after investigation and exclusion of any other disease process. Some may have shown electrocardiographic changes on exercise testing, but this was not mandatory to the diagnosis.

Retrieval of patients

Despite the use of a mobile coronary care unit many of the early sudden deaths had occurred by the time the unit had arrived as it was subject to the delays inevitable in any system where the patient had to initiate a call for help. This made a careful definition of the study group essential and this was done by a comparison with the Edinburgh community study (Armstrong et al., 1972).

Patients were usually referred to the unit through their general practitioners. If a patient telephoned his or her general practitioner with a history suggestive of ischaemic heart disease the doctor was encouraged to call the mobile coronary care unit directly before seeing the patient. The doctor did this by telephoning a special number connecting him to the hospital coronary care unit. The nurse on duty took details of the patient and called the doctor on call for the mobile unit. The doctor then drove the mobile unit to the patient's address. Meanwhile the nurse called a normal 2-man ambulance which also proceeded to the patient's home.

The doctor in the mobile unit was accompanied by a nurse from the

hospital coronary care unit if there was one available. Sometimes a medical student chose to accompany the unit. In order to make the system more flexible the doctor in the mobile unit was equipped with a portable 2-way radio to the hospital coronary care unit.

On arrival at the patient's bedside the doctor connected him or her to a monitor using limb leads. He then took a medical history, examined the patient and advised the general practitioner of his findings. If the patient had had over 20 minutes chest pain or sudden breathlessness or syncope he or she was admitted to the hospital coronary care unit in the mobile unit. No patient refused admission if it was advised. If the patient was considered not to need admission to a coronary care unit the general practitioner and the doctor from the mobile unit decided the best course of action between them; either to leave the patient at home or to admit him to a general medical ward.

The ambulancemen assisted the two doctors in setting up apparatus for monitoring and taking the electrocardiogram. They were encouraged to ask questions and were told of the significance of any arrhythmias on the monitor and the purpose of any treatment given. If any patient had a cardiac arrest the ambulancemen would commence resuscitation if they arrived first and then took a full part in the continuing treatment of the patient when the mobile unit arrived, under the supervision of the doctor in the mobile unit.

The emphasis was placed on integrating the mobile unit into the existing services, not acting as a separate service. By this means it was hoped to give the patient a smooth transition from being at home to being admitted to hospital.

Staffing of the unit was carried out by seven post-registration doctors with an interest in ischaemic heart disease. These covered the

unit on a rota basis so that it was available throughout the day and night. 206 general practitioners in a carefully defined area in South and East Edinburgh were contacted and asked if they would take part in the study - all agreed. It was emphasised to these doctors that the patients in most need of intensive care were those seen earliest after the onset of their symptoms.

Mobile coronary care unit

The mobile coronary care unit consisted of a Morris LD 1 ton ambulance of the standard type used by the Scottish Ambulance Service. It was specially modified in that the patient area was cleared, then replaced by a central trolley bed with access to the head end for intubation and shelves on each side of this area. There was a portable radio link with the coronary care unit and the ambulance depot.

Equipment used was a Cardiac Recorders Portascope monitor, considerably adapted by the addition of a Uher 4-channel reel to reel tape recorder. Patients were monitored using standard limb electrodes and bipolar leads 1 or 2 could be visualised on the monitor screen at any time. Both of these traces were continuously recorded on electro-magnetic tape on the Uher recorder. A voice channel was also included for tagging each patient's rhythm strip on the recorder by giving the patient's name at the start of each recording. A battery-operated Cardiostat T electrocardiographic recorder was also used for producing the initial standard 12-lead electrocardiogram.

Other apparatus included two drug cases; one containing routine drugs for pain relief and antiarrhythmic therapy, the other contained necessary equipment and drugs for the treatment of cardiac arrest.

Definition of the study group - delays

Patient delay in calling for help was one of the most potent
sources of bias when studying a group of patients early after the onset
of their symptoms, for many who did not call rapidly for aid had a cardiac
arrest before any medical aid arrived. The patients in the study group
were therefore questioned when first seen regarding the various time
intervals from when their symptoms started until making their first moves
to get medical aid, and when that help actually arrived.

Definition of the study group - time after onset

Any study of changes occurring after the onset of symptoms had to
try to define as nearly as possible the actual time of onset, particularly
in the case of ischaemic heart disease where changes occurred in minutes
rather than hours. In this study the time intervals were defined, as far
as possible, when the patient was first seen, in consultation with any
relatives or neighbours who were present. A common problem was that pain
or other symptoms often came on gradually or varied in intensity to such
a degree that the time of onset was difficult to define. The research
team were given special instructions to ask, firstly when the most
severe attack commenced and secondly, whether that attack reached its
most severe within 10 minutes of its onset - sudden onset. The onset of
the most severe attack was regarded as the definitive time of onset and
any preceding symptoms were regarded as prodromal.

Patients in whom symptoms did not reach their most severe within
10 minutes were classified as crescendo or stuttering onset depending
on whether the symptoms gradually built up or fluctuated in intensity
without going away. Despite these precautions occassional difficulties
in classification were encountered, when the research team made a decision

based on their clinical knowledge and in consultation with the research fellow.

Another problem with exact definition of the time of the onset of the ischaemic process and the symptoms experienced by the patient was highlighted by those patients with a gradual onset of their symptoms; namely the relationship between the cellular changes in the myocardium and the symptoms experienced by the patient. In this study there was no choice but to regard the onset of symptoms as the onset of the ischaemic process. This may have been a fair assumption in the sudden onset group, particularly if early electrocardiographic changes were present, but it was highly unlikely that the time of infarction could be defined accurately in patients with gradual onset of their chest pain.

It may be that the time of onset itself is a meaningless concept, for it has been shown that patients who have a cardiac arrest as their initial sympton often have no objective signs of myocardial damage after resuscitation (Cobb et al., 1975). Similarly it has been shown in the animal model by Jennings (1972) that all the ischaemic changes normally associated with myocardial necrosis were completely reversible for up to 40 minutes after occlusion of a coronary artery.

It is possible to imagine a situation where an area of a patient's myocardium may be maintained for some time at this reversible stage by reduced coronary blood flow, with ultimately no cellular damage if the flow improves or infarction if flow is further embarrassed. For these reasons some emphasis has been placed upon the type of onset of symptoms in this study.

Retrieval of data

Information on demographic data was gathered on data sheets filled

in when the patient was first seen. The first page, which included
the time the call was received by the hospital coronary care unit was
filled in with the patient's name and serial number but not added to the
rest of the patients' data until these were processed. This ensured
confidentiality while the data sheets were in circulation. The
information on these sheets was coded and put onto punched cards by
removal of a data strip in the right hand margin. This was a device to
protect confidentiality and to reduce transcription errors.

Arrhythmia analysis

The electrocardiogram taped while patients were being examined
and transferred to the hospital coronary care unit were obtained on the
last 53 patients with myocardial infarction in the study. Tapes from
the Uher recorder were transcribed onto 7" tapes for rapid playback.
They were analysed at 60 times normal speed using a replay tape deck,
by eye and by passing them through a hybrid analog computer (Neilson,
1972). This was pre-programmed to recognise the normal electrocardiogram
and so detect and isolate abnormal rhythms.

Information was obtained in this way on the arrhythmias present,
ventricular ectopic beats and heart rate in the patient's home and in
the mobile unit on the way to hospital. This information was used to
examine the possibility that transport in the mobile unit caused an
increase in arrhythmias.

Anxiety analysis

Another sub-group of 75 patients with myocardial infarction was
examined in order to check if management by the mobile unit had caused
these patients to be more anxious than normal on arrival at the hospital

coronary care unit. All the patients admitted to the hospital coronary care unit during the last four months of the study were examined on admission to make a comparison between those admitted in the mobile unit and those admitted through the accident and emergency department.

Of the 75 admitted in the mobile coronary care unit 56 were males and 19 females. Their average age was 57 years. 52 patients had had a myocardial infarction, 13 had myocardial ischaemia and the rest a variety of cardiac and non-cardiac diagnoses. Apart from those admitted in the mobile unit 302 patients were brought into the study after admission through the accident and emergency department. These patients represented all the patients admitted to the hospital coronary care unit over the four months of the study.

The questionnaire used to estimate the patients degree of anxiety consisted of 10 items culled from the Neuroticism Scale Questionnaire and showed to be those which best discriminated anxious from non-anxious patients (Cattell, 1965). Several considerations influenced the decision to measure anxiety in this way. It was felt inappropriate to use physiological indices, such as heart rate or skin temperature which, at this stage of illness might be expected to be more related to the physical state of the patient. The method used also had to be short and non-stressful.

The nurse who administered the questionnaire was told that it was designed to measure the patient's reaction to the coronary care unit, but not that it was to estimate anxiety nor did she know how the questionnaire was scored. If the nurse considered that the patient was in any way distressed by the questionnaire she was instructed to stop at once. The questions took on average less than two minutes to complete.

Acceptability and Confidentiality

All information for the study was transposed onto sheets kept separately from the patient's notes and locked in a filing cabinet. The only exception to this was when patients were in transit into the hospital when the information sheet contained only the patient's study number.

The use of removable strips for the transcription of information onto punched cards meant that there was no way of identifying the patient in the computer except through his or her study number, which was under lock and key.

As this study was purely descriptive and involved no departure from generally accepted modes of treatment it was not considered necessary to ask the patient's permission to enter him or her in the study.

CHAPTER 4

RESULTS

THE IMPACT OF A MOBILE CORONARY CARE UNIT ON THE COMMUNITY

Estimation of the population at risk with ischaemic heart disease

In order to measure the effectiveness of the mobile unit it was necessary to estimate the total number of people which it would have treated had it been one hundred percent successful. The first step was to calculate the number of patients with ischaemic heart disease in the area covered by the unit during the period of the study.

Unfortunately no figures for the morbidity from ischaemic heart disease were available for the period of the study. An estimate was therefore taken from the Edinburgh community study (Armstrong et. al., 1972) which was performed three years before. There was no marked change in the mortality from ischaemic heart disease over that period in Edinburgh, being 4.54/1000 for people between 35 and 75 years of age during the community study and 4.58/1000 in 1972 the year of the present study (Registrar General for Scotland, 1968-1973). It was therefore inferred that the morbidity from ischaemic heart disease during that period had not varied markedly.

The total population aged between 20 and 70 years and living in the carefully defined area of Edinburgh, served by the mobile unit, was derived from census estimates of small area populations (Registrar General for Scotland, 1972, 1973). These figures were entered in Table 5 in the age and sex groupings shown.

Episode rates of ischaemic heart disease for these groups were taken from the Edinburgh community study and also entered in the table. The number of attacks of ischaemic heart disease expected during the period when the mobile coronary care unit was working was then calculated by multiplying the episode rates by the population at risk. This gave the number of attacks expected in a year. This was in turn divided by 365 to give the number daily and multiplied by 440, the number of days in the

TABLE 5   Expected Number of Episodes of Heart Attacks in the Study Population (Armstrong et al., 1972)

	MALES				FEMALES				ALL
	20 –	40 –	50 –	60–69	20 –	40 –	50 –	60–69	(20–69)
Mid Term Population (000s)	32.0	13.3	13.2	11.9	33.1	14.8	16.2	16.2	150.7
Episode Rate/1000/Year (from community study)									
Myocardial infarction	0.37	3.45	8.84	12.96	–	0.51	2.36	4.22	3.06
Unattended deaths	–	1.21	3.17	5.68	–	–	0.64	2.24	1.21
Insufficient data	–	–	0.88	1.50	–	–	–	0.82	0.33
Ischaemia	–	1.70	3.63	5.40	–	0.71	1.17	2.72	1.46
Expected Number of Attacks (to whole number)									
Myocardial infarction	14	55	141	186	–	9	46	82	554
Unattended deaths	–	19	50	81	–	–	12	44	219
Insufficient data	–	–	14	22	–	–	–	16	60
Ischaemia	–	27	58	77	–	13	23	53	265

study to give the expected number of attacks during the study.

During the community study it was discovered that some of the most important data on patients with ischaemic heart disease was hidden in two ways. One group, the unattended deaths, was obtained by examining the death certificates of patients. Those certified as having died of myocardial infarction were included in the study. The other group had insufficient data but some subjective evidence that they had sustained a myocardial infarction. The difficulty with both of these groups of patients was that they had usually died soon after the onset of their symptoms, before a definitive diagnosis could be made. They were therefore important groups for a full description of patients with ischaemic heart disease and were included in Table 5.

Some of the cells of the table were blank because insufficient patients were seen in the community study to calculate accurate episode rates. The final figure in the ALL column was thus not a total but was calculated from the overall episode rate, including the small numbers omitted from some of the cells.

The expected numbers in the table were an estimate of the total number of patients with an attack of ischaemic heart disease in the community served by the mobile unit during the period of the study. As might be expected there was an increasing number of episodes with age and more males were attacked than females.

The expected episodes were used in Table 6 to compare with the actual number of patients picked up by the mobile coronary care unit. It was estimated that 840 episodes of myocardial infarction occurred in the community during the study period but the mobile coronary care unit attended only 168 (20.0%). This low percentage reflected several factors. Some patients died unattended despite the availability of a mobile unit.

TABLE 6   Observed and Expected Episodes of Myocardial Infarction

in the Study Population

	MALES 20 -	40-	50 -	60-69	All Ages
Observed (from MCCU)	2	17	45	52	116
Expected (from Table 4.1)	(14)	(74)	205	289	617
% Seen	14.2	23.0	21.9	18.0	19.0

X^2 goodness of fit = 2.0,N.S. i.e. the observed patients were similar

in proportion at all age groups to that expected.

	FEMALES 20 -	40 -	50 -	60-69	All Ages
Observed	1	4	15	31	51
Expected	-	(9)	(58)	142	223
% Seen	-	44.4	25.9	21.8	23.3

X^2 goodness of fit (40 - 69 years) = 2.1,N.S. i.e. the observed

patients were similar in proportion at all age groups to that expected.

Others were treated at home, whereas some were admitted to hospital directly, either because the general practitioner did not call the mobile unit or because the patient made his own way there.

Despite the relatively low proportion of patients seen by the mobile unit their age and sex categories were not different in proportion from those in the community, as measured by a X^2 goodness of fit test (Appendix B).

A similar method was used to compare the community experience of myocardial ischaemia with that experienced by the mobile coronary care unit (Table 7). It was expected that 266 patients would have had an episode of myocardial ischaemia during the period but only 62 patients were seen by the mobile unit (23.3%). Both sexes showed a similar pattern; there was a higher proportion of young people seen by the mobile unit than might have been expected by chance ($0.025 > p > 0.01$).

The reason for this was not clear but assuming that a patient, later proved to have had ischaemia, was less obviously ill than a patient with infarction general practitioners might have been more likely to 'play safe' and call the mobile unit for younger patients, being more inclined to treat older patients at home if their symptoms were not severe. Despite these differences the proportion of males to females was similar to that seen in the community and similar to the proportions for patients with myocardial infarction.

Another important variable for comparison of the community experience of ischaemic heart disease with the patients seen by the mobile unit was the relative severity of the disease in the two groups. As many patients in the community study died very early after the onset of their symptoms the only complete measure of severity was to compare their mortalities over the acute stage of the illness.

TABLE 7   Observed and Expected Episodes of Myocardial Ischaemia

in the Study Population

	BOTH SEXES 20 -	40 -	50 -	60-69	MALES 20-69	FEMALES 20-69
Observed	3	13	27	19	43	19
Expected	–	40	81	132	174	92
% Seen	–	32.5	33.3	14.4	24.7	20.7

X^2 goodness of fit (ages 40-69) = 9.4, $0.025 > p > 0.01$, i.e. higher proportion of young ischaemics than expected by chance. No significant difference between the proportion of males and females.

In order to do this the patients seen by the mobile coronary care unit were taken and the expected number of deaths for each sub-group calculated from the community study figures. This gave the expected number of deaths if the patients collected by the mobile coronary care unit had had the same mortality rates as the community. These estimated numbers of deaths were then compared to the actual number seen in patients collected by the unit (Table 8).

The aim at this stage was simply to compare the severity of disease in the community with that of patients collected by the mobile unit. As the mobile unit appeared after the community study, treatment of cardiac arrests in the community had not existed at that time. To get an accurate comparison of the severity of the two groups it was therefore decided to regard cardiac arrests in the mobile unit as observed deaths, even if successfully resuscitated.

Table 8 showed that patients seen by the mobile coronary care unit had a significantly lower mortality than would have been expected in a similar group of patients in the community. Thus only 30/47 (63.8%) males and 12/23 (52.2%) females who would have been expected to die in the community actually did so.

It was expected that the greatest disproportion between the number of deaths occurring in the community and the number in patients treated by the mobile unit would be amongst those patients in the community who died very soon after the onset of their symptoms - too quickly for even a mobile coronary care unit to reach them. Table 9 showed the patients seen by the mobile coronary care unit who died or arrested classified by the time when they were first seen after the onset of their symptoms - observed deaths. The table also showed the proportion of mobile unit patients who would have died at different times if they had been in the

TABLE 8   <u>Observed Deaths and Arrests in the Mobile Unit compared</u>
<u>with Expected</u>

	MALES 20 –	50 –	60–69	20–69
Number of Episodes	19	44	52	115
Expected Fatality (%)	32.9	38.3	46.9	41.3
Expected Deaths	6	17	24	47
Observed Deaths and MCCU Arrests	O	12	18	30

X^2 goodness of fit (over 60 vs. under 60) = 6.1, $0.01 < p < 0.025$

i.e. less patients died in all groups than might have been expected

by chance.

	FEMALES 20 –	60–69	20–69
Number of Episodes	19	31	50
Expected Fatality (%)	33.6	53.7	46.0
Expected Deaths	7	17	23
Observed Deaths and MCCU Arrests	3	9	12

X^2 goodness of fit = 5.1, $0.025 < p < 0.05$, i.e. significantly

less observed deaths than expected in all groups.

TABLE 9   Expected and Observed Deaths in Patients with Myocardial

Infarction for Various Time Intervals

Number of Deaths (+ Arrests in Mobile Unit)	Time Intervals (hours)					TOTAL
	O - 1	-2	-4	-24	-4 wks	
Expected	33	4	4	11	19	71
Observed	13	3	3	8	15	42

X^2 goodness of fit = 14.3, $0.005 < p < 0.01$, i.e. significantly less

deaths observed in the mobile unit patients than expected.

X^2 omitting first hour group = 2.2, N.S. i.e. difference between

observed and expected deaths due to small number of first hour observed

deaths.

community - expected deaths.

The table showed that there were significantly less deaths in the mobile unit than the number expected, as shown previously, but it also showed that the only area of major discrepancy between the community and patients seen by the mobile unit was in patients within an hour of the onset of their symptoms. This was as might have been expected, for a doctor-manned mobile coronary care unit responding to calls from the patients general practitioner will be able to reach relatively few of the sudden cardiac deaths known to be such an important feature of ischaemic heart disease.

Thus it was established that the mobile unit was able to retrieve a reasonable cross-section of the population at risk in the community, except for those patients dying within an hour of the onset of their symptoms, i.e. sudden cardiac deaths.

Effect of Resuscitation in the Mobile Coronary Care Unit

It was established that the mobile coronary care unit was seeing a representative cross-section of the population at risk after the first hour from the onset of their symptoms, although only 20.0% of them were retrieved overall. The next step was to calculate if these patients seen after the first hour were helped by the mobile unit.

Table 10 showed similar data to Table 9 with the addition of figures on the actual number of deaths in the mobile unit, i.e. patients who were resuscitated in the mobile unit to leave hospital alive were not included in the third row. In this case the number of observed deaths were significantly less than might have been expected by chance, for all times. Most of the patients with a cardiac arrest who were resuscitated were seen within the first two hours of the onset of their symptoms. In order

TABLE 10 · Expected Deaths, Observed Deaths and Arrests and

Observed Deaths only in the Mobile Unit

Number of Deaths	Time After Onset (hours)					TOTAL
	0 - 1	-2	-4	-24	-4 wks	
Expected	33	4	4	11	19	71
Observed and Community Arrests	13	3	3	8	15	42
Observed only	9	0	2	6	15	32

X^2 goodness of fit = expected deaths vs. observed deaths omitting the first hour group = 8.1, $0.025 < p < 0.05$, i.e. significantly less observed deaths than expected for patients first seen after the first hour.

to check that these resuscitations had a lasting effect upon the mortality
of patients admitted in the mobile coronary care unit a series of life
tables were drawn up (Table 11). These were constructed using data from
(a) the community study, (b) the patients admitted to the mobile unit
and (c) the patients admitted to the mobile unit with all arrests in the
unit classified as deaths. They were drawn up only for patients first seen
after the first hour from the onset of patients' symptoms so that the
community patients could be compared with those in the mobile coronary
care unit.

The benefit of using life tables in this situation was that they
could make the most of the available data and give a picture of patient
mortality which could be compared, community with mobile unit, at each
time interval. The construction of the tables themselves was described
in the appendix.

L_x was the number of patients alive at the beginning of each time
interval, d_x the number who died within the time interval. 'Admitted'
column showed the number of patients who were first entered into the study
during that time interval. This column was not used for the community
data for all the patients were present from the beginning of the time
intervals.

L_x' was the average number of patients at risk during the time
interval and in the mobile unit patients was equal to the number alive
at the beginning of the interval, l_x plus half of the 'admitted' group.
This was because patients were admitted at a constant rate through each
time interval so the average number at risk were the number present
halfway through the time interval, i.e. those present at the beginning
and half of those admitted during the interval.

The assumption that patients were admitted at a constant rate

TABLE 11   Life Tables (a) Community Study, (b) Mobile Unit and
(c) Mobile Unit - Arrests treated as Deaths

Time (hrs)	L_x	d_x	Admitted	L_x'	q_x	e^o_x	SE
(a) 1-2	818	21	0	818	0.0256	97.43	0.55
2-4	797	26	0	797	0.0326	94.25	0.81
4-6	771	18	0	771	0.0233	92.06	0.94
6-12	753	29	0	753	0.0385	88.51	1.11
12-24	724	24	0	724	0.0331	85.58	1.22
24-48	700	28	0	700	0.0400	82.16	1.34
48-4wks	672	84	0	672	0.1250	71.89	1.56
+4wks	588			588			
(b) 1-2	38	0	43	59.5	0.0000	100	-
2-4	81	2	33	97.5	0.0205	97.95	1.44
4-6	112	1	17	120.5	0.0083	97.14	1.64
6-12	128	1	14	135	0.0074	96.42	1.78
12-24	141	4	8	145	0.0276	93.76	2.17
24-48	145	8	3	146.5	0.0546	88.64	2.70
48-4wks	140	7	0	140	0.0500	84.21	3.04
+4wks	133						
(c) 1-2	34	3	43	55.5	0.0541	94.59	3.04
2-4	74	3	33	90.5	0.0331	91.46	3.44
4-6	104	3	17	112.5	0.0267	89.02	3.62
6-12	118	1	14	125	0.0080	88.31	3.66
12-24	131	4	8	135	0.0296	85.69	3.78
24-48	135	8	3	136.5	0.0586	80.67	3.95
48-4wks	130	7	0	130	0.0538	76.33	4.07
+4wks	123						

throughout the time intervals was not true for patients seen at under one hour after the onset of their symptoms, their average time for admission being 44 minutes. This was an additional reason to omit first hour patients from the calculation and was a limitation of the use of life tables in this situation.

Q_x was the proportion of patients dying at each time interval, i.e. d_x/L_x'. e_x^o was the percentage cumulative survival at the end of each time interval and SE was the standard error of that survival rate. The percentage cumulative survivals and their standard errors were plotted in Fig. 2.

The patients from the community study (a), showed no significant difference in mortality from the patients seen in the mobile coronary care unit where arrests in the mobile unit were all regarded as deaths (c). On the other hand when the community patients were compared to actual survival in the mobile unit, i.e. arrests which were resuscitated in the unit were counted as living (b), there was a highly significant decrease in mortality for the patients treated by the mobile unit.

In other words the treatment of cardiac arrest by the mobile unit confirmed the earlier finding that the mobile unit increased the survival of its patients above that seen in the community, whereas if no resuscitation had been performed the survival rates would have been similar to those normally seen in the community.

The life tables also showed that the resuscitations performed on patients soon after the onset of their symptoms significantly decreased the mortality for the patients in the mobile unit over patients in the community for the next four weeks; the improvement was not simply a temporary one.

A corollary to these findings was that, apart from resuscitation

CUMULATIVE SURVIVAL FROM 1st HOUR FOR COMMUNITY PATIENTS (A),
MOBILE UNIT PATIENTS (B), AND MOBILE UNIT PATIENTS DEATHS + ARRESTS (C)

% CUMULATIVE SURVIVAL (FROM 1st HOUR)

error bars represent + 1 S.E.M.

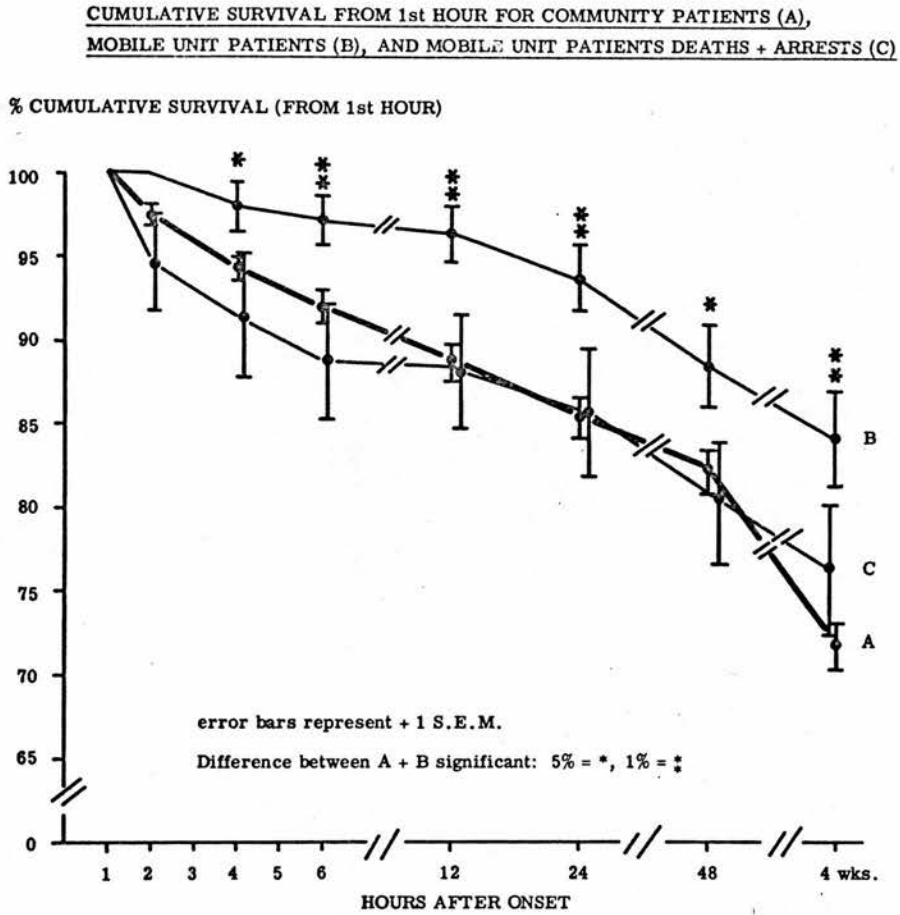Difference between A + B significant: 5% = *, 1% = **

HOURS AFTER ONSET

FIGURE 2   Results of life tables.

from cardiac arrests, patients in the mobile coronary care unit had no advantage over the community as a whole. It would appear that preventative measures in the mobile unit short of resuscitation, e.g. prophylactic anti-arrhythmic therapy, had no effect upon the patients' final outcome.

Reasons for poor retrieval of patients within an hour of onset of symptoms

Figure 3a shows the cumulative percentage of patients retrieved by the mobile coronary care unit by the time after the onset of the patient's symptoms. This was compared to similar data for the hospital coronary care unit before the institution of the mobile unit (Fulton, 1969). The figure showed that 23% of patients attended by the mobile unit were first seen within an hour of the onset of their symptoms compared to 2% who arrived at the hospital coronary care unit within that time. 52% of those seen by the mobile unit were reached within 2 hours compared to 15% in the hospital unit previously.

Thus the number of patients receiving intensive care within an hour was higher than previously but still only covered a quarter of the patients. The reasons for this were examined in more detail.

Figure 3b showed the median time for patients to receive care. It showed the median times from the onset of symptoms to the time before the patient called for help, the time before the general practitioner arrived and the time for the general practitioner to call the mobile unit. These data were shown for comparison with similar figures obtained for hospital patients in the community study (Armstrong, et. al., 1972).

The mobile unit reduced all of the time intervals. Thus the reduction in time for the arrival of the mobile unit was not simply a reflection of the removal of administrative delay in getting the patient from home to hospital.

Patient initiated delay

The reduced delay in this group was not fully understood. The change from a median time of 1 hour 30 minutes in the community study to 1 hour in the mobile coronary care unit was possibly due to selection by the general

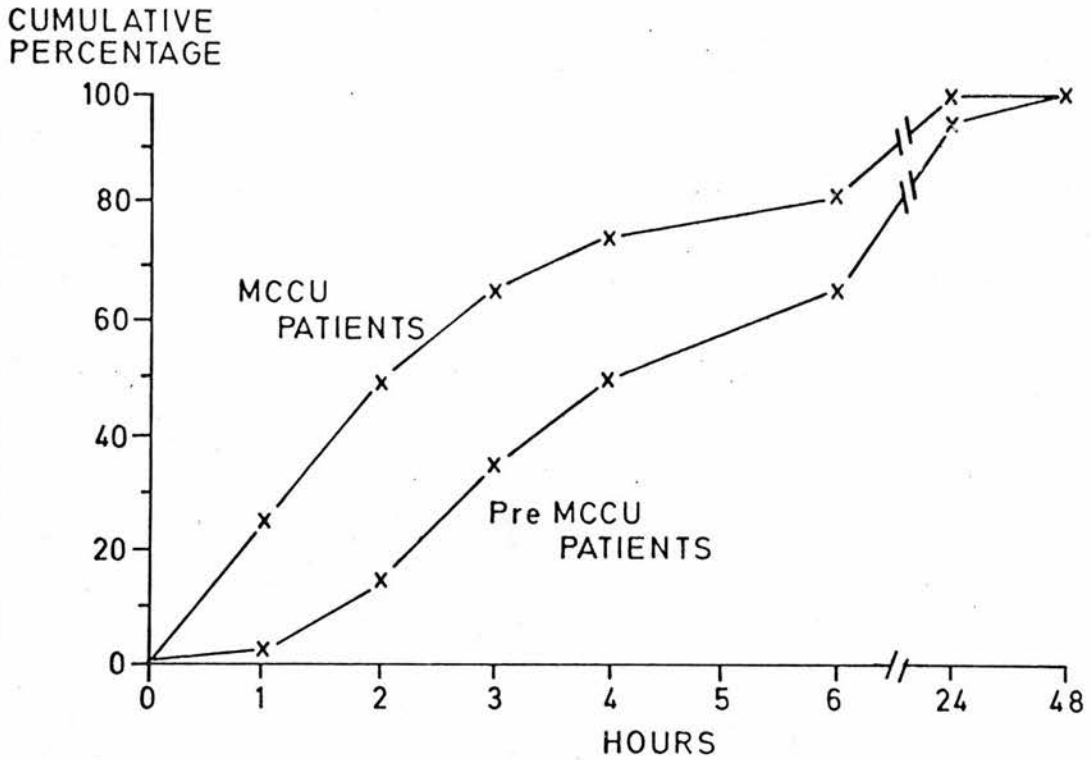## TIME OF ADMISSION OF PATIENTS TO CORONARY CARE

FIGURE 3a   Cumulative percentage of patients under intensive care.

MEDIAN TIMES FROM ONSET OF PAIN TO EVENTS LEADING TO HOSPITAL ADMISSION PRIOR TO AND USING MOBILE CORONARY CARE UNIT
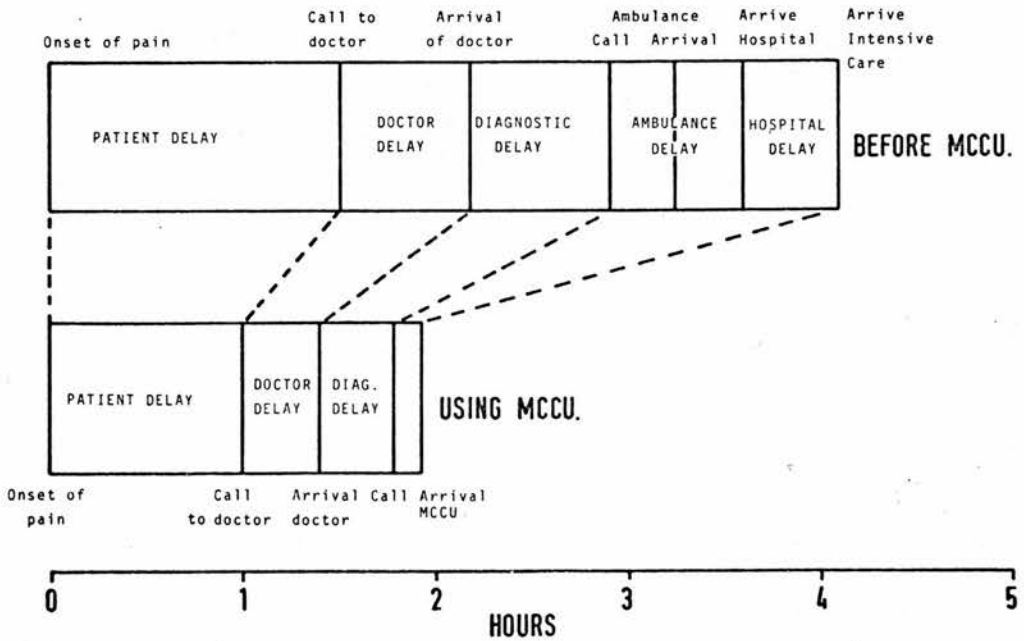

FIGURE 3b   Causes of delay in reaching intensive care.

practitioners for they had been informed at the beginning of the study that the unit could do most for patients seen early after the onset of symptoms.

It was possible, though unlikely, that patients had heeded the warnings given locally of the dangers of chest pain and the necessity for rapid treatment after the results of the community study became known. Table 12 showed the reasons given for delay by the patients in the study. Those who called for help within 30 minutes of the onset of their symptoms considered that they had acted quickly and could rarely give any reason for delay. 107 (40.0%) of patients had called for medical help within 30 minutes. Patients who later proved to have sustained myocardial infarction behaved in a similar way to those who had not.

Delays due to external causes occurred in only 19 patients (7.1%). 12 of these were unable to call for help as they were living alone without a telephone and were too ill to contact neighbours. 7 patients managed to contact their general practitioner's staff but he was unavailable. Patient initiated delay was the biggest single cause of delay affecting 127 (47.6%) of the patients. The great majority of patients in this group said that their symptoms were not initially severe and did not warrant calling a doctor. This has been described by Hackett (1973) as a form of denial of frightening symptoms. He stated that these patients transferred the cause of their pain to another, less worrying disease process, e.g. indigestion, but this was uncommon in the present study.

To clarify further whether the patients were denying their pain a set of questions was put to them about the type of the onset of their symptoms. If they attained their worst severity within 10 minutes they were classified as being of sudden onset, if they took over 10 minutes to reach a maximum they were gradual onset and classified as stuttering

TABLE 12   <u>Main Reason given for Patients Delaying Calling for</u>

<u>Medical Help after the onset of their Symptoms</u>

	Final Diagnosis (%)		TOTAL
	<u>Myocardial infarct.</u>	<u>No infarct.</u>	
<u>No Delay</u>			
Called within 15 mins.	44 (28)	24 (22)	68 (25)
Called 15-30 mins.	19 (12)	20 (19)	39 (15)
<u>External Causes</u>			
Unable to call help	9 (6)	3 (3)	12 (4)
Unable to contact help	5 (3)	2 (2)	7 (3)
<u>Patient Initiated Delay</u>			
Symptoms initially mild	63 (39)	49 (45)	112 (42)
Thought it was other disease	5 (3)	2 (2)	7 (3)
Did not wish to disturb Dr.	4 (2)	4 (4)	8 (3)
<u>Others</u>			
Other Causes	6 (4)	3 (3)	9 (3)
Not Known	5 (3)	0 (0)	5 (2)
TOTAL	160 (100)	107 (100)	267 (100)

onset where the symptoms took over 10 minutes to reach a maximum but varied in intensity thereafter.

Figure 4 showed the patients who considered their initial symptoms unimportant classified according to these three groups. Most of these patients had a gradual or stuttering onset of their symptoms. Some patients described an almost imperceptible onset of pain, noticed only when they went to bed at night and building up over some hours. Occasional patients appeared to react inappropriately, waiting for some hours in severe pain before calling the doctor, but this was not common.

General practitioner delay

The reduction in the general practitioners arrival time and diagnostic delay was not surprising as general practitioners had been advised to call the mobile unit before seeing the patient if the symptoms described to them by message sounded genuine. Patients for whom the general practitioner called the unit directly were seen significantly faster than those visited first by their doctor ($X_c^2 = 4.2$, $0.025 < p < 0.05$).

Overall delay - age, sex and social class

There was no significant difference in the speed of admission between males and females, though females did take a little longer. For the age groups there was a highly significant excess of older men admitted more quickly than younger ($X^2 = 14.6$, $0.0005 < p < 0.001$). This age difference did not exist for females. There was no significant difference in the speed of admission for patients in different social classes.
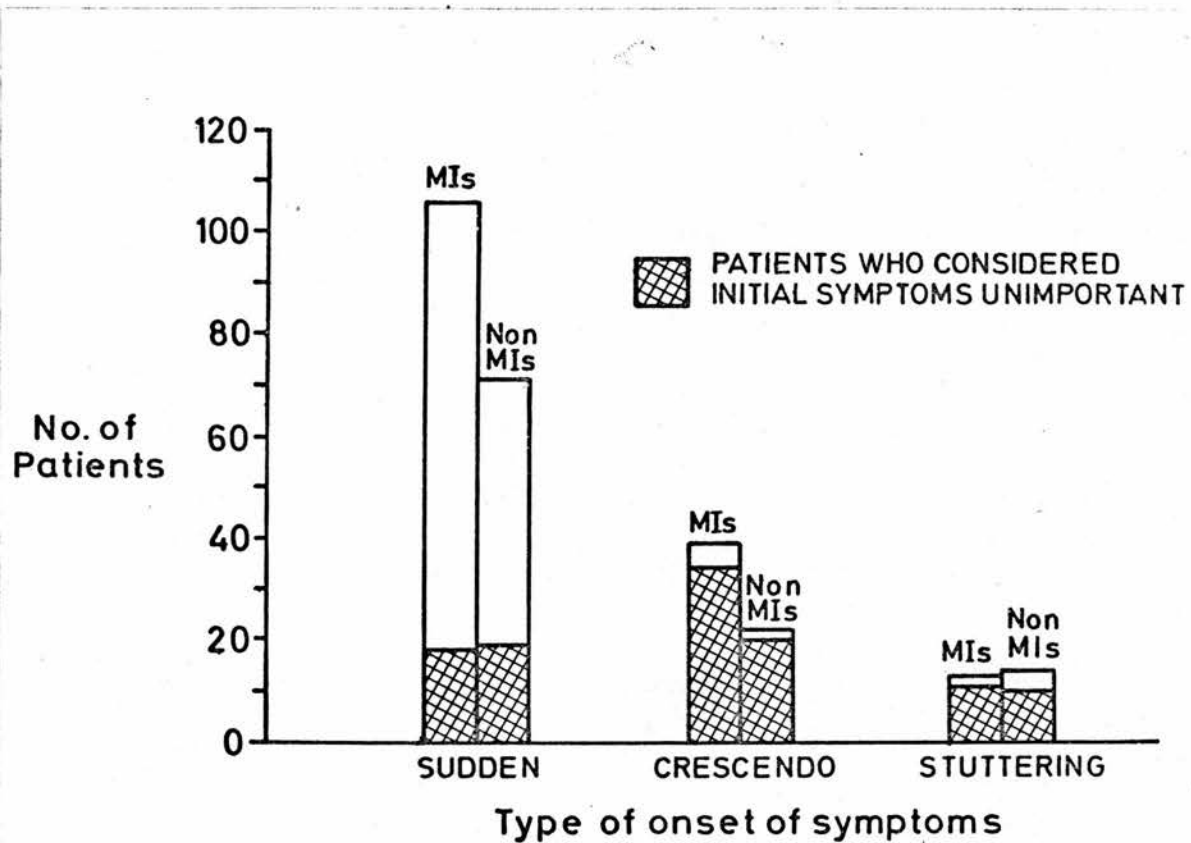
FIGURE 4   Number of patients who considered their initial symptoms

unimportant by the speed of onset of those symptoms.

Severity of the attack

Table 13 showed the speed of arrival of the mobile unit for patients with cardiogenic shock and cardiac failure. Cardiogenic shock was defined as a patient with a blood pressure of less than 100 MM. Hg. together with signs of peripheral vasoconstriction, pale, cold extremeties, sweating or cyonosis; or with a urinary output of less than 250 mls/hour or with clouding of consciousness. Cardiac failure was defined as marked post-tussive basal crepitations or a raised jugular various pressure or a third heart sound. Patients with these complications received help significantly faster than those without complications. Table 13 also showed a more subjective measure of severity, namely the speed of onset of symptoms. There was a highly significant relationship between sudden onset of symptoms, i.e. those reaching their worst within 10 minutes and rapid arrival of the mobile unit. Thus both objective and subjective measures of severity showed that severity was related to the rapid arrival of the mobile coronary care unit.

Other factors

Previous history of myocardial infarction or angina, crescendo angina, previous contact with medical help, self-medication after the symptoms started and time of day were all examined but none showed a clear relationship with the speed of arrival of the mobile coronary care unit.

It appeared that the patient was the major delaying factor in obtaining help from the mobile coronary care unit.

The principal factors causing patients to call for help quickly were those connected with the severity of the patients symptoms and to a lesser extent signs.

TABLE 13   Effect of Severity of the Acute Attack upon Time from

Onset of Symptoms to Arrival of the Mobile Unit

Objective Severity

| Complications Present | Compared to Overall Median Time | | TOTAL |
	Faster	Slower	
Cardiogenic Shock	9	5	14
Cardiac Failure	28	15	43
Neither of Above	40	58	98
TOTAL	77	78	155

$x^2 = 8.4$, $0.01 < p < 0.025$, i.e. those with complications received help

faster than those without.

Subjective Severity

| Type of Onset of Symptoms | Compared to Overall Median Time | | TOTAL |
	Faster	Slower	
Sudden	67	37	104
Gradual and Stuttering	10	41	51
TOTAL	77	78	155

$x^2_c = 25.7$, $p < 0.0005$, i.e. those with sudden onset of symptoms much more

likely to receive help earlier.

The Impact of a Mobile Coronary Care Unit upon Home Care

Difficulty of predicting outcome from initial data

It was an unfortunate fact that mild initial symptoms did not mean that the patient was safe.   Table 14a showed that although there was a clear relationship between their initial severity and the number of patients who later died a large number of patients died without such initial symptoms or signs.

More important was Table 14b which showed the patients who had had a cardiac arrest and were successfully resuscitated.   These were not more likely to have had cardiogenic shock or failure at their initial examination.   On the other hand cardiac arrests for which the patient was resuscitated and left hospital alive were commoner in patients seen early after the onset of their symptoms, (c = 2.9, p = 0.004) whereas deaths showed no such trend with time.

Thus patients who had severe initial symptoms tended to call for help early but if they arrested were less likely to survive whereas patients with less severe symptoms tended not to call for help as quickly, but were more likely to have a cardiac arrest from which they could be saved.   There was thus a 'Catch 22' situation in which patients who could not be helped received it quickly, whereas those who could be helped, particularly early after the onset of their symptoms, received aid comparatively slowly.

More detail of complications at the initial interview in the mobile coronary care unit were shown in Table 15.   48 patients who were free of cardiogenic shock or failure in the mobile unit developed these complications in the hospital coronary unit and 16 who had these signs in the mobile unit lost them in the hospital.   This represented a statistically significant increase in severity overall in the hospital unit.

TABLE 14a   Severity of the Attack by Outcome in Patients with Myocardial Infarction

Deaths

| Place of Death | Complications in Mobile Unit | | | TOTAL |
	Neither	Failure	Shock	
Died in Mobile Unit	0	0	10	10
Hospital Coronary Unit	5	7	3	15
General Ward	4	3	0	7
Survived Hospital	91	34	11	136
TOTAL	100	44	24	168

All deaths vs survivors: test for trend $c = 4.8$, $p \ll 0.005$

i.e. close relationship between mortality and severity in mobile unit.

Ignoring deaths in the mobile unit $c = 1.94$, $p = 0.06$ i.e. not

quite statistically significant at 5% level.

TABLE 14b

Arrests who survived to leave hospital

| Place of Death | Complications in Mobile Unit | | | TOTAL |
	Neither	Failure	Shock	
Arrested in Mobile Unit	3	4	3	10
Arrested Hospital Coronary Unit	7	1	0	8
Arrested in Ward	0	0	0	0
Did not Arrest	81	29	8	118
TOTAL	91	34	11	136

All arrests vs non arrests: test for trend $c = 1.4$, N.S.

i.e. no relationship between severity and likelihood of a cardiac

arrest from which the patient was resuscitated.

TABLE 15   Comparison of Number of Patients with Complications

of Cardiogenic Shock or Failure in the Mobile Unit

and in the Hospital

Hospital complications (shock or failure)	Mobile Unit shock or failure Present	Absent	TOTAL
Present	41	48	89
Absent	16	48	64
TOTAL	57	96	153

Sign test: 64 patients changed category - 16 lost, 48 gained

complications.   This was statistically significant $p < 0.01$, i.e.

significantly more patient gained complications in the hospital

coronary care unit than lost them compared to the mobile unit.

One of the factors which must have played a part in this increase was that the hospital coronary care unit was better equipped for detecting these complications, even though the definitions were identical. The stay in the hospital unit was also longer than the stay in the mobile unit giving a better chance of detecting any abnormalities. On the other hand the increase in severity in the hospital unit was not uniform for all categories suggesting that another mechanism also played a part.

Thus Table 16 showed that the increase in complications in the hospital coronary care unit, compared to the mobile unit was most marked for patients seen within an hour of the onset of their symptoms, and became less marked for patients seen later.

This finding was of some concern for it suggested that the patients seen earliest after the onset of their symptoms, when their outcome was most likely to be affected by the therapy in the mobile coronary care unit, were showing the most marked increase in severity. In order to clarify whether or not treatment was artificially increasing the area of myocardial damage when the muscle was still theoretically susceptible to such influences the 37 patients seen within an hour of the onset of their symptoms were checked. The only treatment given frequently enough to cause such a change in the condition of the patients was morphine. There was however no relationship between those patients whose condition worsened and morphine treatment in the mobile unit. It seemed likely then that the patients seen earliest after the onset of their symptoms were naturally unstable in the severity of their disease, though what influenced that severity was not known.

It was seen then that the relationship between the clinical state of patients seen in the mobile coronary care unit, while still in their

TABLE 16   <u>Patients without Cardiogenic Shock or Failure in the</u>

<u>Mobile Unit. Number who gained these complications</u>

<u>in the hospital by time</u>

Hosp. Coronary Unit Shock/Failure	Time after onset when seen in Mobile Unit (hrs)				TOTAL
	-1	-2	-4	4-	
Present	16	14	10	8	48
Absent	4	7	17	20	48
TOTAL	20	21	27	28	96

Test for trend $c = 3.9$, $p < 0.005$, i.e. highly significant relationship
between patients developing shock or failure in the hospital coronary
care unit for the first time and being seen by the mobile unit soon after
the onset of symptoms.

own homes, and that on admission to hospital was a complex one. This fact had important implications for home care of patients. It appeared that the initial clinical state of patients was not a good guide to their outcome so that any attempt to define a group of patients fit enough to be treated at home difficult. The attempt would indeed be the more formidable the earlier the patients were seen after the onset of their symptoms.

Prediction of outcome using complex data

The mobile coronary care unit was in a unique position to examine
the relationship between the initial state of patients and their outcome
in hospital. Patients could be examined by the mobile unit in their own
home with the minimum of disturbance, but with the facilities of a
coronary care unit to hand. By increasing the amount of information
collected in the home it was hoped to predict which patients were most
in need of intensive care and which could be safely treated elsewhere,
either in a general medical ward or in the patient's home.

Prediction of Final Diagnosis

The information collected about each patient in the mobile unit
was listed in Table 17. These data were compared with the final diagnosis
of the patients in hospital. Nine of the factors showed a relationship
with the presence or absence of the final diagnosis of myocardial
infarction. These were shown in Table 17 also.

Thus older patients who were active or exerting themselves as
symptoms commenced were more likely to have sustained myocardial
infarction. Those in whom pain was present, whether or not they had
received therapy were also more likely to have had infarction. On the
other hand a recent previous myocardial infarction was not usually
associated with a new infarct, especially if the previous attack had been
within the past two months. This may have been related to the quite
severe attacks of ischaemic pain which some patients had shortly after
myocardial infarction without fresh muscle damage.

Recent onset angina on the other hand was related to the presence
of myocardial damage. Oddly more of the patients with myocardial
ischaemia had seen a doctor in the month prior to the acute attack when

TABLE 17   Initial Factors Discriminating Between Patients with and
without Myocardial Infarction

	Group with Infarction	Test	Signif (p)
Mean age	Older	$t = 2.9$	0.004
Sex	-	-	-
Major symptom (pain etc.)	-	-	-
Pain present when seen	Present	$x_c^2 = 8.3$	0.002
Radiation of pain	-	-	-
Speed of onset of symptoms	-	-	-
Time after onset symptoms	-	-	-
Activity with symptoms	More active	$x_c^2 = 5.9$	0.02
Previous history MI	No Ml recently	$x^2 = 10.8$	0.02
Previous angina	Recent onset	$x_c^2 = 4.8$	0.05
Other medical disease	-	-	-
Medical advice past 1/12	None	$x_c^2 = 8.1$	0.004
Occupation	-	-	-
Work record	-	-	-
Smoking history	-	-	-
Medical treatment	-	-	-
Cardiogenic shock	pallor	$x_c^2 = 6.8$	0.01
	cyanosis	$x_c^2 = 9.0$	0.003
Cardiac failure	4th heart sound	$x_c^2 = 3.9$	0.05
Blood pressure	-	-	-
Pulse	-	-	-

compared to the number of patients with infarction. As might have been expected patients with pallor, cyanosis or a fourth heart sound were all associated with myocardial infarction.

In order to make the best use of these data the different factors were combined in a multiple discriminant analysis. This was done by calculating a linear-logistic discriminant function.

The probability of any one patient having had a myocardial infarction can be calculated using the factors, e.g. age, previous angina, described. A model was constructed to combine the factors which was summarised in mathematical terms as:

$$Log \frac{p}{1 - p} = C_0 + C_1 z_1 + C_2 z_2 + C_3 z_3 \ldots C_n z_n$$

where p was the probability of the patient having had an infarct and where z_1 to z_n were whole numbers representing the presence or absence of the factors examined. These variables were shown in column 2 of Table 18. C_1 to C_n were coefficients which gave a weighting to each factor depending upon how good that factor was at predicting whether or not a patient had had a myocardial infarction. C_0 was a constant, also calculated from the data.

These coefficients had standard errors which were calculated (Column 4 in Table 18) and from these the relative significance of each factor was calculated. All the factors made independent contributions to predicting the patients diagnosis with a significance of less than 10% and were therefore all included in the analysis.

The next step was to calculate the scores for each of the patients in the study. A score of zero gave the patient a 50% chance of having had a myocardial infarction, i.e. the analysis was of no help in deciding

TABLE 18   Results of a Discriminant Analysis for predicting

Myocardial Infarction from the Initial Examination

Factors	Variables (Z)	Coefficients (C)	Significance (p)
Age	Numeral	−0.3	0.07
Actions with symptoms	At rest/asleep = 0)) Active = 1)	−5.1	0.07
Pain present	No pain = 0)) Present = 1)	−9.4	0.004
Previous MI	None = 0)) Over 1 yr ago = 1)) 2-12 mths ago = 2)) less 2 months = 3)	+3.4	0.04
Previous angina	None/over 1/12 = 0)) Started 1 mth = 1)	−7.5	0.02
Medical advice in past month	No = 0)) Yes = 1)	+6.1	0.04
Pallor	Absent = 1)) Present = 0)	+5.7	0.05
Cyanosis	Absent = 1)) Present = 0)	+16.8	0.01
Fourth heart sound	Absent = 1)) Present = 0)	+6.3	0.08
CONSTANT		−3.8	

the likely diagnosis, patients with negative scores were more likely
to have had a myocardial infarction, those with positive scores less
likely to have had an infarct. (More details of the calculations involved
were given in Appendix B.)

The scores for the patients in the study group and their likelihood
of having had a myocardial infarction were shown in Figure 5. This showed
that patients with scores less than -5 had over a 75% likelihood of having
had a myocardial infarction, those scoring over +5 had less than a 20%
chance of having had an infarct.

The intermediate group of patients who scored between -5 and +5 could
not be reliably predicted. These consisted of 85/262 (32.4%) of the group
as a whole.

Prediction of Severity

The data collected in the mobile coronary care unit (Table 17,
Column 1), was then used in order to predict a 'good risk' group of
patients. In this way it was hoped to define a group of patients, who
would normally have been admitted to hospital intensive care units, but
who would have been safe to treat at home.

The patients were divided into two groups. The first, those who
had had a cardiac arrest or signs of cardiogenic shock or cardiac failure
or any major arrhythmias in hospital which required immediate treatment
(ventricular tachycardia, R on T ectopic beats, sinus bradycardia with
hypotension, atrial tachycardia, heart block) as defined in the therapeutic
schedule (Appendix A), were regarded as 'bad risk' patients. Those
patients without any of these complications in the hospital were regarded
as 'good risk'. Patients who were already classified as 'bad risk'
because of complications in the mobile coronary care unit were excluded
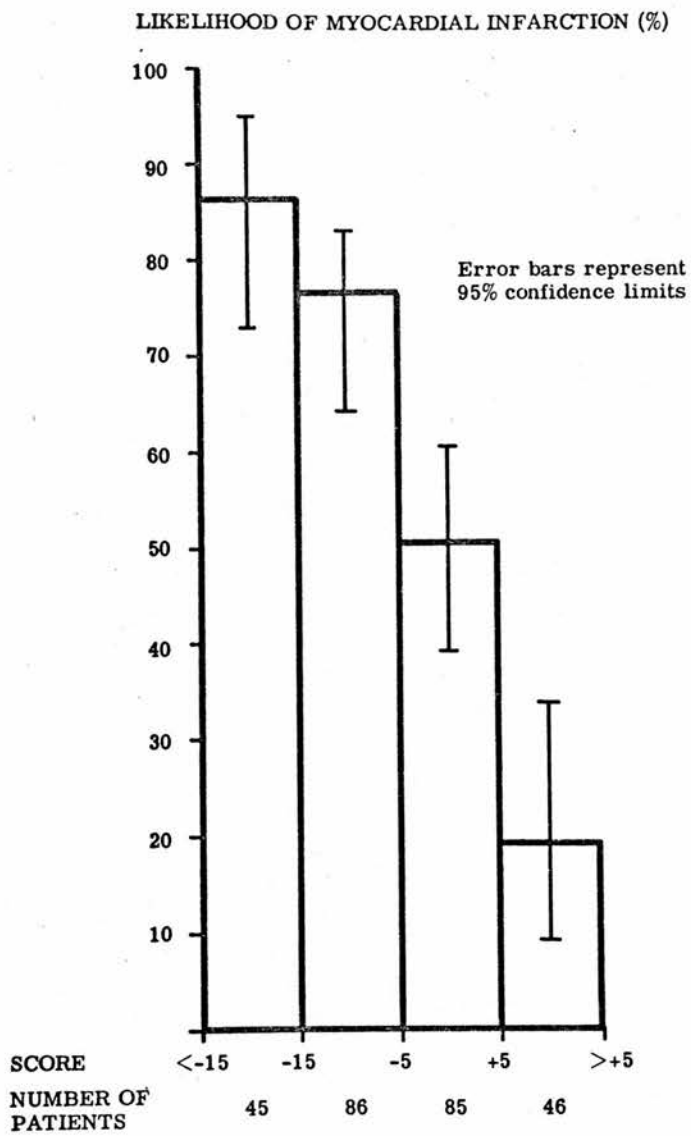
FIGURE 5   Likelihood of a patient having myocardial infarction

for various scores on the index.

from the analysis.

Of the 265 patients admitted to the hospital coronary care unit from the mobile unit 225 were 'good risk' on admission to hospital. Of these 80 remained 'good risk' throughout their stay in hospital. In theory therefore these 80 patients did not require specialised treatment, and could have been left at home if they could have been identified by the mobile unit when they were still at home.

Unfortunately none of the data collected in the mobile coronary care unit showed a statistically significant relationship at the 5% level with the presence or absence of the 'good risk' group. This supported the argument given previously that the outcome of patients in hospital was difficult to derive from their initial state. This approach was therefore not useful for defining a 'good risk' group.

One of the reasons for this failure may have been that the 'bad risk' group was not homogeneous, but consisted of many different types of complications with many possible causes for them. Thus the causes of sinus bradycardia with a low blood pressure were probably different from the causes of atrial tachycardia and to predict both complications from initial data might require each to be examined separately and in detail. Such an approach would require large numbers of patients in each of the 'bad risk' categories with huge numbers of patients and the resulting equations would probably be far too complex for day to day use.

The initial electrocardiogram

The function of the electrocardiogram in hospital practice was mainly to give a final definitive diagnosis for patients with myocardial infarction. For this purpose coding of the electrocardiogram was performed at a relatively late stage in the hospital coronary care unit and most classifications were based on the development of Q waves and ST segment changes. The criteria often depended upon evolutionary changes with time to confirm the acuteness of the attack. These criteria were well suited to patients already in an intensive care unit where he or she could come to no harm.

The function of the electrocardiogram was rather different in the mobile coronary care unit. The problem at the initial examination was not to make a definitive diagnosis, excluding patients with equivocal changes, but rather to use the electrocardiogram as a screening test so that patients who were in any way likely to run into trouble would have adequate treatment. The emphasis was on spotting all patients liable to get into trouble rather than excluding those without definite changes.

For this purpose the standard classifications were far too strict in their criteria, for Q waves did not develop in many cases within the first few hours of infarction and of necessity only one electrocardiogram was available so that evolutionary changes with time could not be assessed.

For these reasons a new electrocardiographic classification was made which paid attention to the minor changes associated with myocardial ischaemia (Table 19).

The classification was based on a standard classification with two further categories added. The standard classification was described in detail on the first page of the Methods chapter (World Health Organisation, 1966). An example of a 'possible' inferior myocardial infarction and a

TABLE 19   <u>New Classification of the Electrocardiogram</u>

1. Possible change   i) ST elevation of 1 mm in anterior leads

                          (any 2 of V_3 to V_6)

                     ii) ST elevation of 1 mm in inferior leads

                          (any 2)

                    iii) ST elevation of 1 mm in posterior leads

                          (any 2 of V_7 to V_9)

     <u>with</u> reciprocal depression of ST segments of 1 mm.

2. Probable change   As above but with 2 mm ST segment elevation.

3. Pathological change As World Health Organisation classification

                          (1966).
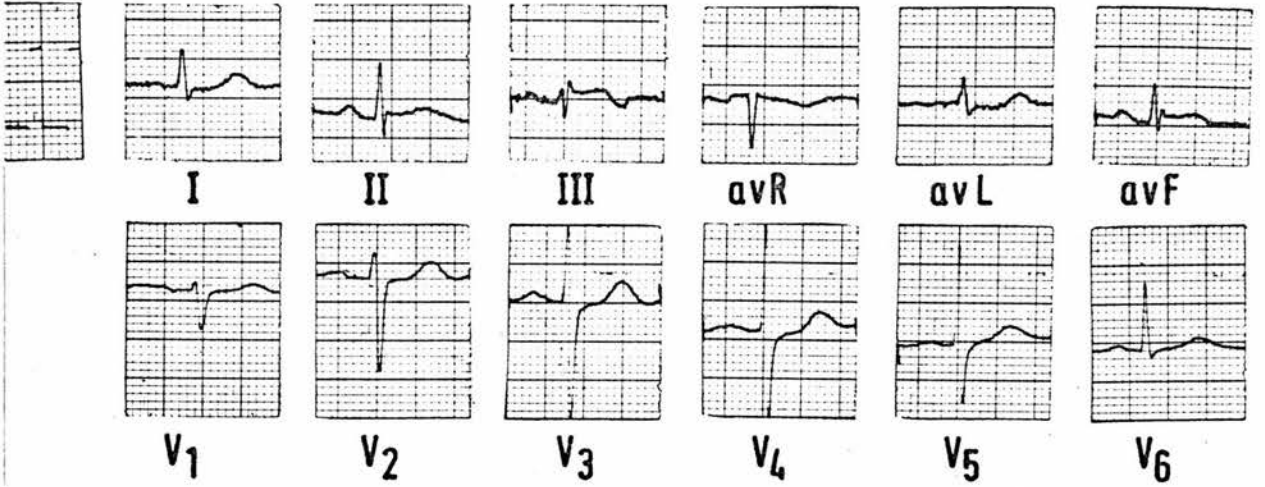
FIGURE 6a   'Possible' inferior myocardial infarction by the
                 new classification.
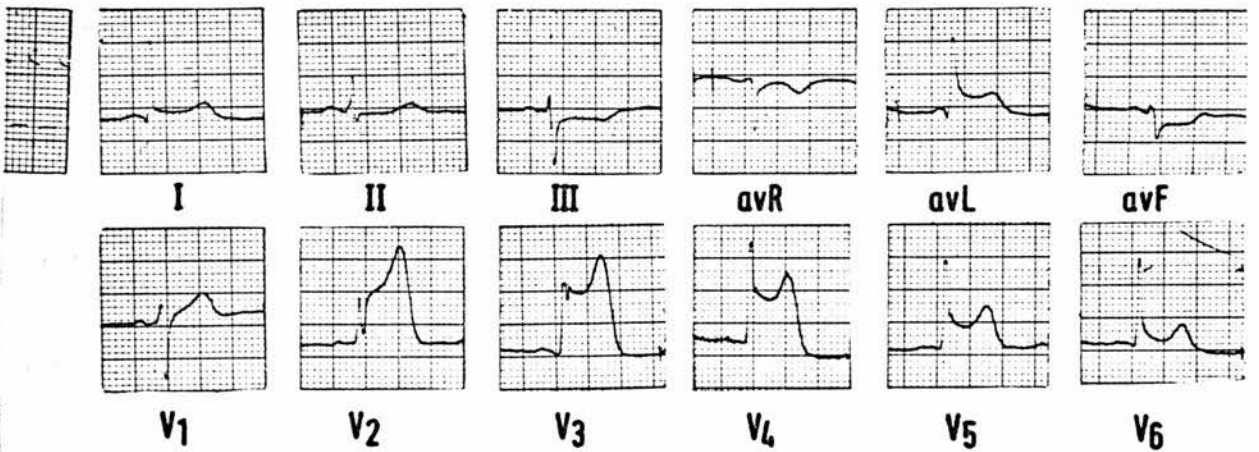

FIGURE 6b   'Probable' anterior myocardial infarction by the
                 new classification.

'probable' anterior myocardial infarction using the new classification
was shown in Figure 6.

Prediction of Diagnosis

In order to compare the classification with the standard one in
practice the patients were classified according to whether they were
ultimately shown to have had a myocardial infarction or not. Using the
original W.H.O. classification the initial electrocardiogram was positive
for 61/147 patients who later were found to have had myocardial infarction,
a sensitivity of 41.5%, whereas using the new classification 129/147 (87.8%)
were correctly classified. At the same time the number of patients with
a negative electrocardiogram who had not had a myocardial infarction, i.e.
the specificity of the test, was reduced from 92.5% to 77.4%.

As it was more important at the initial examination to overtreat
patients rather than to undertreat them this classification was a
considerable improvement as a simple screening test.

Figure 7 showed the sub groups of the initial electrocardiogram
taken in the mobile coronary care unit used to predict whether or not
patients would have a final diagnosis of myocardial infarction. The
electrocardiogram alone, using the new classification, was a better
predictor for myocardial infarction than all the clinical data used in
the multiple discriminant analysis (Figure 5). There was no group at
about a 50% likelihood of infarction making it a useful discriminator
for all the groups of patients. The 'possible' electrocardiographic
change group with a 66% likelihood of infarction was the least well
predicted group but consisted of only 38/253 (15.0%) of the patients.

When the electrocardiographic changes were added to all the clinical
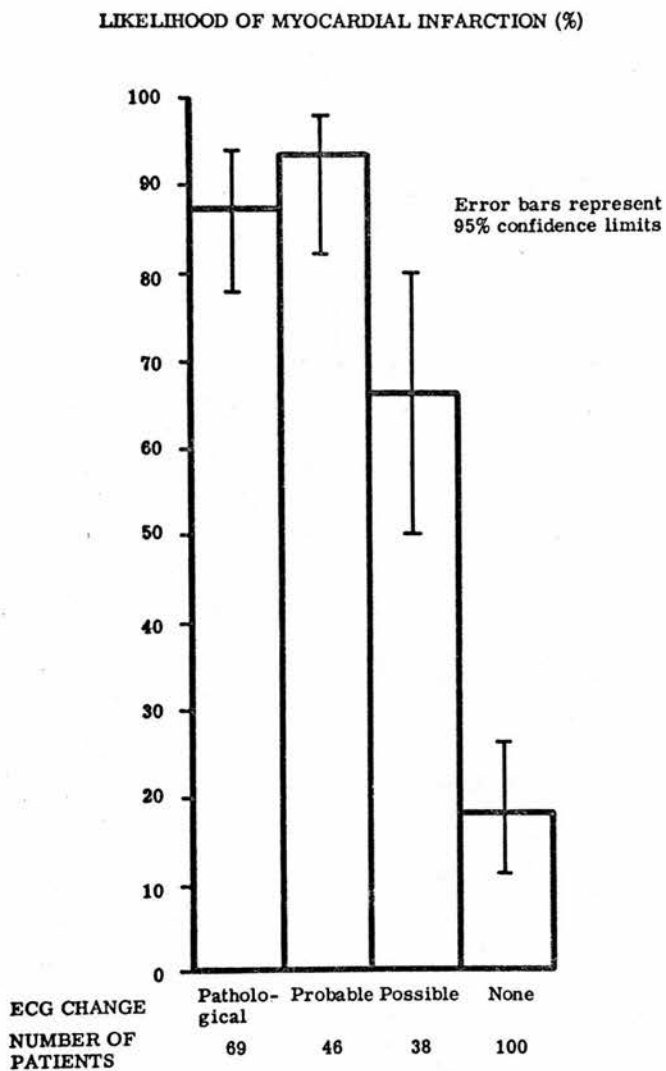data gathered previously only four factors gave additional information for

FIGURE 7   Proportion of patients with myocardial infarction by

electrocardiographic change by the new classification.

separating the patients with myocardial infarction from the others. These were the presence of pain when the patient was first seen, previous angina, previous myocardial infarction and the presence of cyanosis. The variables for this equation were scored as in Table 18 and the coefficients were shown at the bottom of Figure 8.

This analysis was a slight improvement over the use of the electrocardiogram alone. If a score of zero was taken as the point below which patients might be expected to have had a myocardial infarction, 91% would be correctly classified compared to the sensitivity of the electrocardiogram alone at 88%. The score was also more specific, for patients without myocardial infarction were correctly classified 83% of the time compared to 77% for the electrocardiogram alone.

Prediction of Severity

Prediction of the final diagnosis was useful up to a point. Of more concern to a doctor at the initial contact with a patient was to predict the ultimate severity of the attack. In particular, it would have been useful to predict which patients were likely to have a cardiac arrest in hospital. It has already been shown that none of the clinical factors alone showed a significant relationship with the presence of complications later.

The initial electrocardiogram was related to the presence of complications in the hospital. However as Table 20 showed, although the relationship between the initial electrocardiographic changes and the 'bad risk' patients was very close, all of the electrocardiographic categories contained some 'bad risk' patients and could therefore not be used to define a group who could safely be treated outside an intensive care unit. A normal initial electrocardiogram predicted a mild course
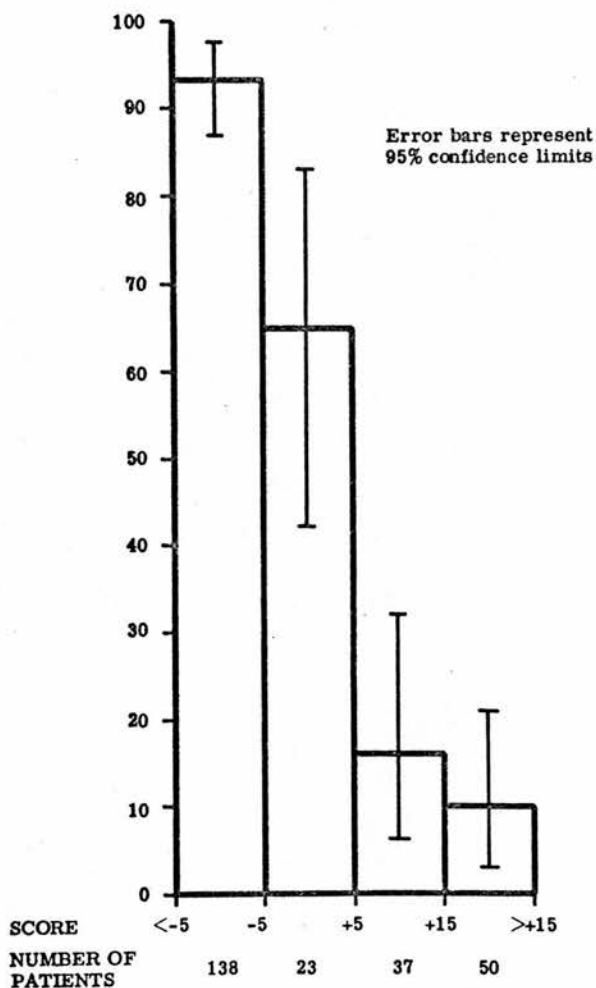
FIGURE 8   Proportion of patients with myocardial infarction by the score based on the formula: $\text{Log}\left(\dfrac{P}{1-P}\right) = 4.9\, Z_1 - 10.3\, Z_2 - 13.7\, Z_3 + 23.1\, Z_4 + 45.7\, Z_5 + 19.0\, Z_6 - 40.2$; where Z_1 was previous myocardial infarction, Z_2 was recent onset angina, Z_3 was presence of pain, Z_4 was absence of cyanosis, Z_5 was no ECG change, Z_6 was 'possible' ECG change.

TABLE 20   Initial Acute Electrocardiographic Change related to

Severity of Outcome

Outcome	Acute Electrocardiographic Changes				TOTAL
	None	Possible	Probable	Pathological	
Bad Risk	37	23	31	42	133
Good Risk	52	11	6	9	78
TOTAL	89	34	37	51	211

x^2 = 28.9, p < 0.0005, i.e. very strong relationship between 'bad risk'
and major electrocardiographic changes.

Definitions: Bad risk - Cardiac arrest or signs of cardiogenic shock or
              failure. Any major arrhythmias; ventricular
              tachycardia, R on T ectopic beats, sinus
              bradycardia with hypotension, atrial tachycardia,
              heart block.
       Good risk - None of the above.
The study group did not include patients already classified as 'bad risk'
in the mobile unit.

of the disease in 52/89 (58.4%) of patients but this was not accurate enough to be of practical use, particularly as 3 patients with a normal initial reading suffered a cardiac arrest in hospital later.

One of the clinical factors, while not significant on its own was related to ultimate severity in combination with electrocardiographic changes. This was the speed of onset of symptoms; sudden onset of symptoms (at their worst within 10 minutes of the onset of symptoms) being associated with a severe outcome. Figure 9 showed the patients defined according to their electrocardiographic changes and the speed of the onset of their symptoms, as shown in the formula at the bottom of the figure.

A group was defined with an 80% likelihood of being 'good risk', i.e. without complications in the hospital. More important none of the patients who scored less than -1 had a cardiac arrest later in hospital. In other words patients with a normal initial electrocardiogram and a gradual onset of symptoms did not have a cardiac arrest later in hospital as long as they were uncomplicated at the time of their initial examination.

This group comprised a relatively small proportion of the patients, but the formula gave a good measure of the relative severity of patients for the other groups, with a mortality of zero in one group to a mortality of 20.3% in the most severe group.

The electrocardiogram was thus seen to be the most useful single factor for making decisions about the likely outcome for any one patient with ischaemic heart disease. Despite this there was no foolproof method of defining a completely 'good risk' group of patients though a small group who were unlikely to have a cardiac arrest could be defined.

This type of approach to the problem of defining a 'good risk' group is liable to be the most productive for the future, despite its
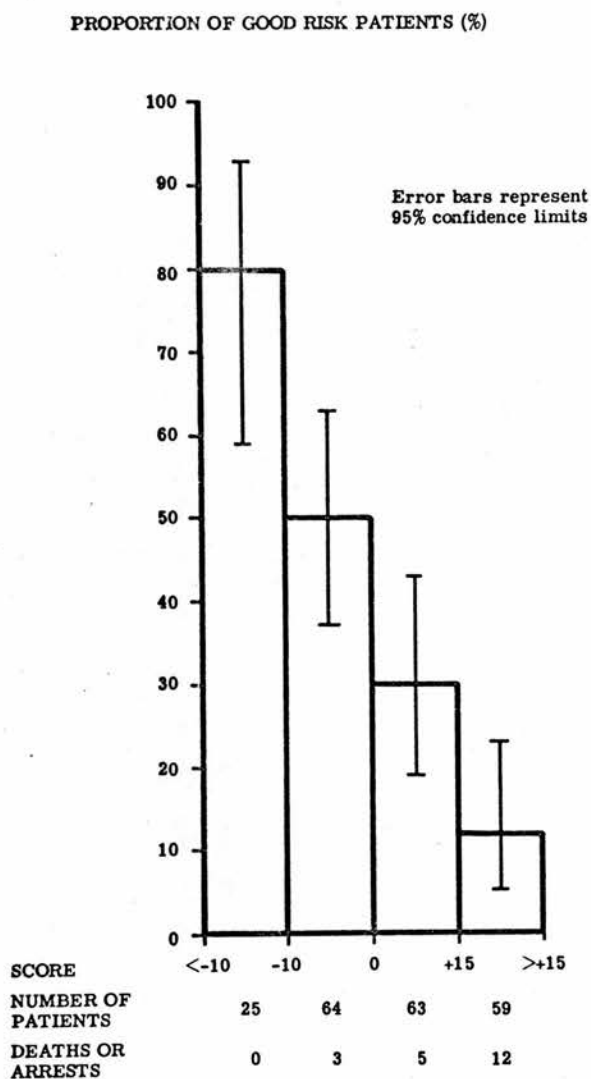
PROPORTION OF GOOD RISK PATIENTS (%)

FIGURE 9   Proportion of patients without complications for each

score by the formula: $Log\left(\frac{p}{1-p}\right) = 10.0 + 9.3 Z_1$

$- 6.4 Z_2 - 20.3 Z_3$; where Z_1 is sudden onset of symptoms,

Z_2 is possible ECG change and Z_3 is no ECG change.

difficulties.   Many factors remain which might be of use in defining such a group.   Certainly such an approach appears more reasonable than the wholesale condemnation of all intensive coronary care units for all people which has been a feature of the British approach in the medical press recently (Cochrane, 1976).

Impact of a Mobile Coronary Care Unit upon Hospital Services

Comparison with other Mobile Units

As stated previously, the only function of mobile coronary care units for which enough information was available for making comparisons was the ability of such units to treat patients with ventricular fibrillation in the community. During the 14 months of the present study 19 patients were found to be in ventricular fibrillation at some time during their treatment by the mobile coronary care unit.

Of these patients, 13 (68.4%) survived the initial arrest to be admitted to hospital and 12 (63.1%) left hospital alive, though 5 of these had had further cardiac arrests in hospital from which they were resuscitated. These figures compared favourably with the results from other units (Table 3) though the number of patients seen was small.

The patients were seen relatively late after the onset of their symptoms, compared to other units, with a median time from the onset of symptoms for the 19 patients of 40 minutes. The study covered a population of 300,000 and lasted 14 months. Thus the comparative figures for Table 4 were 5.4 patients seen in ventricular fibrillation per 100,000 population a year and 3.4 patients saved from ventricular fibrillation per 100,000 population a year. Thus although the relative slowness of the unit meant that few patients were seen in ventricular fibrillation, the success of the resuscitation methods meant that a reasonable number of patients were saved each year compared to other units.

In the earlier sections of these results the impact of the Edinburgh mobile unit was measured in terms of the population with ischaemic heart disease and the proportion of that population resuscitated from a cardiac arrest. That was a much more precise measure of the effectiveness of such a unit but similar figures were not available from any other community with a mobile unit. It was therefore necessary to compare the units in terms of the total population served by the unit.

Comparison with Other Coronary Services

A mobile coronary care unit cannot function in isolation. It was important that the hospital coronary care unit at which it was based should continue monitoring patients until the likelihood of them arresting with treatable arrhythmias had largely passed. Thus when measuring the effectiveness of services for the treatment of patients it was necessary to take into account the hospital coronary care unit as well as the mobile coronary care unit.

If all the services for patients with ischaemic heart disease were to be evaluated it was necessary to include all the patients seen by these various services. For these reasons the figures in this section included all 'non-routine' patients as well as routine. These were patients who were admitted to the mobile or hospital coronary care units primarily for the treatment of arrhythmias rather than for the treatment of myocardial infarction and also patients initially thought to have had a myocardial infarction but later proved not to.

Table 21 showed all patients admitted to the intensive coronary care facility during the 14 months of the study. These totalled 1365 of whom 308 were admitted to the coronary care unit in the mobile unit, whereas 1057 were admitted through the accident and emergency department to the coronary care unit. The mobile unit was, at that time, covering a limited area of Edinburgh and that was why such a low overall percentage of cases were admitted via the mobile unit.

The number of deaths in the Accident and Emergency department due to ischaemic heart disease was impossible to assess as many patients had arrested when they were first seen and often no definitive diagnosis was made. They were therefore not included.

Any comparison between the patient groups must try to take into

TABLE 21   Coronary Care Services (Dec. 1971 - Feb. 1973)

	A & E	MCCU	CCU	WARD	HOME
Entering via A & E					
Number	1057 →		1057 →	931 →	880
Died (%)	Not Known		126 (11.9)	51 (5.5)	
Arrested-Survived 4 weeks (%)	4 (0.4)		34 (3.2)	6 (0.6)	
Entering via MCCU					
Number		308 →	293 →	268 →	257
Died (%)		15 (4.9)	25 (8.5)	11 (4.1)	
Arrested-Survived 4 weeks (%)		14 (4.7)	8 (2.7)	0	
Total Arrests which Survived (% of People at Risk)	4 (0.4)	14 (4.7)	42 (3.1)	6 (0.5)	

account the relative severity of illness suffered by the patients. To make a comparison between the patients admitted via the accident and emergency department and those brought in via the mobile unit the death rates were compared for that time during which both groups of patients were treated similarly; during their stay in the hospital coronary care unit and general ward. During this time 177/1057 (16.7%) of patients admitted via the Accident and Emergency department died, whereas 36/293 (12.3%) of patients admitted via the mobile unit died. This difference was not significant at the 5% level but did suggest that patients admitted via the mobile unit were a little less severely ill than the others.

There were however more cardiac arrests who were successfully resuscitated in the group attended by the mobile unit. 22/308 (7.1%) of patients seen by the mobile unit were successfully resuscitated from a cardiac arrest to leave hospital alive compared to 44/1057 (4.2%) admitted through the accident and emergency department. This difference was statistically significant (X_C^2 = 4.0, 0.025 < p < 0.05).

The mobile unit successfully resuscitated 4.7% of its patients from cardiac arrest, compared to 3.1% successfully resuscitated in the hospital unit. Previous information showed that had the mobile unit patients died they would have fitted with the expected community mortality curve so that it was unlikely that the mobile unit precipitated these arrests. They must therefore have been gains for the coronary care services.

Costing of Services

Costing of services in the health field has been rare. There were many reasons for this - not the least of which was the impossibility of

extracting basic data from government records. The following attempt was made only to provide a measure of the relative cost of the parts of the hospital coronary services for resuscitation of patients.

Costs

Costs were measured as direct staffing costs only. This was in line with the policy of the Scottish Home and Health Department in the costing of their services (Scottish Regional Hospital Board, 1972) where only the costs of junior doctors and nurses directly responsible for the treatment of patients were measured.

Capital costs and other running costs were omitted for two main reasons. Firstly capital costs including depreciation of the value of buildings and equipment were omitted because their complexity would make any estimate worthless. An example was the depreciation on the Accident and Emergency department structure, built in 1873 as an integral part of the structure of the hospital and upgraded numerous times. It's replacement value today would be a gross overestimate of its depreciation value, but the latter was impossible to calculate.

Secondly, both capital costs and running costs were difficult to describe in realistic terms. The cost of a patient admitted to a coronary care unit could not be measured in terms of savings for if the patient were not there another patient would have simply stayed in longer or another would have been admitted to the intensive care area from the general ward. Even if the bed had been left empty for a while the basic services of the hospital, heating and lighting would scarcely be altered by the absence of one patient.

Direct staffing costs on the other hand represented a more flexible resource. The staff could be redistributed if one patient was not

admitted. The cost still existed but could be used in more ways than capital costs or running costs. Staffing costs also represented a major component of the costs of health services being fairly stable at about 70% of the total costs. Costs were at 1972 prices.

Effectiveness

Effectiveness was measured as the number of patients who were resuscitated from a cardiac arrest to live for four weeks after the onset of their symptoms. This in general represented the whole of the acute attack. The coronary services in hospital aimed to keep patients alive for up to four weeks at which time they were generally assumed to be able to manage for themselves.

In order to compare the coronary services with another service it would have been necessary to compare prolongation of life or even quality of life in the patients seen by the services, but the aim of this part of the study was a limited one - to measure the relative effectiveness of the various parts of the hospital coronary care services at resuscitation.

Accident and Emergency Department (Table 22)

For general medical admissions including coronary care a medical registrar was continuously on call on a rota basis. They received no extra duty payments at that time. Two staff nurses were also continuously available for the general medical admissions. Thus 7 staff nurses were required to maintain cover continuously (Table 21). This £17,500 per annum came to £21, 038.25 over the 440 days of the study - (there were 366 days in 1972). 12.2% of patients admitted to general medicine over this time were transferred to the coronary care unit (Scottish Hospital

TABLE 22

STAFFING COSTS FOR PATIENTS WITH ISCHAEMIC HEART DISEASE

Accident and emergency department

General medical registrar	£ 3,500.00
7 staff nurses @ £2,000.00	14,000.00
	£ 17,500.00 per annum

Mobile coronary care unit

General medical registrar	£ 3,500.00
1 staff nurse 1/6 time	333.33
	£ 3,833.33 per annum

Hospital coronary care unit

2 general medical registrars	£ 7,000.00
1 nursing sister	2,400.00
14 staff nurses @ £2,000.00	28,000.00
	£ 37,400.00 per annum

General medical ward

Staffing costs for junior staff	£348,734.00 per annum

(Scottish Regional Hospital Boards, 1973)

Inpatient Statistics, 1973). Thus the cost of staffing for these patients was £2,566.67 over the period of the study.

Mobile Coronary Care Unit

A rota of doctors covered the unit at night for which no extra duty payments were made. A nurse worked with the unit part time on a voluntary basis (Table 21). This amounted to £3,833.33 per annum or over the 440 days of the study £4,621.00.

Coronary Care Unit

Two full time doctors together with a sister and 14 nurses covered the coronary care unit. This came to a total of £37,400.00 per annum or £45,084.93 over the period of the study.

General Medical Ward

Full staffing costs for one year were obtained from Scottish Hospital Costs (Scottish Regional Hospital Boards, 1972, 1973). As 12.2% of general medical patients were from the coronary care unit a total of £51,147.65 was spent over a period of 440 days.

Table 23 showed these figures set in a model of the coronary care services at the Royal Infirmary in Edinburgh. These were based on the costs set out above and Table 21.

The cost per resuscitation for each of the services was not a fair comparison between the services for the mobile unit could not have existed without a hospital back-up unit. Similarly even the primary care staff will be employed for most of their time in duties not directly involved with the treatment or prevention of cardiac arrest. Thus a comparison of the relative costs for each service was not relevant to the argument.

TABLE 23   Coronary Care Services (Dec. 1971 – Feb. 1973)

	A & E	MCCU	CCU	WARD	HOME
Number of patients seen	1057 + deaths	308	1350	1199	1137
Arrests which survived (%)	4 (0.4)	14 (4.5)	42 (3.1)	6 (0.5)	–
Total cost of service (£)	2,566.67	4,621.00	45,084.93	51,147.65	
∴ Cost per patient (£)	<2.43	15.00	33.40	42.66	
∴ Cost per resuscitation (£)	641.67	330.07	1,073.45	8,524.61	

Total Costs £ 103,420.25   or   £ 90,123.36 per annum.

∴ Total Costs per patient discharged   £ 90.96

∴ Total Costs per resuscitation   £ 1,566.97

On the other hand Table 23 did show that the total cost of the mobile coronary care unit was small compared to the costs of the other parts of the service.

Using these data the costs for the patients admitted during the period of the study were calculated. Table 24 showed the results of this calculation. The figures for the numbers of patients and costs were all derived from Tables 22 and 23. The costs of the hospital coronary care unit and general medical ward patients admitted via the mobile unit or the accident and emergency department were derived from the total costs by the proportion of the patients seen by each system.

The patients admitted via the accident and emergency department had overall costs of £88.16 per patient discharged alive, whereas those admitted via the mobile unit had increased costs at £100.54 each. This extra cost was offset by the greater success of the patients admitted via the mobile unit in surviving a cardiac arrest to leave hospital alive; for the costs per patient resuscitated were £588.74 less for patients admitted via the mobile unit.

Looking at the effect of the mobile unit on the coronary services as a whole the mobile unit added a cost of £4621.00 to the coronary services while contributing 14 more successful resuscitations. With the mobile unit the overall cost per resuscitation was $\frac{£103,420.25}{66}$ or £1,566.97, whereas without the mobile unit the cost per resuscitation would have been $\frac{£103,420.25 - £4,621.00}{66 - 14}$ or £1,899.99.

Thus with the mobile unit collecting only a small proportion of the patients admitted to the hospital coronary care unit the cost per resuscitation was considerably lower than without the mobile unit. As the major function of the mobile unit was to increase the efficiency of resuscitation within the hospital services this was an important finding.

TABLE 24   Costs for patients admitted via accident and emergency or mobile unit

Service provided in:	A & E	MCCU	HOSP.CCU	WARD	HOME
Entering via A & E					
Number of patients	1057+ ⟶	1057 ⟶		931 ⟶	880
Total costs (£)	2,566.67		35,299.83	39,715.15	
Number of resuscitations	4		34	6	

Total costs £ 77,581.65
Cost/patient discharged £ 88.16
Cost/patient resuscitated £ 1,763.22

Service provided in:	A & E	MCCU	HOSP.CCU	WARD	HOME
Entering via MCCU					
Number of patients		308 ⟶	293 ⟶	268 ⟶	257
Total costs (£)		4,621.00	9,785.10	11,432.50	—
Number of resuscitations		14	8	0	—

Total costs £ 25,838.60
Cost/patient discharged £ 100.54
Cost/patient resuscitated £ 1,174.48

Adverse Effects of a Mobile Coronary Care Unit

Arrhythmias

The West of England study suggested that hospital treatment for patients with myocardial infarction had no advantage over home treatment (Mather et al., 1976). As many patients had cardiac arrests and were successfully resuscitated in coronary care units it may have been that these units were originally precipitating the arrests.

If intensive care was possibly precipitating cardiac arrests it was also important to check if a mobile coronary care unit could be having a similar adverse effect. Several workers (McNeilly and Pemberton, 1968; Kuller et al., 1972) have stated that a high proportion of pre-hospital deaths occur in ambulances on the way to hospital. The possibility that transport of patients might be a source of danger to them was tacitly admitted by Mulholland and Pantridge (1974) when they administered practolol and sotalol to patients to reduce their incidence of tachycardia during transport.

Continuous taping of the electrocardiogram was performed on a sub-group of the patients in the study during the period when the patient was at home and during transfer to hospital in the mobile coronary care unit. Details of these patients were given on Page 42. Taping of the electrocardiogram was considered the only reliable method of detecting arrhythmias particularly those of the self-terminating variety. This followed evidence from a coronary care unit (Vetter and Julian, 1975) that watching a monitor screen alone was an uncertain method of quantitating arrhythmias compared to a continuous taping system.

54 patients with myocardial infarction were examined during the last three months of the study. Figure 10 showed the maximum heart rate for these patients before and during movement and also indicated any treatment given in the time shortly before movement of the patient. 21/54 (38.8%) of
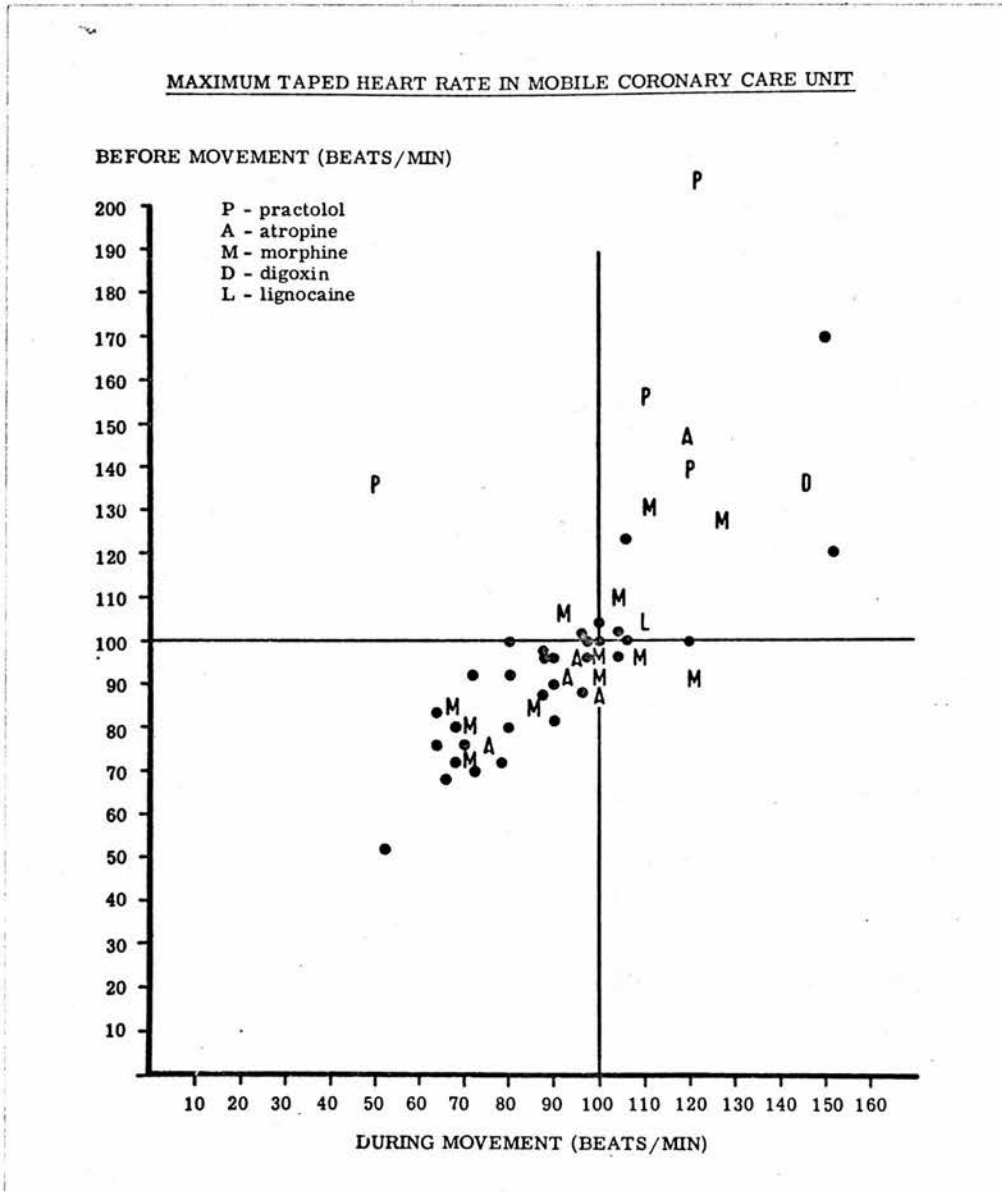
MAXIMUM TAPED HEART RATE IN MOBILE CORONARY CARE UNIT

BEFORE MOVEMENT (BEATS/MIN)

P - practolol
A - atropine
M - morphine
D - digoxin
L - lignocaine

DURING MOVEMENT (BEATS/MIN)

FIGURE 10   Maximum heart rate before and during movement for 54

patients and any therapy given.

patients showed a sinus tachycaria of 100 per minute or more before being moved compared to 23/54 (42.6%) during movement. More important 10 patients altered their rate when movement occurred so that some patients with sinus tachycardia lost it during movement whereas others developed sinus tachycardia during movement. Of the 10 patients 6 developed tachycardia and 4 lost it. This difference (10-6) was not significant by the sign test.

If only the 31 patients who did not receive treatment were considered one without sinus tachycardia initially, developed it during movement, whereas 3 with sinus tachycardia initially lost it in the mobile unit. Thus the mobile unit did not increase the incidence of sinus tachycardia, nor was it preventing an underlying adverse effect by treatment, for those without treatment showed no increase in their experience of tachycardia.

Figure 11 showed the minimum heart rate for the same patients. Sinus bradycardia defined as a rate of 60 beats per minute of less occurred in 18/54 (33.3%) of patients at some time before they were moved and 11/54 (20.4%) during movement. Of the 12 patients whose minimum heart rate changed from 60 and below to above or vice versa 3 developed it during movement whereas 9 lost it. This difference was not statistically significant.

Most of the patients who lost their sinus bradycardia had received treatment. Of the 31 untreated patients sinus bradycardia developed, having not been initially present in 2 patients whereas in those initially present only 1 lost it without treatment.

Thus transporting patients in the mobile unit was shown not to cause a significant amount of inappropriate sinus tachycardia or sinus bradycardia and this was not maintained by treating patients with drugs.
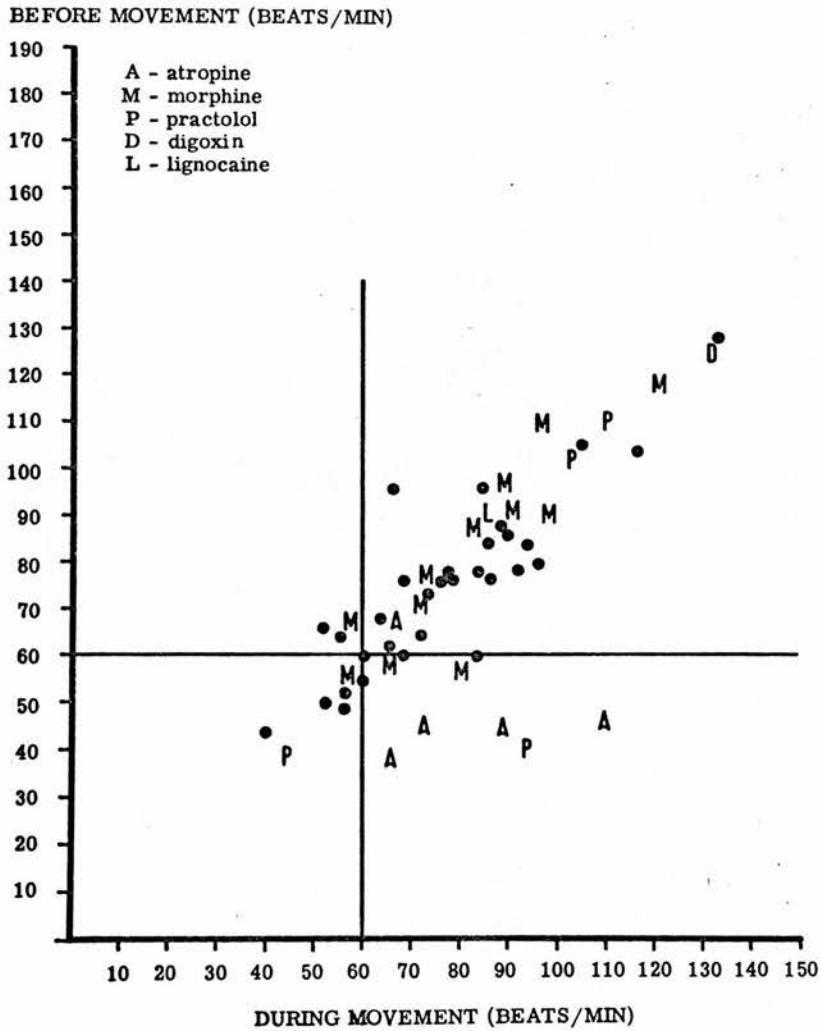
FIGURE 11   Minimum heart rate before and during movement for 54
patients and any therapy given.

Table 25 showed ventricular arrhythmias before and after movement. There was no increase in the incidence of arrhythmias during movement. Indeed there was a tendency for arrhythmias to settle during transport.

TABLE 25   Incidence of Arrhythmias in Patients with Myocardial

Infarction Before and During Transfer in the Mobile Unit

Ventricular Ectopic Beats

During Transfer	Before Transfer			TOTAL
	None	Mild	Severe	
None	15	11	2	28
Mild	4	17	0	21
Severe	3	1	0	4
TOTAL	22	29	2	53

Definitions: Mild - Ventricular ectopics only.

Severe - R/T ectopic beats, ventricular tachycardia

(3 ectopic beats over 100/min), ventricular

fibrillation.   (1 case before transfer)

See Appendix A.

Heart Block

During Transfer	Before Transfer			TOTAL
	None	Heart Block	Asystole	
None	47	1	2	50
Heart Block	0	2	0	2
Asystole	1	0	0	1
TOTAL	48	3	2	53

Sign test showed no significant difference between arrhythmias before

and during transfer.

Anxiety

Anxiety in patients with myocardial infarction has been quoted as being a potent source of arrhythmias (Bishop and Reichert, 1969) and hospital coronary care units have been accused of increasing such anxiety (Klein et. al., 1968). Although coronary care units have not proved to be as anxiety-provoking as was at first feared (Hackett, 1968) no measurement of the psychological status of the patients transported by a mobile coronary care unit has previously been made.

This arose because questionnaires which measured anxiety were too long to be answered by patients when they were acutely ill. Details of the questionnaire and its development for this study were given on page .

Two background studies were carried out before the main one in order to validate the methods used. In the first the results of estimating anxiety by the short questionnaire used in this study were compared with those obtained by means of a standard method of quantitating anxiety.

142 male patients attending a follow up clinic for review of their progress one year after admission to a coronary care unit were given form G of the Cattell 8-parallel Form Battery (Scheier and Cattell, 1960), a standard questionnaire for the measurement of psychological anxiety. At the same time the patients completed the short version of the Neuroticism Scale Questionnaire used in this study. The mean score on the short questionnaire was 5.1 with a standard error of 0.24. For the form G the mean score was 5.4 with a standard error of 0.22. Correlation between the two measures was good ($r = 0.5$, $p < 0.001$).

The second study used form A of the 8-parallel Form anxiety battery to measure anxiety within 24 hours of admission in 30 male patients in the general medical wards of the hospital. They had been admitted as

emergencies with a variety of illnesses other than ischaemic heart disease. Their mean anxiety score was 5.8 so they were more anxious than a population outside hospital with a mean score of 5.0 (Philip, 1972). This high mean anxiety seen in patients in hospital has been confirmed many times previously in patients with peptic ulcer (Philip and Cay, 1972) and ischaemic heart disease (Cay et. al., 1972).

The questionnaire was then administered to a sub group of 75 patients taken sequentially at the end of this study as they were admitted to the hospital coronary care unit in the mobile unit. At the same time patients admitted via the accident and emergency department were similarly examined. The questionnaire was given to patients at an average time of 29 minutes after admission to the hospital coronary care unit.

Table 26 showed the mean anxiety scores for the patients admitted in the mobile coronary care unit compared to the scores for 301 patients admitted concurrently from the accident and emergency department. There was no significant difference in the scores for the group as a whole, nor for patients with myocardial infarction. For the patients admitted through the accident and emergency department those with a myocardial infarction were signficantly less anxious than those without (t = 2.19, p = 0.03), but no such difference was seen for patients admitted in the mobile unit.

There was no relationship between anxiety and the time after the onset of symptoms before patients called for help in patients admitted in the mobile unit; patients seen within an hour of the onset of their symptoms had a mean anxiety score of 5.7, not significantly different from the group as a whole. There was however a relationship between severity of symptoms, as measured by the presence of cardiogenic shock or failure, and early admission to the mobile unit. It appeared that

TABLE 26   Mean Anxiety on Admission related to Diagnosis and
            Mode of Admission

Mode of Admission	Mean Anxiety Scores ($\pm$ 1 s.e.m.)		
	Myocardial infarction	No myocardial infarction	All diagnoses
via Mobile coronary care unit	5.7 $\pm$ 0.32	5.1 $\pm$ 0.48	5.6 $\pm$ 0.27
via Accident and emergency	5.5 $\pm$ 0.16	6.3 $\pm$ 0.20	5.6 $\pm$ 0.13

the severity of infarction was much more important for bringing patients into intensive care quickly than the patient's anxiety.

Six of the patients admitted via the mobile unit arrested later in the coronary care unit. Their anxiety score was an average of 5.2 compared to 5.8 for those who did not arrest. These differences were not statistically significant. Thus anxiety immediately after leaving the mobile unit was not associated with cardiac arrest in the hospital coronary care unit.

Coronary care in general and mobile coronary care units in particular were therefore not associated with increased anxiety in the patients they treated. Treatment in a mobile coronary care unit did not increase anxiety more than admission through an accident and emergency department and anxiety on admission was not associated with precipitating a cardiac arrest in patients admitted to the hospital coronary care unit.

CHAPTER 5

DISCUSSION

Laurence in his textbook of pharmacology (Laurence, 1962) described how therapeutic agents pass through three stages of acceptability: the first when the drug is new and it is hailed as a panacea, the second when its limitations and side effects become obvious when it is rejected as being worse than poison and the third stage where both of these extreme views are fused so that the usefulness of the drug becomes defined and its limitations and dangers understood.

Mobile coronary care units have encountered the first two of Laurence's stages. It is hoped that this thesis will contribute to a third stage.

The Effect of the Study upon the Thesis

In this section it is proposed to examine the original thesis phrase by phrase in the light of the findings of this study and to revise it as necessary.

> 'A doctor-manned mobile coronary care unit is
> effective in reaching a significant proportion
> of the population at risk with ischaemic heart
> disease.'

This study showed that a doctor-manned mobile unit in an urban area and during its first year of functioning could reach 20% of all patients with ischaemic heart disease in a community. The age and sex breakdown of the patients with myocardial infarction was similar to that seen in the community. The severity of disease in the patients seen by the mobile coronary care unit, as measured by the mortality within the first four weeks of the acute attack, was significantly less than was seen in the community. This was due to the inability of the mobile coronary care unit to reach many of the sudden cardiac deaths, i.e. those patients who collapsed and died very soon after the onset of their symptoms. Thus only 39.4% of cardiac arrests expected in the group of patients studied within an hour of the onset of their symptoms were actually seen, whereas for patients seen after the first hour the proportion who arrested was similar to that expected in the community.

> 'It reduces the mortality of these patients
> significantly .....'

It was an important limitation of the mobile coronary care unit, not seeing many of the cardiac arrests expected within an hour of the onset of a patients symptoms. However, if the first hour after the onset was ignored the mobile unit did resuscitate a significant proportion of

the patients, increasing their survival rate to well above that expected
in the community.

If the patients who were successfully resuscitated were counted as
deaths the patients in the mobile coronary care unit showed a very
similar mortality curve to that of the community from which they came.
This indicated that apart from the treatment of cardiac arrest, the mobile
coronary care unit played little or no part in reducing the mortality of
its patients. Thus prophylactic anti-arrhythmic treatment and early
treatment for cardiac failure or cardiogenic shock had had no effect upon
the mortality of the patients.

> ' ..... and gives information about patients it
> fails to reach.'

Retrieval of patients within an hour after the onset of symptoms
was considerably more effective using the mobile unit than without it.
Thus 23% of the patients seen by the mobile unit were seen within an hour
compared to 2% in the hospital coronary care unit. Unfortunately the
great majority of patients who had had a cardiac arrest within that time
did so within the first 15 minutes and relatively few of these were
reached.

Delay in reaching patients was largely due to a reluctance on the
part of the patient to call for help. The reasons for this were generally
logical: patients with more severe symptoms called for help more quickly
than those without. Unfortunately the initial severity of symptoms did
not relate closely to the final outcome, particularly for patients with
primary arrhythmias leading to cardiac arrest.

Those patients most able to be helped by the mobile unit, the
sudden cardiac deaths, did not have particularly severe initial symptoms.
As a result they were in no hurry to call for medical aid. On the other

hand patients who had severe symptoms called for help relatively rapidly. If they had a cardiac arrest however it was much more likely to be due to poor cardiac output and therefore untreatable. Thus the unfortunate situation arose where the patients with treatable cardiac arrests were out of reach of medical help whereas those with untreatable cardiac arrest tended to get help quickly.

As a corollary it was impossible, using a simple clinical grading of severity to define a group of patients who were liable to have an arrhythmic treatable cardiac arrest later.

Instability of the clinical severity of patients with ischaemic heart disease was much more marked in patients seen early after the onset of their symptoms. Thus the final outcome for such patients was more difficult to assess from their state when seen in the mobile unit than patients seen later after the onset of symptoms.

> 'It provides an effective means of making decisions
> about home and hospital treatment for patients with
> ischaemic heart disease.'

Some of the less obvious findings in the mobile coronary care unit particularly electrocardiographic changes did give some information on the likely outcome for patients with ischaemic heart disease. By using these findings patients could be incompletely divided into high and low risk groups, depending upon their likelihood of developing complications later. It was considered that this approach, with careful refinement and upgrading as circumstances change could form the basis for deciding which patients would be most likely to benefit from hospital treatment and which could safely be treated at home. Another group which could be quite successfully defined was those patients who were most likely to have had myocardial infarction.

The function of the mobile unit in this was to provide a safe environment in the patient's home so that more detail about his or her state at the initial examination could be obtained. Thus those factors which were useful for predicting how the patient would react to the attack could be separated from those which were not.

The importance of the electrocardiogram was emphasised in this study. It could have given invaluable added information to general practitioners about the likely difficulties patients were liable to encounter.

'It is a cheap and effective adjunct to the hospital

services for patients with ischaemic heart disease .....'

The mobile coronary care unit resuscitated a group of patients in the community and it was difficult to see how else that group could have survived without the mobile unit. The resuscitated patients comprised 4.7% of the patients brought into the hospital coronary care unit by the mobile unit. This compared with 3.1% of patients who were resuscitated from cardiac arrest in the hospital coronary care unit itself. If the mobile unit was not actually precipitating cardiac arrests it was therefore having an important impact upon the problem of cardiac arrest in the community and added considerably to the effectiveness of a hospital service as far as the treatment of such arrests was concerned.

It was unlikely that the mobile unit was precipitating arrests because, if all arrests in the mobile unit were counted as deaths the patients seen by the mobile unit had a similar mortality to the community from which they were taken. If the mobile unit had been precipitating arrests it would have been expected that patients in the mobile unit were more likely to arrest than the community at large. This was not the case.

Costing of the services showed firstly how difficult even a

simplified exercise for costing can become. It appeared however that
the mobile unit was a relatively cheap extra cost when compared to the
other, now generally accepted, costs for the hospital coronary care unit
and general medical ward.

> ' ..... and has no adverse effect upon these
>
> patients.'

The figures for arrhythmias and anxiety in the mobile coronary care
unit showed that the unit was not dangerous or unpleasant for the patients.
The severity of the disease itself was usually such that patients were
only concerned with obtaining rapid and complete relief from their
symptoms.

The Effect of the Study upon Previous Work

Much of this study covered new ground, particularly in regard to the comparisons between patients seen by the mobile unit and the patients in the community. Only one previous study (Crampton et al., 1975) has attempted to relate the effects of a mobile coronary care unit with the community. As discussed previously he claimed an association between a falling death rate from myocardial infarction and the inception of a mobile unit. No evidence was given that these changes were cause and effect (p 18).

The present study was the first to restrict a mobile coronary care unit to a defined area and population. It was therefore possible to make a direct comparison of mortality rates at different times after the onset of symptoms between patients in the community and those in the mobile unit. This detail was not given in Crampton's data. In particular, no evidence could be obtained from his study about the patients that the mobile unit was unable to reach.

In the present study using the community data it was possible to show a discrepancy between the expected number of patients and those actually seen in the mobile unit. It was also possible to define that group as being patients who died within an hour of the onset of their symptoms, i.e. the sudden cardiac deaths.

The inability of even a doctor-manned mobile coronary care unit to reach such patients has been suspected for some time and led to the formation of the emergency squads aimed at resuscitating people with sudden cardiac arrest (Cobb et al., 1975; Nagel et al., 1975). No previous study has attempted to describe the size of the problem - nor to show the limited impact that a doctor-manned mobile coronary care unit could have upon it.

Despite this limited impact the mobile coronary care unit did

retrieve 25% of its patients within an hour of the onset of their symptoms.

This was a considerable improvement over the hospital coronary care unit

which had seen only 2% of its patients within an hour (Fulton, 1969). 70%

of the successful resuscitations in the mobile unit were performed within

2 hours of the onset of patients symptoms. This agreed with the findings

of the Belfast unit (Adgey et al., 1969) who found that 74% of their

resuscitations were performed within that time. Thus despite the

difficulties the mobile coronary care unit did make some impact upon

these early patients.

It was surprising that the only measurable effect of the mobile

coronary care unit came from resuscitation of patients from cardiac

arrest. Anti-arrhythmic and other therapy was given to over 40% of the

patients, but appears to have had no effect upon outcome. It has been

said (Pantridge, 1970) that preventative measures, particularly

lignocaine, are less effective for patients seen early after their onset

of their symptoms. Valentine (1974) in a double-blind controlled trial

of lignocaine, given by general practitioners in the community, claimed

that the drug reduced the number of cardiac arrests later, but the

differences he quoted were not statistically significant at the 5% level.

It may be that a different treatment regime is indicated for these

patients in the future, if prophylactic treatment is to have any effect

on mortality.

Much has been written previously about the causes of patient delay

in calling for help after the onset of their symptoms (Fulton, 1969;

Smyllie et al., 1972; Gilchrist, 1973) and this study confirmed that

patients were reticent to take on the sick role. The mobile coronary

care unit did little to remove that reticence. Education has increased

the speed of patient reaction in some areas (Black and Brown, 1973) and the Belfast workers have shown that a greater proportion of patients came under care in less than an hour as their mobile coronary care unit became more established (Adgey et al., 1971). It appears that people in the community can be encouraged to call for help more rapidly but that this is a slow process.

The patients seen in the mobile coronary care unit had called for help a little earlier than those in the hospital coronary care unit but the reasons given for delay in calling for help were rational and concerned mainly with the severity of symptoms. This poses a problem for the future; should a health education programme encourage people to respond irrationally to mild symptoms, and if it did would it be successful? If not, how else can patients in danger of cardiac arrest be persuaded to call for help quickly?

Patients seen by the mobile unit had little in the way of external causes for delay. A small proportion of patients (7%) did have difficulty in contacting help. These administrative delays can be reduced by encouraging general practitioners to make themselves more available or by having a system whereby patients could contact the mobile unit directly.

Patients seen quickly in this study were those with rapidly severe symptoms and to a lesser extent signs and were those whose general practitioners phoned directly for the mobile unit, possibly signifying a clear history. It has previously been found (Vetter et. al., 1976) that a close relationship exists between the speed of admission to hospital and clinical severity in patients with ischaemic heart disease, and the present study confirmed this.

The West of England study (Mather et al., 1976) implied that all

patients with ischaemic heart disease would be as well treated at home. The present approach to the admission of patients to hospital coronary care units is certainly somewhat uncritical, for patients are often admitted to intensive care up to 48 hours after the onset of their symptoms, when the likelihood of an arrhythmic cardiac arrest is remote. Even the relatively acute patients seen in the present study had a significant proportion (27.3%) who did not have any complications during their hospital stay.

Nevertheless the West of England study derived its findings from a group of patients which was not seen until some time after the onset of their symptoms and therefore past the worst danger. The present study suggested that treatment of patients early after the onset of their symptoms could significantly improve their mortality over that of the community in general. It also emphasised that patients who had arrhythmic cardiac arrests often did so with little warning or specific clinical signs. It would appear to be potentially dangerous to extend the West of England study to patients seen soon after the onset of their symptoms, particularly if clinical findings alone were used to decide which patients were safe to enter in such a trial.

Several workers have used various methods of multi-variate analysis to predict deaths in hospitals or after discharge (Norris et. al., 1969; Chapman and Gray, 1973; Coronary Drug Project, 1974). These indices gave a measure of severity for each patient but were restricted in their uses, for most patients who died in hospital died of cardiogenic shock or failure, for which there was no prophylactic treatment. The indices were therefore of little help in management. The indices constructed in this study attempted to predict two of the major problems faced by the primary care physician; the diagnosis of the patient with

chest pain and the likelihood of him or her having complications which would require treatment in a hospital environment.

The indices were successful at detecting the presence of myocardial infarction, but the more difficult problem - of defining a good risk group of patients who did not require hospital management - was not fully solved. The study did serve to emphasise the relative importance of the electrocardiogram in this regard, and the misleading nature of clinical data.

The initial electrocardiogram has been regarded previously as being of doubtful value for patients early after the onset of their symptoms. Thus Sachs (1971) showed that over 50% of patients with myocardial infarction had no classifiable electrocardiographic abnormality on admission. He also showed that 9% of this group died in hospital and another 4% had a cardiac arrest later. In the present study only 41.5% of patients with myocardial infarction showed electrocardiographic changes according to the standard classification (World Health Organisation, 1966). Using the new classification described in this study the electrocardiogram was found to be more useful as a screening test with a positive result for 87.8% of the patients with myocardial infarction.

A minority of general practitioners have portable electro-cardiographic machines largely because of doubts about the usefulness of the initial electrocardiogram in the early stages of ischaemic heart disease. This study suggested that such equipment with different criteria could help the general practitioner for making difficult decisions about the management of patients with ischaemic heart disease.

The mobile coronary care unit provided a safe habitat for a fuller examination of patients before transfer from their homes. However all

of these analyses require to be re-tested on new groups of patients in order to show whether or not the findings are generally applicable.

The mobile coronary care unit was relatively slow at arriving at patients with ventricular fibrillation in the community, taking a median time of 40 minutes to reach 19 patients. All of the other units examined (Table 4) were faster. This was the major reason the mobile unit retrieved a small proportion of the patients in ventricular fibrillation, seeing only 5.4 patients per 100,000 population each year. Only one of the five other units examined saw less arrests in the community.

On the other hand the unit was relatively successful at resuscitating those patients it did see. 63.1% of patients in ventricular fibrillation when first seen, survived for four weeks representing 3.4 patients per 100,000 population each year. Only the Seattle unit at 9.6 per 100,000 population a year saved more.

Nevertheless the slowness of the unit was a problem. Several factors contributed to this slowness. The unit was not set up to take calls from the general public, only from general practitioners or ambulancemen. This made a marked difference to the speed with which calls could be received from patients with sudden cardiac arrest. Another factor was the relative newness of the Edinburgh unit. The Belfast unit (Pantridge et al., 1975) saw an increasing proportion of their patients within the first hour after the onset of their symptoms for the first three years of its functioning. As the Edinburgh unit had been in action for only 14 months at the end of this study it was likely that the numbers retrieved early would be likely to increase with time.

Another difference between the various units was their relative complexity. Thus both the Seattle and Miami units (Cobb et al., 1975; Nagel et al., 1975) consisted of three basic units with several emergency

back-up units for commencing resuscitation. The Charlottesville
system (Crampton et al., 1975) had two units as had the Brighton
workers (White et al., 1973). The Belfast and Edinburgh groups had
only one unit in the areas they covered. It would be important for a
true comparison of the effectiveness of these units to take into
account the resources used by each system, but no detailed information
of this type was given by the other units.

The most effective unit for the treatment of cardiac arrest in
the community was the one based at Seattle. This was due to the speed
with which such a system reached patients with sudden cardiac arrests.
This unit is attempting to increase the proportion of patients
resuscitated by teaching the general public resuscitation methods until
the unit arrives. If this is successful their resuscitation rate will
be much greater.

A large proportion of people seen by such units have instantaneous
cardiac arrest. Unfortunately over half of these patients appear to
have a bad prognosis despite resuscitation; they have no objective
signs of myocardial damage as increased by serum enzymes or the electro-
cardiogram but they do have narrowing of all three major coronary
arteries and are very likely to re-arrest. Thus of the patients with
treated ventricular fibrillation 80% of those with signs of myocardial
necrosis survived for one year compared to only 68% of those without
signs of necrosis (Cobb et al., 1975).

These high risk patients appear to have a chronic tendency to
have ventricular fibrillation. At present they pose a severe limit upon
the possible results of this type of mobile coronary care unit, for as
the units get faster in arriving at patients so they retrieve a larger
proportion of this high risk group and their long term results will

probably appear to get worse.

The only answer to this dilemma is for all such mobile units to compare their results with the community. In this way it will be obvious whether the units are retrieving a higher proportion of the population at risk with some patients having a greater likelihood of re-arrest, or whether they are simply becoming less effective at resuscitating the same patient groups.

Comparison of the mobile unit with the other hospital services was made in relation to their costs. No previous attempt has been made to cost any of the coronary care services. The costs were then related to the number of cardiac arrests successfully resuscitated by the services. The patients seen initially by the mobile unit used up more resources but were much more likely to be resuscitated if they had a cardiac arrest that those admitted via the accident and emergency department.

Resuscitation from cardiac arrest was the only outcome measured in relation to the costs of the services. This was thought to be the most important function of the coronary services. Many other measures of outcome could have been made, e.g. presence of any remaining cardiac symptoms, patients ability to work, but these were complex measurements and not declared aims of the mobile coronary care unit.

The costs were all measured at 1972 prices. Enormous increases in staffing costs have occurred since that time. Junior hospital doctors in particular are now paid for any units of medical time for which they are on call. These costs will have risen roughly in proportion for each of the services mentioned, so that the ratio of costs for patients admitted in the mobile unit or via the accident and emergency department will have remained approximately the same.

The cost of staying in the general medical ward was of particular interest. It came to approximately 50% of the total cost for each patient. This is one of the pressures leading to early discharge from hospital for patients with ischaemic heart disease; in some centres as early as 48 hours after admission, virtually eliminating the ward stay (Pantridge et al., 1975).

Adverse effects of intensive care units have been proposed (Mather et al., 1976; Cochrane, 1976) on the grounds that the West of England study found no advantage in hospital care and therefore the patients who have cardiac arrests in coronary care units and are resuscitated must have had these arrests precipitated by the unit itself. The mechanism invoked is that anxiety caused by the complex apparatus of intensive car units causes an outpouring of catecholamines which in turn causes arrhythmias (Klein et al., 1968).

If this were the case for hospital coronary care units, mobile coronary units might be expected to be a greater hazard. Only one paper has given any evidence of changes in heart rhythm in a mobile coronary care unit, (Mulholland and Pantridge, 1974). This paper has been examined previously and no convincing evidence of an untoward effect of the mobile unit was found. The present study found that patients showed little or no change in heart rate during transport, whether or not the patients had received any medication before being moved. There was also no evidence of an increase in arrhythmias at that time; indeed the number of arrhythmias tended to settle.

Anxiety in hospital coronary care units has been studied in some detail (Hackett et al., 1968; Dominian and Dobson, 1969; Cay et al., 1972). These studies agreed that hospital coronary care units were not disturbing to patients in general. However the studies were made in

retrospect after the patients left the units. This was the first study where anxiety was actually measured shortly after admission to the unit, when patients might have been expected to have been most anxious. No previous evidence has been obtained about anxiety after travel in a mobile coronary care unit.

This study showed that patients from the mobile unit were no more anxious than those in general medical wards in the hospital. There was no relationship between those patients with high anxiety scores and later cardiac arrest. It seems that the mobile unit did not cause patients to become anxious, nor did it precipitate cardiac arrests.

The Effect of the Study upon Future Research

Effectiveness

One of the major priorities in health services throughout the world is the development of realistic measurements of costs and effectiveness so that a proper evaluation of medical services can be made. This study has shown that, on a community basis the mobile coronary care unit retrieved 20.0% of the population at risk with ischaemic heart disease in the community and resuscitated 7.6% of the patients with myocardial infarction. This gave an overall proportion of 1.5% of the patients in the community resuscitated by the mobile unit.

This figure is meaningless in itself. It was unlikely that the hospital coronary care unit resuscitated much more than 1% of the population on a community basis (Table 1), but it was impossible to say if these results were good or bad in relation to the resources used. Even such a simple measure of effectiveness as the number of patients resuscitated has not been measured previously in relation to costs. Thus the present study showed that in certain restricted areas the mobile unit was reasonably effective compared to the existing services for coronary care, but it was not possible to evaluate the coronary services as a whole. Nor did the study give a yardstick for a comparison between different services within the health service, e.g. the relative cost effectiveness of the coronary services and general surgical services. It is obvious such basic comparisons between services are essential if decisions about the desirability or otherwise of any new services are to be made.

The first stage for any proper system of measuring effectiveness must be some form of community surveillance of the disease in question.

This has been emphasised several times in relation to the present study. Such registers of patients have been set up in several centres for ischaemic heart disease (World Health Organisation, 1976) but only the workers in North Karelia have described a related analysis of their treatment methods. This did not involve a comparison of home and hospital treatment, nor a mobile coronary care unit.

In the present study a surveillance system had been set up in the area some time before. This was lucky and meant that the patients seen by the mobile unit could be evaluated in a community context.

The next step must be for a similar evaluation of the other services used by the patients with ischaemic heart disease. In this way it will be possible to estimate what proportion of patients are receiving therapy and which are not. By using simple measures of outcome, such as the number of patients resuscitated, it should then be possible to make initial comparisons of the effectiveness of the different services for different outcomes.

The next step will be to develop more meaningful outcomes - not simply cardiac arrests or mortality but the degree of disability suffered by a patient due to illness. In this way it may eventually be possible to compare patient disability from different diseases and develop an overall scale of effectiveness in relation to the resources used.

Mobile Coronary Care Unit

It is difficult to imagine a more rapid resuscitation system for sudden cardiac deaths than that developed by the fire departments in Miami and Seattle, but more work is needed to clarify the reason for their relatively poor resuscitation results. It is important to know if the type of patient they are seeing is more difficult to resuscitate than

the patients seen in Belfast for this may be an inherant limitation on the faster mobile coronary care units.

The rapid retrieval systems are in a perfect position for controlled trials into the limitation of the size of myocardial infarction. As the units see patients so soon after the onset of symptoms any reduction of spread of myocardial damage by treatment would be most obvious in these patients. It would be preferable for the outcome of such to be related to a reduction in mortality of patients from cardiogenic shock or cardiac failure, rather than the more nebulous measures of myocardial damage; ST segment elevation in the electrocardiogram or myocardial enzyme release. Thus drugs thought to have an effect upon myocardial damage could be given randomly to patients seen within a short time of the onset of their symptoms, and their outcomes compared.

Despite these possibilities for development two major drawbacks will always cause mobile units to be relatively inefficient methods of reaching patients. The first of these is the natural tendency for people to delay calling for help after the onset of symptoms. Thus the patients in the present study considered that they had not delayed calling for help up to 30 minutes after the onset of their symptoms. By this time a large proportion of the sudden cardiac deaths will have occurred. Although some of these will be saved by a very rapid mobile unit most will not; either because they were alone or because of a lack of first-aid resuscitation by the bystanders.

A second limitation will be the use of such units in areas of low population density. These areas will have problems simply due to the necessity to travel long distances to get to patients, but there will be an associated problem of finding sufficient staff to run such a unit where

the population is scattered.

Mobile coronary care units are therefore an interim answer to
some of the problems of ischaemic heart disease. They are, at present,
capable of resuscitating successfully between 1.4 and 9.6 (Table 4)
patients per 100,000 population each year, representing up to 20% of
the deaths due to primary arrhythmias in the community. They probably
have no other effect upon mortality. On the other hand the coronary
services already generally accepted in the community are unlikely to have
more effect than this upon the community; probably considerably less.
It makes sense then to add a mobile unit to any other intensive coronary
care facility, whose primary aim is to reduce the mortality from ischaemic
heart disease. Even the relatively slow unit in this study increased
considerably the number of resuscitations from cardiac arrest, compared
to the pre-existing services.

Ischaemic Heart Disease

The future for the treatment of ischaemic heart disease and the
problem of sudden cardiac deaths must lie not with treatment, however
intensive, but with prevention. It has been estimated that even a
partially successful programme of prevention must have more ultimate
effect than the most widespread intensive care for patients after the
onset of the disease (Kuller, 1969).

Thus a reduction in the incidence of ischaemic heart disease by 20%
would reduce its mortality by about 20%. In order to achieve similar
results a hospital based programme, such as mobile and hospital coronary
care units would have to treat or prevent all the deaths from primary
arrhythmias at the acute stage. Alternatively, all patients with
ischaemic heart disease would have to be admitted to intensive care at

a median time of 2 hours after the onset of symptoms and the treatment
facilities would have to be capable of preventing all deaths from
whatever cause, arrhythmias or shock.

Information from different countries has shown that the incidence
of ischaemic heart disease varies enormously from place to place. This
has led to the hope that factors associated with a high risk of heart
disease can be isolated and modified to prevent many of the attacks
(McGill, 1968). Several factors have been isolated which have just such
an association with the high risk areas. These included cigarette
smoking, hypertension, high serum cholesterol, obesity, gout (Kannel and
Gordon, 1971), diabetes (Atherosclerosis Study Group, 1970) and family
history (Stamler et al., 1974).

Unfortunately modification of these risk factors on an experimental
basis has not been very successful for the prevention of ischaemic heart
disease. Thus modification of the diet (Stamler et. al., 1974),
reduction of hypertension (Veterans Administration Group Study, 1970),
and increasing exercise (Hellerstein, 1968) did not lead to a significant
reduction of deaths from ischaemic heart disease. Stopping cigarette
smoking was of some value however (Stamler, 1971).

Modifications of these risk factors may be reasonable to use at
an individual level but except for reducing smoking are unlikely to have
much impact on a national level. Such risk factors do make it possible
to define high risk groups who would be candidates for trials of therapy
for the prevention of ischaemic heart disease. Another possible approach
would be to use therapeutic agents to prevent the early sudden deaths
from ischaemic heart disease. So far no such attempts have been made.

For the time being then mobile coronary care units still have a
unique part to play in the salvaging of patients during the earliest

phase of the attack of ischaemic heart disease. Perhaps as important
they will act as catalysts for research into the prevention of the early
and late deaths of patients with ischaemic heart disease.

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ACKNOWLEDGEMENTS

APPENDIX A

ADMINISTRATIVE POLICY OF THE CORONARY CARE UNIT,
ROYAL INFIRMARY, EDINBURGH - NOVEMBER, 1973

A. **Admission Policy**

    1. All patients under 70 years of age suspected of having sustained a myocardial infarction during the preceding 24 hours, whether or not complications are present.

    2. All patients (irrespective of age) who are suffering from a major disturbance of rhythm or conduction, i.e. ventricular fibrillation or tachycardia, or malignant types of ventricular ectopic beats, or second or third degree heart block or asystole, at the discretion of admitting doctors.

B. **Discharge Policy**

    1. Uncomplicated cases should be transferred from the Unit to the waiting ward 48 hours after the onset of symptoms.

    2. Those who have experienced serious arrhythmias are not discharged until a complication free period of at least 24 hours has elapsed. If there has been ventricular tachycardia, ventricular fibrillation or advanced heart block, a period of at least two days free from the arrhythmia is required before transfer.

    3. If the patient appears to have sustained a fresh infarction after admission to the Unit, he should be retained for 48 hours after the onset of the new attack.

C. Mobile Coronary Care Unit

Every effort should be made to admit patients brought
in by the Mobile Coronary Care Unit to the Coronary Care
Unit even when the diagnosis of infarction remains in
some doubt.

THERAPEUTIC SCHEDULE

PAIN

10 mg. morphine or 5 mg. diamorphine + 50 mg. cyclizine
for severe pain. Proportionately smaller doses should
be used for less severe pain. The dose may be repeated
within one hour if ineffective. Nitrous oxide (entonox)
may be used if morphine is proving ineffective or
producing severe side-effects.

ARRHYTHMIAS

(a) VENTRICULAR ECTOPIC BEATS

If ventricular ectopic beats are associated with brady-
cardia, the bradycardia should be corrected before
treating the ectopic beats themselves.

If the ventricular ectopic beats are not associated with
bradycardia, they should be treated if they are of the
following kinds:-

(i)   R on T.

(ii)   Runs of two or more with R-R intervals at less
       than 0.40 seconds.

(iii) Multiform.

Ventricular ectopic beats of these types should
be treated as for ventricular tachycardia.

(b) <u>VENTRICULAR TACHYCARDIA</u>   Runs of 3 or more (rate
greater than 100/minute).

If digitalis or bradycardia are not implicated as a cause
of ventricular ectopic beats or tachycardia, the treat-
ment should be as follows:-

100 mg. lignocaine i.v. stat followed by an i.v.
infusion of 0.75 gram lignocaine in 500 ml. laevulose
12 hourly for 36 hours as a minimum but for longer if
suppression is not complete.

The initial lignocaine injection should take place over
1-2 minutes. If necessary, a further 50 or 100 mg. of
lignocaine should be given stat and similar doses should
be repeated subsequently if ventricular ectopic beats
re-emerge. If the regime suggested is not adequate to
suppress ventricular ectopic beats or ventricular tachy-
cardia, lignocaine should be infused at a rate of 1-2
grams in 500 ml. laevulose in each period of 12 hours.

If lignocaine therapy fails to suppress the ectopic
rhythm, the following therapy should be used (in the
order stated, unless contra-indicated).

(i)   If there is continuous V.T. associated with hypo-
tension or failure, countershock should be used
giving i.v. valium if the patient is conscious.

   (ii)   Practolol up to a total of 20 mg. given in
           individual doses of 5 mg. i.v.

  (iii)   Mexiletene 150 mg. i.v. over 5 mins., followed
           by infusion as described in the appendix.

   (iv)   Phenytoin up to 250 mg. i.v. in doses of 50 mg.
           with a check on B.P. and ECG between each dose.

    (v)   Procaine amide up to 1 gram i.v. with check on
           B.P. and E.C.G. between each dose of 100 mg.

If these methods fail, consideration should be given to
overdrive ventricular pacing and bretylium (5 mg./k.g.
i.m.).

In patients who have been receiving lignocaine, anti-
arrhythmic therapy with oral procaine amide 500 mg. 4
hourly is started 4 hours before the lignocaine is dis-
continued. The procaine amide therapy should be continued
for 6 weeks if renal function is normal.

In patients uncontrolled by lignocaine or procaine amide,
long-term therapy may be attempted with practolol 200 mg.
b.d., quinidine as kinidin durules 0.25 - 0.50 grams b.d.,
or mexiletene initially 250 mg. 8 hourly.

(c) <u>ACCELERATED IDIOVENTRICULAR RHYTHM (SLOW VENTRICULAR</u>
<u>TACHYCARDIA</u>

When ventricular ectopic beats are occurring in runs at
a rate less than 100/minute, no treatment will be given
except for associated disturbances of rhythm and conduction.

(d) <u>VENTRICULAR FIBRILLATION</u>

    (i)   Immediate defibrillation at 200 W. secs. If ineffective repeat at 400 W. secs.

   (ii)   If asystole develops apply external cardiac massage and artificial ventilation. The duty anaesthetist should be called if difficulty is encountered inserting an endotracheal tube.

 (iii)   If the patient has required artificial ventilation, or if there has been a delay in defibrillating, or if the ventricular fibrillation is refractory to DC shock, 100 m.Eq. $NaHCO_3$ should be administered. The arterial pH, pCO_2 and HCO_3 should be checked and if necessary further bicarbonate given to correct pH.

  (iv)   Give anti-arrhythmic drugs as for ventricular tachycardia.

(e)   i.   <u>SUPRAVENTRICULAR TACHYCARDIA</u>
      ii.   <u>ATRIAL FLUTTER</u>
   iii.   <u>ATRIAL FIBRILLATION</u>

If the ventricular rate exceeds 120/min. and the patient has not received digitalis preparation in the last 2 weeks, give digoxin 0.5 mg. i.m. followed by 0.25 mg. orally t.i.d. Digoxin may be given i.v. slowly as an initial dose if the ventricular rate exceeds 140/min. or pulmonary oedema is present. Practolol may be given 5-20 mg. i.v. as the initial treatment for supraventricular tachycardia, and used i.v. or orally to supplement

digoxin therapy for other supraventricular arrhythmias.

Synchronised DC shock should be considered:

(i)   if the ventricular rate exceeds 140/min.

(ii)   if the atrial arrhythmia persists uncontrolled.

Start with t0 ws. or less and increase subsequently as necessary.

iv.   P.A.T. WITH BLOCK

(a)   If the patient has not received digoxin, treatment should be given as for other atrial tachycardias.

(b)   If there is a history of recent treatment with a digitalis preparation, the drug should be stopped and oral potassium chloride given in a dose of 2 grams t.i.d.   If necessary, phenytoin or practolol should be given for tachycardia.

(f)   SINUS BRADYCARDIA

If the heart rate is less than 50/min., or if it is less than 60/min. and associated with ventricular ectopic beats, or hypotension, the legs should be elevated.   If this does not increase the heart rate adequately, atropine should be given i.v. or i.m. in a dose of 0.6 mg. and repeated as necessary.   If there is no response pacing may be necessary.

(g)   HEART BLOCK

(i) 1° AV BLOCK

This requires no treatment but should be carefully observed. If associated with bifascicular block (R.B.B.B. + L.A.D or R.B.B.B. + R.A.D) or with complete L.B.B.B., insertion of a prophylactic pacing electrode should be considered.

(ii) Second and Third Degree AV Block

    (a) In <u>inferior infarction</u> AV block is relatively benign and requires treatment only if associated with hypotension, syncope, cardiac failure or ventricular ectopic rhythm, when atropine should be given i.v. or i.m. in a dose of 0.6 mg. and repeated as necessary. If there is not response a pacing electrode should be inserted.

    (b) In <u>anterior infarction</u> the development of second degree or complete AV block indicates extensive cardiac damage, and a pacemaker should be inserted. If asystole or extreme bradycardia occurs, it should be treated with isoprenaline infusion (2 mg. in 500 ml. at 12-20 drops per minute) while a pacing electrode is inserted. Mortality is high.

    (c) In <u>chronic heart block</u> emergency insertion of a temporary pacemaker is indicated following syncope or major ventricular arrhythmias.

INDICATIONS FOR INSERTION OF A PACING ELECTRODE

(1) Any brady arrhythmia unresponsive to atropine if associ-

ated with syncope, hypotension, cardiac failure or ventricular ectopic rhythm.

(2) First degree heart block if associated with bifascicular block (R.B.B.B. + L.A.D. or R.B.B.B. + R.A.D.) or with complete L.B.B.B.

(3) Heart block of second or third degree associated with acute anterior infarction.

(4) Asystole.

(5) Overdrive for ventricular arrhythmias as indicated in the paragraph on ventricular tachycardia.

All staff should be familiar with the working of the pacing apparatus and instructions are included in the Appendix.

ASYSTOLE

Procedure for patients without a pacing electrode in position.

(i) A sharp blow to the chest.

(ii) External cardiac massage and artificial respiration.

(iii) Institution of isoprenaline infusion (2 mg. in 500 ml. 5% laevulose at 12 - 20 drops per minuts).

(iv) Insertion of a pacing electrode.

CARDIAC FAILURE

Oxygen should be given to all cases of cardiac failure.

Criteria for the use of diuretics:

(i) Clinically obvious pulmonary oedema, e.g., acute

dyspnoea with cyanosis, numerous basal creps. etc.

(ii)   Radiological evidence of pulmonary congestion or oedema.

If one or more of the above criteria are fulfilled, a single dose of 40 mg. frusemide should be given i.m. or orally. The need of diuretics should be assessed daily; if they are given on successive days potassium supplements should also be prescribed.

Criteria for the use of digoxin:

   (i)   Tachycardia - 100/min.

  (ii)   Third heart sound.

 (iii)   Radiological evidence of pulmonary congestion.

  (iv)   Cardiomegaly.

If two or more of the above crietria are present, an initial dose of digoxin of 0.5 mg. should be given i.m. or orally followed by 0.25 mg. 8-hourly orally for one day and renewed subsequently.

CARDIOGENIC SHOCK

Oxygen should be given. Digoxin should be given only if there are signs of pulmonary congestion or right-sided heart failure.

VENOUS PRESSURE MONITORING

A venous pressure line should be inserted in severe cardiac failure or shock if the jugular venous pressure cannot be measured.

ANTICOAGULANTS

Unless contraindicated warfarin should be prescribed for all patients.

Day I   -   Warfarin 20 mg. orally

Day II -   Warfarin 10 mg. orally

Day III -   Warfarin 5 mg. orally.

The prothrombin time should be checked before giving the third dose.

APPENDIX

DOSAGE OF DRUGS USED IN THE C.C.U.

Aminophylline

250 mg. i.v. slowly over 5 minutes.

Bretylium tosylate

5 mg./Kg. i.m.   Therapeutic effect starts in about 20 minutes.

Maintenance dose 3 mg./Kg. 8-12 hourly.

Calcium Gluconate

10 mls. of a 10% solution.

Isoprenaline

1-5 mg. in 500 ml. laevulose as i.v. infusion, at a rate of 10-20 drops per minute.   Constant E.C.G. monitoring should be observed and the rate of infusion regulated to avoid producing ventricular ectopic beats or ventricular fibrillation, and to avoid a sinus tachy-cardia - 120.

Lignocaine

50 - 200 mg. i.v. stat over a period of 1-2 minutes. Effect produced within one minute.

0.75 - 2 grams in 500 ml. 5% laevulose 12-hourly.

Mexiletene (KO 1173)

This is an amine with some similarity in structure to phenytoin.

The most common side effect when administered in the acute situation is vomiting - usually soon after the initial bolus. Hypotension with or without bradycardia may occur.

Intravenous regime:

150 mg. i.v. bolus given over five minutes followed by infusion:-

Bottle 1	500 mg. in 250 ml. laevulose in 3 hours (of which the first 250 mg. to be given over 30 minutes and the further 250 mg. to be given in 2½ hours).
Bottle 2	500 mg. in 500 ml. laevulose in 8 hours.
Bottles 3 and 4	500 mg. in 500 ml. laevulose in 12 hours each.

Oral therapy:

600 mg. oral loading dose if intravenous therapy with either mexiletene or lignocaine has not been given.

Maintenance dose:- 250 mg. 8 hourly.

There is no contraindication to giving lignocaine if

if required to a patient already on mexiletene.

Phenytoin

Up to 250 mg. i.v. in individual doses of 50 mg. with a check on B.P. and E.C.G. between each dose. Effect produced within one minute.

Orally in a dosage of 100 mg. t.i.d.

Potassium Chloride

This may be given in a dose of 1-2 grams t.i.d. orally, or as 50 m.Eq. in 500 ml. laevulose at a rate not exceeding 15 m.Eq. per hour.

Practolol

5-20 mg. i.v. in 5 mg. doses. Effect may be delayed ten minutes.

Orally in a dosage of 100-200 mg. b.d.

Procaine amide

100 mg./min. i.v. for a total of 1000 mg. (with B.P. and E.C.G. records at each aliquot of 100 mg.). Effect produced within one minute.

I.V. ADMINISTRATION SHOULD BE STOPPED AS SOON AS THE ARRHYTHMIA IS CONTROLLED.

Orally 500 mg. - 750 mg. 4 hourly.

Sodium Bicarbonate

100 m.Eq. = 100 ml. of 8.4% $NaHCO_3$ or 170 ml. of 5% $NaHCO_3$.

PACING AND CARDIOVERSION

The doctor available for the insertion of pacemakers is shown
on the rota and may also be covering the mobile coronary care
unit.

Pacemaking

Pacing is utilized to maintain the heart rate between 70 and
80/minute in those patients with heart block or sinus brady-
cardia in whom a rate less than this is associated with cardiac
failure or shock. It is also used as a standby, in the demand
mode, for patients maintaining an adequate rate but who are
liable to asystole or extreme bradycardia.

The pacing electrode is inserted by the percutaneous subclavian
route by one of the doctors who are experienced in this tech-
nique. At the time of insertion, the threshold for pacing
should not exceed 1 volt. It may rise slightly above this
over succeeding days, but should not be allowed to exceed 1.5
volts. The threshold for pacing should be ascertained at
least twice a day. If the patient is being paced continuously,
the threshold may be ascertained by turning down the output
voltage by 0.1 volt decrements until the minimum voltage to
obtain consistent pacing is found. Usually, the patient is
paced at a voltage 2-2½ times that of the pacing threshold.

If the patient is not being paced, the rate of the pace-
maker, in the demand mode, should be increased until it
exceeds that of the patient and until pacing is consistently
obtained. The output voltage should then be reduced until

the minimum voltage necessary to obtain consistent pacing
is found.   If the patient does not require pacing at that
time, the rate of the demand pacemaker should be turned down
to 40/minute.

Only battery-operated demand pacemakers should be used.

Statistics and programming

The data obtained during this study was transferred to punched cards and provessed using the Statistical Package for the Social Sciences (1975) on an IBM 370. This provided tables and some simple processing of the data and was performed by the author. More complex processing, in particular the multivariate analyses, was carried out on the data by a medical statistician.

Most of the intermediate tests on the data were carried out by the author.

The statistical tests used in this study were standard tests as found in any of the basic textbooks on medical statistics (Armitage, 1971).

$\underline{x^2}$: The x^2 test was used extensively. Yates correction was used in all 2 by 2 tables and was designated x_c^2.

$\underline{x^2 \text{ goodness of fit}}$: This standard test for non-parametric data was used when observed data required to be compared with a standard set of 'expected' data.

$\underline{\text{T-test}}$: This was used for comparison of data where they were normal in distribution.

$\underline{\text{Fourfold Table Test}}$: This was used in 2 by 2 tables where: i. The total number of individuals was less than 40, and ii. Any one cell contained a number less than 5. In a general format the table could be described

a	b	a + b
c	d	c + d
a + c	b + d	a + b + c + d

The numbers in the table are rearranged so that
a + b < c + d, then rearrange again so that a < b   the
result can be read from scientific tables (Geigy, 1970)
where $N = a + b + c + d$, $N_i = a + b$ (after rearranging)
$x_i = a$ and $x = a + c$ (Geigy, p.123).

Sign Test: This or McNamars test were used where a
group of patients was tested twice using the same method at
different times. An example was the presence of cardiogenic
shock in the mobile coronary care unit, then again later in
the hospital coronary care unit. Again a 2 by 2 table can
be described in general terms.

Test 1

		Present	Absent	
Test 2	Present	a	b	a + b
	Absent	c	d	c + d
		a + c	b + d	a + b + c + d

In this situation a x^2 cannot be performed for the
tests were identical. For example, the tests were both for
shock but at different times. The important categories in
this situation were those patients who had changed category,
i.e. b and c . The sign test is a test of the likelihood of
b + c splitting in the ratio b : c   by chance. This likeli-
hood can be found from tables (Geigy, p.105).

Test for trend: This was a more unusual test; not commonly known. It is a test for the comparison of semi-quantitative data. A typical case is shown for survival data when cases were known to be of varying initial severity (Cox, 1970):

	Initial severity			Total
	Mild	Moderate	Severe	
Survived	a	b	c	a + b + c
Died	d	e	f	d + e + f
Total	a + d	b + e	c + f	T

A numerical value was assigned to each of the semi-quantitative variables, i.e. mild = 1, moderate = 2, severe = 3. An observed value, "O", was then calculated:

1. $O = (1 \times a) + (x \times b) + (3 \times c)$

and an estimated value, "E":

2. $E = \dfrac{1(a + d) + 2(b + e) + 3(c + f)}{T}^{*} \times (a + b + c)$

The sum of squares of the grades about the mean grades is then calculated - S.

3. $S = (a + d) \times (1 - Q)^2 + (b + e) \times (2 - Q)^2 + (c + f) \times (3 - Q)^2$

where Q is the result of the expression in square brackets * in 2. above.

Then the variance of the observed value is calculated:

4. $\text{Var (O)} = (a + b + c) \times (d + e + f) \times \dfrac{S}{T \times (T - 1)}$

The null hypothesis for this test states that grade has

no effect on survival and that there will therefore be no statistically significant difference between the observed and estimated values. O, the observed value, is approximately normally distributed with a mean of E , the estimated value, and a variance as calculated. As O can only be an integer a continuity correction $(-\frac{1}{2})$, is applied and the final test criterion is:

5. $$c = \frac{(O - E - \frac{1}{2})^2}{Var\ O}$$

C can be read from tables of standard normal distribution, i.e. if greater than 1.96, the probability that the null hypothesis is correct is only 5% (Cox, 1970).

Life Tables (Seigal 1956): Life tables used for comparing deaths in patient groups have the advantage of using all the available data, including patients who were lost to follow-up. Comparisons can be made throughout the time intervals between two groups. On the other hand one of the difficulties of using life tables is that information is used in a cumulative way. Thus if all the patients have not entered the study at its outset the later results are dependent upon the small amount of information available at the beginning of the study.

The general headings of the life table were explained in the text: the time interval in the first column, l_x the number alive at the beginning of that interval in the second column, d_x the number dying in column 3. "Admitted" column included all patients first seen within the time interval. L'_x was the average number of patients at risk,

i.e. number of patients available halfway through the time interval. It was usually assumed that "admitted" patients were admitted at a steady rate throughout the time interval. This was tested in the present study and found not to be true for first hour patients - this was one of the reasons that the life table was not used for these patients. Otherwise, however, the assumption was true so that l_x' was equal to $l_x + \frac{1}{2}$ admitted . q^x was the proportion of patients dying in the time interval compared to the average number at risk, i.e. d_x/l_x' for each time interval. e_x^o on the other hand was the cumulative survival expressed as a percentage. This was obtained by obtaining p^x, the proportion of patients surviving at each time interval when $p^x = 1 - q^x$.

The cumulative proportion up to the time interval chosen was obtained by multiplying the p^x's in the time intervals before and including the time chosen. For example, the e_x^o at 4-6 hours equals

$$p^x \text{ (1-2 hours)} \times p^x\text{(2-4 hours)} \times p^x\text{(4-6 hours)}.$$

This was multiplied by 100 to give the cumulative survival as a percentage.

The variance of that cumulative survival was calculated from the general formula

$$\text{Variance} = (e_x^o)^2 \; \sum \frac{d_x}{l_x' \, (l_x' - d_x)}$$

and the standard error was $\sqrt{\text{variance}}$.

To test the null hypothesis that there was no difference between the cumulative mortalities at any point the general

formula below was used at any one time interval.

$$c \ = \ \frac{e_{x_1}^{\ o} \ - \ e_{x_2}^{\ o}}{\sqrt{variance_1 \ + \ variance_2}}$$

where 1 and 2 are the two treatments, e.g. mobile coronary care unit and community, and c is the number of standard deviations. The probability of the null hypothesis being true can be obtained from scientific tables (Geigy, 1972).

Linear discriminant analysis (Anderson, 1972): If p is the probability that, for example a patient has a myocardial infarction, it is dependent upon several factors for each patient, for example severity of chest pain. The following model can be used to express the interdependence of p and the factors:

$$Log \ \frac{p}{1 \ - \ p} \ = \ C_o \ + \ C_1 z_1 \ + \ C_2 z_2 \ \ldots\ldots \ + \ C_n z_n$$

where z_1, z_2 are numerical variables representing the degree of any factor, for example no chest pain, 0, moderate chest pain, 1, severe chest pain, 2. C_0, C_1, were constant coefficients which were derived from the data using a maximum likelihood method. The standard error of each of the coefficients was also computed so that the statistical significance of each factor could be assessed. Thus a factor that was important individually may have been found to have had no separate impact when taken with other factors and could be discarded. $Log \ \frac{p}{1 \ - \ p}$ is the natural logarithm of the odds of an infarct occurring and can be converted easily into the probability, p, of an infarct occurring. $Log \ \frac{p}{1 \ - \ p}$ is equal

to zero when there is a 0.5 probability of an infarct being present. Using this method the patients in the study were scored and the percentage of patients with myocardial infarction for each range of scores, e.g. 0 - 5, 5 - 10, was calculated. The score on a new patient can similarly be calculated and the percentage chance of his having sustained a myocardial infarction can be read off the figure. For example, a patient aged to, at rest when symptoms began, no pain when seen, no previous infarct, no previous angina, who sought no medical advice in the past month, was pale on examination but had no cyanosis or 4th heart sound, will be scored as follows:-

$$z_1 = 50, \quad c_1 = -0.3: \quad z_1 c_1 = -15$$

$$z_2 = 0, \quad c_2 = -5.1: \quad z_2 c_2 = 0$$

$$z_3 = 0, \quad c_3 = -9.4: \quad z_3 c_3 = 0$$

$$z_4 = 0, \quad c_4 = +3.4: \quad z_4 c_4 = 0$$

$$z_5 = 0, \quad c_5 = -7.5: \quad z_5 c_5 = 0$$

$$z_6 = 0, \quad c_6 = +6.1: \quad z_6 c_6 = 0$$

$$z_7 = 0, \quad c_7 = +5.7: \quad z_7 c_7 = 0$$

$$z_8 = 1, \quad c_8 = +16.8: \quad z_8 c_8 = +16.8$$

$$z_9 = 1, \quad c_9 = +6.3: \quad z_9 c_9 = +6.3$$

$$c_0 = -3.8: \qquad\qquad -3.8$$

$$\text{TOTAL SCORE} = +4.3$$

As can be seen from figure 5 this scores as between +5 and -5 and the chances of the patient having had an infarct was 51% with 95% confidence limits between 39% and 61%.