Mobile coronary care

The coronary ambulance

G. Sandler and A. Pistevos

From the Coronary Care Service, St. Helen Hospital,¹ Barnsley

The organization of the Barnsley Coronary Ambulance Service covering a population of 200,000 is described and an analysis is made of the first 500 calls over a period of 14 months. A diagnosis of definite (60%), probable (7%), and possible (7%) acute myocardial infarction, based on World Health Organization criteria, was made in 370 patients (74%). The various delay factors from the time of onset of the patient's symptoms up to admission to the hospital coronary care unit are described. Seventy-five per cent of the patients were reached by the ambulance in less than 12 minutes after sending for the ambulance, and 95 per cent in less than 22 minutes. One hundred and eighty-five out of the 370 patients (50%) had a total of 241 individual episodes of cardiac arrhythmia at some time before hospital admission. Cardiac arrest occurred in 16 patients of whom there were only 3 long-term survivors discharged from hospital, all with ventricular fibrillation. The overall mortality in the 370 patients with myocardial infarction was 18 per cent.

An attempt is made to assess objectively the value of the coronary ambulance, and the cost effectiveness is also discussed. It is suggested that the service is both of medical benefit to the patients and of long-term financial benefit to the Government.

The introduction of intensive coronary care has generally reduced the hospital mortality after acute myocardial infarction from 30 per cent with regular hospital care to below 20 per cent with intensive coronary care (Lawrie *et al.*, 1967; Lown *et al.*, 1967; Oliver, Julian, and Donald, 1967; Sloman, 1968). It has been accepted that the major part of this improvement in mortality is due to the detection and successful treatment of the potentially fatal cardiac arrhythmias such as ventricular fibrillation (Lown *et al.*, 1967). Though the risk of developing ventricular fibrillation is greatest soon after the onset of myocardial infarction (Pantridge and Geddes, 1967), it has been repeatedly shown that there is often a delay of several hours in admitting a patient to hospital (Mittra, 1965; McNeilly and Pemberton, 1968; Moss, Wynar, and Goldstein, 1969). As a result, the majority of deaths from coronary thrombosis occur outside hospital (McNeilly and Pemberton, 1968). Pantridge and Geddes (1966, 1967) pioneered the mobile coronary flying squad in Belfast and showed the considerable improvement possible in the early mortality of

this condition, as a direct result of earlier prevention and treatment of ventricular fibrillation. Dewar, McCollum, and Floyd (1969) also reported on a year's experience with a mobile coronary resuscitation team in Newcastle and found disappointing results among the 134 patients treated. Since there are few mobile coronary care services functioning in this country, data on the potentialities of this type of service are limited to date. The Barnsley coronary ambulance went into service on 1 January 1970, and has dealt with approximately 700 calls over an 18-month period. It was felt that the results obtained with the first 500 calls in the first 14 months of operation of the service would therefore be of interest.

Organization of service and population covered

The population covered by the service is 200,000 and is predominantly a coal-mining community. Most of this population lives within a 6-mile radius of St. Helen Hospital (now Barnsley District General Hospital), though no strict geographical limits are observed by the coronary ambulance. Barnsley itself has a population of 70,000 and is covered by the Barnsley Ambulance Service, while the

Received 9 March 1972.

¹ Now the Barnsley District General Hospital.

remaining 130,000 people are in the territory of the West Riding County Council Ambulance Service. In order to avoid the inevitable administrative difficulties inherent in employing two separate ambulance authorities, and the resulting unnecessary delay in responding to a call, it was mutually agreed by the two authorities that the Barnsley Ambulance Station, which is approximately half a mile, and three minutes, away from the hospital, would garage and staff the vehicle and deal with all calls irrespective of origin in Barnsley or West Riding territory.

The coronary ambulance

The coronary ambulance itself is a purpose-built vehicle on a standard B.M.C. ambulance chassis. The interior design is similar to that used in Belfast with some modifications (Fig. 1). There is a specially designed mobile central trolley which adjusts to any desired height and is easily tipped into the Trendelenburg position for shocked patients. The head rest elevates for dyspnoeic patients, and arm rests facilitate intravenous therapy. Where possible, the patient is placed on this trolley at home and remains there until admitted to the coronary unit. There is ample working space around the trolley, when anchored to the ambulance

floor, so necessary for efficient cardiopulmonary resuscitation. Shelves and cupboards support and accommodate equipment. There is a small hand wash-basin with pumped-up warm water, an efficient heater and seating accommodation for four. Powerful fluorescent lighting and a mobile spotlight are available. A static inverter run off an extra 12-volt heavy duty battery provides two 240-volt outlets for mains operated apparatus if required. There is a two-way radio-telephone link between the ambulance and the station, and any messages for the coronary unit are transmitted via the ambulance station.

Ambulance equipment

The monitoring and resuscitation equipment is all battery powered and includes a defibrillator, oscilloscope, electrocardiograph, pacemaker, and suction apparatus. A portable Minuteman automatic respirator is available as well as an ample supply of oxygen in cylinders fixed in the ambulance. Other respiratory equipment includes an Ambu bag, Brooke airways, and endotracheal tubes. All the usual nursing dressings and accessories are available. A full range of cardiovascular drugs is carried in a special drug case, and any drugs used are replaced at the hospital immediately after each call before the ambulance returns

FIG. 1 *The coronary ambulance.*

to the station. Intravenous infusion bottles are supported by four roof-mounted brackets, and it is standard practice to set up an intravenous drip on all patients as soon as they are brought into the ambulance, if not required earlier in the house, to allow immediate access for intravenous therapy in an emergency.

Coronary team

This consists of a doctor and sister/staff-nurse who have been specially trained in intensive coronary care in the hospital coronary care unit. Provision of a continuous service has meant an increase of one senior house officer to the medical establishment, but it has not been found necessary to increase the nursing establishment of the coronary unit. Evening and weekend coronary ambulance duties are shared with the general medical registrar to allow adequate off-duty for the senior house officer and to provide valuable experience for the registrar. Since the establishment of the general medical unit, with which the coronary care unit was closely associated, included two house physicians who provided continuous medical cover, there was no difficulty in obtaining emergency medical attention when required for patients in the coronary unit, when the coronary care senior house officer was out on ambulance duty. An ambulance driver and colleague are provided at all times from the normal establishment of the Barnsley Ambulance Service.

Coronary ambulance call procedure

All general practitioners in the area were notified of the scheme, often by personal contact, but also by circular. They were provided with an ex-directory telephone number which connects them directly with the coronary care unit, bypassing the hospital switchboard, a frequent cause of communication delay in hospital. The practitioner is encouraged to notify the unit immediately on receipt of a call about a patient whom he judges from the symptoms, and often from previous know-

ledge of the patient, may have a coronary thrombosis. The doctor is not necessarily required to visit the patient first, thus reducing further any possible delay between onset of symptoms and application of intensive care facilities. It was envisaged at the onset that this might result in a number of false alarms, but this was considered an acceptable risk when weighed against the benefits of minimizing delay. Calls are also accepted from trained nurses and first-aid attendants in local collieries and steel works, and calls from members of the public, passed on to the coronary unit after a 999 call to the Ambulance Station, may be accepted if there is a known or suspicious past history of ischaemic heart disease. To date it has not been felt possible or advisable to accept calls from the general public relating to collapse in view of the probable high incidence of noncardiac causes.

On receipt of the call at the coronary care unit, the ambulance station is contacted and the coronary ambulance dispatched to pick up the coronary team at the hospital. On arrival at the patient's house the first procedure is to connect the patient to the oscilloscope ensuring immediate supervision of cardiac rhythm. Arrhythmias are treated along prescribed lines with suppressive drugs, and cardiac arrest dealt with by external cardiac massage and mouth-to-mouth respiration, followed by defibrillation for ventricular fibrillation, and intracardiac adrenaline and calcium chloride for asystole. Heart failure and cardiogenic shock are also treated at home and the patient will be returned to hospital only when his clinical condition is satisfactory. Doubtful cases of myocardial infarction are always brought back to hospital for further assessment. The patient remains monitored continuously in the ambulance on the return journey. Before the ambulance is returned to the station, all equipment is checked for battery state; these are replaced if exhausted, and any drugs or intravenous fluids used are replaced, so that the ambulance is in a state of complete readiness for the next call.

TABLE I *Delay factors involved in various stages of coronary ambulance service*

	< 30 min	30-60 min	1-2 hr	2-4 hr	4-6 hr	6-12 hr	12-24 hr	> 24 hr
Onset - general practitioner notification	33%	13%	12%	14%	8%	12%	5%	3%
General practitioner call - coronary care unit call	35%	26%	19%	10%	2%	3%	1%	4%
General practitioner call - patient visited	63%	16%	9%	7%	1%	1%	1%	1%
Onset - general practitioner visit	17%	17%	16%	17%	10%	15%	7%	1%
Onset - coronary care unit called	7%	14%	19%	21%	10%	13%	10%	6%
Onset - ambulance arrival	3%	10%	25%	21%	11%	18%	9%	3%
Onset - admission to coronary care unit	0	1%	19%	31%	16%	15%	12%	3%*

* 16 patients died at home and were not admitted.

Results

Table 1 shows the incidence of delay at some of the stages in the service from the onset of symptoms to final admission to the hospital coronary unit. One-third of the patients had notified their doctors within 30 minutes of onset of symptoms, and another third took up to 4 hours; a further 20 per cent from 4 to 12 hours and the remainder up to 36 hours. The general practitioner visited the patient in 60 per cent of cases before calling the coronary ambulance, and in 60 per cent the visit was made within 30 minutes of being called. The coronary unit was contacted by the practitioner in 35 per cent of the patients within 30 minutes of his visit, and in a further 26 per cent within 1 hour. The ambulance journey from hospital to the patient's home was less than 12 minutes in 75 per cent of the calls and less than 22 minutes in 95 per cent of the calls, the time required for this journey being dependent on the distance from the hospital. The time from the onset of symptoms to arrival of the coronary team at the patient's home was less than 1 hour in 13 per cent, between 1 and 2 hours in 25 per cent, and 2 to 4 hours in 21, so that almost 60 per cent of the patients were seen within 4 hours of onset. Usually the time spent by the team at the patient's home was 15 to 30 minutes, but longer periods up to 3 hours were necessary in a few instances of cardiogenic shock or intractable arrhythmias. The total time from onset of symptoms to admission to hospital was less than 2 hours in 20 per cent, and less than 4 hours in just over half the patients. A further 26 per cent were admitted in 4 to 9 hours, and the remaining 21 per cent were delayed for periods ranging up to 36 hours before they came into hospital.

The diagnosis of myocardial infarction in the 500 calls, based on the modification by Sloman and Brown (1970) of the World Health Organization Classification (1969) is shown in Table 2. Sixty per cent had a

definite infarction and 14 per cent probable and possible infarction, leaving 25 per cent in whom infarction was not present. This 25 per cent included atypical chest pain, other nonischaemic cardiovascular disease, respiratory infections, and in 2 instances perforated peptic ulcer.

Cardiac arrhythmia The initial cardiac rhythm at home is shown in Table 3. Sinus rhythm was present in 75 per cent of patients, comprising 46 per cent with normal heart rate (< 90/min) and 29 per cent with sinus tachycardia (90–140 beats/min). Sinus bradycardia was present in 9 per cent. Ventricular fibrillation was found in 2 patients immediately on arrival of the team, only 1 of whom was successfully defibrillated, but 4 patients were found in recent cardiac asystole, and all succumbed in spite of attempts at resuscitation. Table 4 shows the total incidence of arrhythmia at any time at home or in transit to the hospital. Two hundred and forty-one separate episodes of arrhythmia occurred in 185 of the 370 patients with infarction (50%); 45 of these patients had 2 episodes of arrhythmia and 12 had 3 episodes. Arrhythmias were much more frequently encountered at home (92% of episodes) than in the ambulance (8% of episodes). The relation between the incidence of arrhythmias and the time at which the patient was first seen after onset of symptoms is shown in Fig. 2. This shows that arrhythmias are in general more frequent soon after the onset, but this is not entirely consistent since only 25 per cent of patients seen in less than 30 minutes after onset had arrhythmias compared with the peak incidence of 63 per cent seen within 30 minutes and 1 hour. Though the histogram refers to both ventricular and supraventricular arrhythmias combined, a similar distribution is seen if the two types of arrhythmia are analysed individually.

TABLE 2 Incidence of acute myocardial infarction (WHO criteria) in first 500 calls

Class	Criteria	No. of patients	Per cent
1. Definite	(a) Unequivocal electrocardiographic evidence ± typical history	155	31
	(b) Equivocal electrocardiographic + raised serum enzymes ± typical history	119	24
	(c) Normal electrocardiogram + raised serum enzymes + typical history	21	4
	(d) Necropsy evidence	4	1
2. Probable	Typical history + equivocal electrocardiogram + equivocal increase in serum enzymes	34	7
3. Possible	Typical history + equivocal or no electrocardiographic abnormality + no increase in serum enzymes	37	7
Total		370	74

TABLE 3 Initial cardiac rhythm at home in 370 patients with acute infarction

	No.	Per cent
Sinus rhythm (a) <90/min	170	46
(b) 90-140/min	108	29
Sinus bradycardia	33	9
Atrial tachycardia	21	6
Nodal tachycardia	1	0.3
Atrial flutter	2	0.6
Atrial fibrillation	24	7
Idioventricular (heart block)	6	2
Ventricular tachycardia	1	0.3
Ventricular fibrillation	2	0.6
Ventricular asystole	4	1

Ventricular arrhythmia Ventricular arrhythmia (58%) was more frequent than supraventricular arrhythmia (42%). The commonest ventricular arrhythmia was occasional unifocal ventricular ectopic beats requiring no treatment. All other types of ventricular arrhythmia were treated and include in order of frequency unifocal ectopics (more frequent than 1 in 10), multifocal ectopics, R-on-T ectopics, and ventricular tachycardia which was least common. The treatment most frequently successful in ventricular arrhythmias was a single intravenous dose of 100 mg lignocaine, but continuous infusion of 1 to 4 mg/minute was required in some cases. There were 11 episodes of intractable ventricular arrhythmia in which even a combination of lignocaine (4 mg/minute), intravenous phenytoin (250 mg), and intravenous procainamide (250 mg) failed to achieve control.

Supraventricular tachyarrhythmia The most frequent supraventricular tachyarrhythmias were atrial tachycardia (>140 beats/minute, sometimes with abnormal P waves) and atrial fibrillation. Supraventricular ectopic beats occurred in only 5 per cent of episodes, with nodal tachycardia and atrial flutter least frequent of all. Intravenous sympathetic beta-blocking drugs such as practolol (5 mg at 5-minute intervals up to a total of 25 mg) and oxprenolol (2 mg, 4 mg, 6 mg, bolus doses), were used most often in treating the supraventricular tachyarrhythmias, with intravenous ouabain (0.1 to 0.25 mg) for atrial fibrillation. There were only 3 episodes of supraventricular arrhythmia (frequent ectopic beats) which failed to respond to all treatment and none led to any serious consequences.

Supraventricular bradyarrhythmia The most frequent supraventricular bradyarrhythmia was sinus bradycardia (31 episodes) which

TABLE 4 Incidence of arrhythmia at any time (individual episodes)

Type of arrhythmia	No. of episodes	Per cent
Supraventricular		
Sinus bradycardia	32	13
Atrial tachycardia	23	10
Nodal tachycardia	4	2
Atrial flutter	2	1
Atrial fibrillation	25	10
Ectopic beats – atrial	< 1:10	9
	> 1:10	3
nodal	< 1:10	—
	> 1:10	1
		5
Ventricular		
Ectopic beats – unifocal	< 1:10	54
	> 1:10	31
multifocal	< 1:10	3
	> 1:10	15
R-on-T		8
Ventricular tachycardia	< 100/min	3
	> 100/min	5
Ventricular fibrillation		10
Ventricular asystole		11
Combined fibrillation and asystole		2
	241	100

was also the most frequent of all supraventricular arrhythmias, usually associated with inferior infarction (50%) and was successfully treated in all cases with intravenous atropine 0.6 to 1.2 mg. Heart block, occurring in 9 per cent of the patients, was also most commonly associated with inferior infarction (42%). Complete heart block was most common (11 patients) with left bundle-branch block close behind (10 patients), followed by right bundle-branch block (6 patients) and first-degree block (5 patients). Both sinus bradycardia and heart block were found more frequently soon after the onset of symptoms, the peak incidence of both occurring within one to two hours of

FIG. 2 Incidence of arrhythmia related to time after onset of symptoms.

onset. Complete heart block was usually successfully treated with an intravenous combination of atropine (0.6 mg) and hydrocortisone (100 mg). In three instances intravenous isoprenaline (2 µg/min) was also required. First-degree block was not usually treated. The eventual prognosis of the heart block was poor, with an overall mortality of 56 per cent. Both left and right bundle-branch block carried a high mortality (60% and 80%, respectively), with a 44 per cent mortality in complete heart block.

Cardiac arrest Sixteen patients (4%) developed primary cardiac arrest, 12 at home and 4 in the ambulance on the return journey to hospital. Ventricular fibrillation occurred in 4 patients, 2 at home, of whom 1 failed to respond to defibrillation, and 2 in the ambulance, both of whom were successfully defibrillated. All 3 of these patients successfully resuscitated after ventricular fibrillation survived to leave hospital and all still remain alive to date. There were 12 patients with asystole, 10 in the home and 2 in the ambulance. Though 3 of these patients were successfully resuscitated following cardiac massage and intracardiac adrenaline (1 ml of 1:1000) and calcium chloride (10 ml of 10% solution) all 3 subsequently died in hospital. There were thus 3 permanent survivors out of 16 patients with cardiac arrest and these 3 all had had ventricular fibrillation. No patient with cardiac asystole survived. Five patients arrested within 2 hours of onset of symptoms, 4 patients in 2 to 4 hours after onset, 1 patient in 4 to 6 hours, 4 patients in 6 to 12 hours after onset, and the remaining 2 patients between 18 and 36 hours after onset. Age, sex, and site of infarction were not significant factors in determining cardiac arrest.

Cardiac failure Left ventricular failure was found in 42 per cent of patients with myocardial infarction, and of these one-third were considered severe enough to warrant treatment with intravenous frusemide, aminophylline, and sometimes intravenous ouabain. Right ventricular failure was less common and occurred in only 17 per cent.

Cardiogenic shock The diagnosis was based on low systolic pressure (< 80 mmHg), cold, clammy skin, and restlessness with confusion. There were 23 patients (6%) who developed cardiogenic shock. Treatment included some or all of the following measures: intravenous noradrenaline (8 to 24 µg/min), intravenous phenoxybenzamine (50 mg over 2 hours), massive doses of intravenous hydro-

TABLE 5 Causes of death in 370 patients with acute infarction

	No. of patients
Ventricular asystole – primary	30
secondary	11
Ventricular fibrillation – primary	1
secondary	—
Cardiogenic shock	17
Cardiac failure	—
Miscellaneous	3
Not known	4
Total	66

cortisone (2.5 g), and isoprenaline infusion (2 µg/min). Five patients died at home, 1 in the ambulance at the time of arrival at the hospital, and 8 others subsequently in the coronary unit giving a total mortality of 72 per cent.

Mortality Sixty-six patients (18%) died among the 370 patients with myocardial infarction of whom 16 died at home and 50 subsequently in hospital. The causes of death are shown in Table 5. The major cause of death was primary cardiac asystole followed by cardiogenic shock and secondary asystole (due to shock or left ventricular failure). Only 1 patient died of ventricular fibrillation. Cardiac rupture occurred in 1 patient and cerebral and pulmonary emboli, respectively, in 2 other patients. Four patients were found dead in bed after transfer to the medical ward from the coronary unit, so were not monitored at the time of death, the cause remaining uncertain. The time after onset at which the patient was first seen did not appear to be a relevant factor in determining mortality. The

FIG. 3 Mortality related to time after onset of symptoms.

extent of the infarction was to some extent correlated with the death rate, being highest with combined anterior and inferior infarction (40% mortality), followed closely by complete anterior infarction (38% mortality). There was also a high mortality of 75 per cent in 8 patients with left bundle-branch block alone.

Discussion

It has been clearly shown that the majority of deaths from acute myocardial infarction occur soon after the onset of the attack (Grace and Chadbourn, 1969; Pantridge and Geddes, 1967; Bainton and Peterson, 1963; Yater *et al.*, 1948) and 40 per cent of these are from potentially reversible ventricular fibrillation and cardiac asystole (Lown *et al.*, 1967). Since the average time between onset of symptoms and admission to hospital may be as much as 12 hours (Lown *et al.*, 1967; Mittra, 1965), it is not surprising that McNeilly and Pember-ton (1968) found that 60 per cent of 901 patients with fatal myocardial infarction died outside hospital. It is therefore clear that any further improvement from intensive coronary care must be based on reducing the interval between onset of symptoms and application of appropriate monitoring and resuscitation facilities. This involves either shortening the preadmission time or bringing intensive care to the patient at a much earlier stage.

Delay factors in admitting a patient to hospital include the time for the patient to notify his doctor, arrival time of the doctor, time for hospital notification, and ambulance travel time. The time between onset of symptoms and notification of the doctor is probably the most important delay factor (Moss *et al.*, 1969), though in the present series over 50 per cent had contacted their doctors within one hour. The commonest excuse for failure of early notification on the series was 'the pain would probably go' especially in anginal patients; other patients rationalized the pain as 'indigestion', 'wind', or 'bronchitis'. In this respect, education of the public in the significance of chest pain and the need to contact their doctor early is likely to be of considerable value in minimizing delay. Avoidance of the sometimes inevitable delay in the doctor visiting his patient can be achieved by arranging for notification of the coronary unit without necessarily visiting the patient first when there are reasonable grounds for suspecting infarction, though only 21 per cent of the doctors did in fact do this in this study. Ambulance delay depends on the traffic situation which may be difficult to control, but casualty departments, a notorious

site of delay (Han *et al.*, 1966), should always be bypassed on return to hospital.

Pantridge and Geddes (1967) showed clearly the feasibility of reaching patients early and successfully treating ventricular fibrillation, but so far very few similar units have been established in this country and data are limited. Kernohan and McGucken (1968) in Ballymena, Northern Ireland, had 3 long-term survivors in 164 calls, and in England, Dewar *et al.* (1969), who are to date the only English team to publish their results, considered that 39 out of 134 patients had benefited from the Newcastle ambulance, but they found that staffing was a problem. To avoid the medical staffing difficulties inherent in a mobile unit, Gearty *et al.* (1971) used a coronary ambulance staffed by non-medical personnel who were trained in defibrillation, but there are obvious limitations in this type of service in dealing with premonitory arrhythmias, heart failure, and cardiogenic shock. In Barnsley the only addition to the medical establishment was one senior house officer who averages 1 to 2 hours a day on ambulance duty, while the remainder of his time is spent in the coronary unit or on general medical work.

In the present series over 50 per cent of the patients had cardiac arrhythmia at some time before admission to hospital. Sinus bradycardia occurred in 9 per cent and was most frequent with inferior infarction (Pantridge, 1968). It was the commonest arrhythmia before cardiac arrest, due to an associated lowering of threshold for ventricular fibrillation (Han *et al.*, 1966). Treatment of sinus bradycardia with intravenous atropine is strongly indicated. The most frequent ventricular arrhythmia was occasional unifocal ectopic beats not requiring treatment, and the most successful drug for the other ventricular tachyarrhythmias was intravenous lignocaine. Of the 16 patients with cardiac arrest - 12 at home and 4 in the ambulance - only 3 survived to leave hospital, all of whom had had ventricular fibrillation, indicating the ominous prognosis of cardiac asystole, in spite of temporary resuscitation of 3 patients.

Heart block in 19 per cent, usually with inferior infarction, carried a poor prognosis, over half the patients dying, though intravenous hydrocortisone and atropine were successful in some patients. Cardiogenic shock in 23 patients also had a high mortality (72%), but very gratifying results were obtained in 3 moribund patients with intravenous nor-adrenaline, phenoxybenzamine, and massive doses of hydrocortisone.

The important question that remains to be

answered is whether the coronary ambulance is worth while. The answer must obviously depend on how its value is assessed. In order to attempt an objective, as opposed to an emotional, evaluation of the coronary ambulance, two main aspects have been considered – the medical benefits and the financial implications. The medical benefits are shown in Table 6 and are assessed by dividing patients into 4 categories.

- 1) Lives definitely saved – death regarded as inevitable in the absence of treatment.
- 2) Lives possibly saved – including serious arrhythmias often developing into ventricular fibrillation and severe left ventricular failure and heart block, both of which conditions may be associated with a high mortality in the absence of treatment.
- 3) Patients possibly improved – less serious arrhythmias not usually leading to catastrophic consequences, but possibly leading to cardiac embarrassment.
- 4) No immediate value.

The lives of 9 patients were saved in the first instance, but the 3 patients resuscitated from cardiac asystole subsequently died in hospital leaving 6 long-term survivors, all of whom are still alive. It was considered that lives possibly saved included 24 patients with potentially serious cardiac arrhythmias, 20 patients with severe left ventricular failure, and 7 with heart block; only 2 patients in this group died subsequently in hospital. An additional 58 patients may have improved as a result of treating less serious arrhythmias, such as sinus bradycardia, infrequent unifocal ectopics, atrial tachycardia, and atrial fibrillation. In this group it is not possible to predict accurately the likelihood of serious complications if left untreated. Nine patients in this group died later in hospital. It is of interest that the majority of deaths in the series came from patients who were found previously to have complications requiring treatment. Sixty-eight per cent of patients received no immediate benefit from the ambulance. Thus, just under a third of the 370 patients with acute myocardial infarction have benefited medically to a greater or lesser extent from the coronary ambulance.

The other important consideration is the cost-effectiveness of the service. The initial capital outlay, which is a non-recurrent expense, was £5,000 for the purpose-built ambulance and all the necessary monitoring and resuscitation equipment. None of this expenditure was a charge on the National Health Service, being raised by grants and voluntary

TABLE 6 *Medical benefits of coronary ambulance*

	Home	Ambulance	Total
<i>Life saved</i>			
1) Ventricular fibrillation	1	2	3
2) Ventricular asystole	1	2	3*
3) Severe cardiogenic shock	2	1	3
<i>Life possibly saved</i>			
1) Arrhythmia – multifocal ventricular ectopics	11	1	12
R-on-T ectopics	7	1	8
ventricular tachycardia	4	—	4
2) Left ventricular failure	19	1	20
3) Heart block	7	—	7
<i>Possible improvement</i>			
1) Sinus bradycardia	22	—	22
2) Frequent unifocal ventricular ectopics	24	4	28
3) Atrial tachycardia and fibrillation	7	1	8
<i>No value</i>	311 patients		

* These 3 patients died later.

subscription. The medical establishment was increased by one senior house officer only, the nurse being supplied out of existing coronary unit nursing staff. The cost of an ambulance call, usually 6 miles and lasting one hour, is approximately £6.00: £2.50 for the senior house officer's time, £1.50 for the nurse's time, and £2.40 for the ambulance (includes one hour's pay for two ambulancemen, petrol, and ambulance maintenance). Since approximately 400 calls were made in the first year the annual running cost was £2,400 (£1,400 paid by the National Health Service and £1,000 paid by the local authority). However, on the credit side must be considered the possible financial benefits accruing to the Government if a male patient is successfully resuscitated from cardiac arrest and returns to work for a number of years, and this includes direct benefits such as income tax, car tax, petrol tax, purchase tax, etc., and indirect benefits such as lack of necessity to pay a widow's pension.

We are greatly indebted to Mr. Fred Hall, M.B.E., chief ambulance officer, and to the staff of the Barnsley Ambulance Service without whose willing and efficient co-operation the coronary ambulance service would not be possible. We also gratefully acknowledge the help given by Miss E. Lees, Matron, St. Helen Hospital, and the unflagging enthusiasm of the coronary care unit nursing staff who have done so much to make this service a success. I should also like to thank Miss M. Tinsley of the Department of Community Medicine, University of Sheffield, for help with data analysis. Finally, we would like to thank Dr. J. F. Pantridge of the Royal Victoria Infirmary, Belfast, for his advice and help during the planning stages of the Service.

References

- Bainton, C. R., and Peterson, D. R. (1963). Deaths from coronary heart disease in persons fifty years of age and younger. *New England Journal of Medicine*, **268**, 569.
- Dewar, H. A., McCollum, J. P. K., and Floyd, M. (1969). A year's experience with a mobile coronary resuscitation unit. *British Medical Journal*, **4**, 226.
- Gearty, G. F., Hickey, N., Bourke, G. J., and Mulcahy, R. (1971). Pre-hospital coronary care service. *British Medical Journal*, **3**, 33.
- Grace, W. J., and Chadbourne, J. A. (1969). The mobile coronary care unit. *Diseases of the Chest*, **55**, 452.
- Han, J., Millet, D., Chizzonitti, B., and Moe, G. K. (1966). Temporal dispersion of recovery of excitability in atrium and ventricle as a function of heart rate. *American Heart Journal*, **71**, 481.
- Kernohan, R. J., and McGucken, R. B. (1968). Mobile intensive care in myocardial infarction. *British Medical Journal*, **3**, 178.
- Lawrie, D. M., Greenwood, T. W., Goddard, M., Harvey, A. C., Donald, K. W., Julian, D. G., and Oliver, M. F. (1967). A coronary-care unit in the routine management of acute myocardial infarction. *Lancet*, **2**, 109.
- Lown, B., Fakhro, A. M., Hood, W. B., and Thorn, G. W. (1967). The coronary care unit: new perspectives and directions. *Journal of the American Medical Association*, **199**, 188.
- McNeilly, R. H., and Pemberton, J. (1968). Duration of last attack in 998 fatal cases of coronary artery disease and its relation to possible cardiac resuscitation. *British Medical Journal*, **3**, 139.
- Mittra, B. (1965). Potassium, glucose, and insulin in treatment of myocardial infarction. *Lancet*, **2**, 607.
- Moss, A. J., Wynar, B., and Goldstein, S. (1969). Delay in hospitalization during the acute coronary period. *American Journal of Cardiology*, **24**, 659.
- Oliver, M. F., Julian, D. G., and Donald, K. W. (1967). Problems in evaluating coronary care units - their responsibilities and their relation to the community. *American Journal of Cardiology*, **20**, 465.
- Pantridge, J. F. (1968). Flying squad services. In *Acute Myocardial Infarction*, p. 316. Ed. by D. G. Julian and M. F. Oliver. E. and S. Livingstone, Edinburgh and London.
- Pantridge, J. F., and Geddes, J. S. (1966). Cardiac arrest after myocardial infarction. *Lancet*, **1**, 807.
- Pantridge, J. F., and Geddes, J. S. (1967). A mobile intensive-care unit in the management of myocardial infarction. *Lancet*, **2**, 271.
- Sloman, G. (1968). Coronary care units: current policies and results. In *Acute Myocardial Infarction*, p. 8. Ed. by D. G. Julian and M. F. Oliver. E. and S. Livingstone, Edinburgh and London.
- Sloman, G., and Brown, R. (1970). Hospital registration in patients with acute myocardial infarction. *American Heart Journal*, **79**, 761.
- World Health Organization (1969). Report (Part II). Working group on ischaemic heart disease registers, Copenhagen.
- Yater, W. M., Traum, A. H., Brown, W. G., Fitzgerald, R. P., Geisler, M. A., and Wilcox, B. B. (1948). Coronary artery disease in men eighteen to thirty-nine years of age. *American Heart Journal*, **36**, 334.

Requests for reprints to Dr. G. Sandler, Barnsley District General Hospital, Gawber Road, Barnsley, Yorkshire.