MEDICAL PRACTICE

Hospital Topics

Mobile Coronary Care Provided by Ambulance Personnel

N. M. WHITE, W. S. PARKER, R. A. BINNING, E. R. KIMBER, H. W. EAD, D. A. CHAMBERLAIN

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Summary

Mobile coronary care has been provided in Brighton by ambulance personnel without immediate help from physicians or nurses. No additional vehicles or staff were required. The capital cost of the experiment was therefore small and additional running costs were negligible. The results have been monitored by retrospective analysis of electrocardiograms recorded in the ambulance and stored on magnetic tape. In the first 12 months of operation to July 1972, 1,082 patients with suspected cardiac emergencies were carried in two vehicles. Subsequent analysis showed that 76% of these patients had acute symptoms from ischaemic heart disease or had circulatory arrest. Eighty-six per cent. of arrhythmias were diagnosed correctly by the ambulance attendants. Though only eight cases of primary ventricular fibrillation occurred during or shortly before transit all were successfully reversed, and five of these patients subsequently left hospital alive. Other benefits of the scheme have included an appreciable reduction in the median delay between onset of presenting symptoms in patients with acute myocardial ischaemia and their admission to hospital.

Royal Sussex County Hospital, Brighton BN2 5BE
N. M. WHITE, M.B., M.R.C.P., Registrar in Cardiology
R. A. BINNING, F.F.A.R.C.S., Consultant Anaesthetist
D. A. CHAMBERLAIN, M.D., M.R.C.P., Consultant Cardiologist

County Borough of Brighton
W. S. PARKER, F.F.C.M., D.P.H., Medical Officer of Health
E. R. KIMBER, F.I.A.O., F.I.C.A.P., Chief Ambulance Officer

Medical College of St. Bartholomew's Hospital, London EC1A 7BE
H. W. EAD, Research Assistant in Electronics

Introduction

The potential value of mobile coronary care has been adequately demonstrated over the past seven years, especially by groups working in Belfast.[1 2] Patients with recent myocardial infarction can be brought under intensive care expeditiously. Arrhythmias which cause serious haemodynamic disturbances or which predispose to cardiac arrest are thus amenable to treatment during a critical phase of the illness, and ventricular fibrillation is correctable if it occurs during or shortly before transfer of the patient to hospital.

Unfortunately practical difficulties have hindered the widespread use of coronary ambulances. Close liaison between individual hospitals and ambulance services may be impracticable in large cities. The provision of highly trained mobile medical and nursing teams has proved an even greater bar. Moreover, death from myocardial infarction usually occurs rapidly after the onset of major symptoms.[3] The number of lives which can be saved by a system of this type will therefore remain relatively small until the need for speedy referral is widely appreciated. Many feel that scarce and expensive resources can be better deployed elsewhere.[4]

We have attempted a compromise solution to this dilemma in Brighton. Ambulance personnel have been fully trained in resuscitation techniques, including the recognition of arrhythmias and the use of electrical defibrillation. They alone man specially equipped vehicles without aid from medical or nursing staff. The results have been monitored by retrospective analysis of the electrocardiograms recorded in the ambulance and stored on magnetic tape. Our experiences in the first 12 months of the scheme are now reported.

Training of Ambulance Staff

Ambulance men were selected for special training by the chief ambulance officer. A six-month course comprised weekly lectures of 90 minutes each given by the consultant cardiologist.

In addition each man worked full-time for one month in the coronary care unit. All participants were encouraged to spend some of their spare time on revision; they were also invited to attend tutorials on the recognition of arrhythmias designed primarily for junior medical staff. At the end of their course they were expected to have sufficient knowledge of the pathology and clinical aspects of coronary artery disease to understand any complications which they might encounter, to recognize all common arrhythmias, to be skilled at routine resuscitative measures, and to be competent to treat ventricular fibrillation with a D.C. shock when necessary.

The first six men were passed as proficient in July 1971; a year later the trained pool comprised 20 men. Only two had failed to reach a satisfactory standard after their six-month course and were returned for further training. After completion of one year of service on the coronary ambulance each man is to receive a short refresher course.

Equipment

Two standard Bedford J1Z ambulances which were part of the existing fleet of 21 vehicles operated by the Brighton service were modified to serve as coronary ambulances. Each was equipped with a defibrillator (Simonsen and Weel model DCX 822/B and British American Optical Company model 10645F) and an electrocardiogram-monitoring oscilloscope (Simonsen and Weel models EAP 625, MS 625/EAP 628 and MDS 036). The signal from the oscilloscope is passed to a Siemens Cardiostat T electrocardiograph to permit a permanent recording of any rhythm disturbance, and also through a frequency modulation system (Cambridge Scientific Instruments Limited, Tele-E-Transmitter) to a Philips 2204 cassette tape recorder for storage. With the exception of the cathode-ray tube of the monitors all equipment is solid-state, but to reduce the risk of failure from vibration and shock the equipment is mounted on Barrymount anti-vibration mounts (Cementation Ltd.). Power is derived from the ambulance 12-V battery and converted to 50 Hz at 230 V by a Valradio transvertor capable of supplying up to 2·6 A. Initially a modified V1 lead was used, but after several months' experience standard limb leads were preferred because patients' clothing was not disturbed.

The electrocardiograms from the tape cassettes were analysed in the coronary unit. The signals were demodulated through a Cambridge Tele-E-Receiver and fed into a Simonsen and Weel EAP 625, MS 625/EAP 628 monitoring oscilloscope, a Simonsen and Weel arrhythmia computer (model EAC 804), and an electrocardiogram writer. Examples of all rhythm disturbances were preserved in permanent form and, when the quality of the tracing permitted, a histogram print-out of rhythm changes was also available.

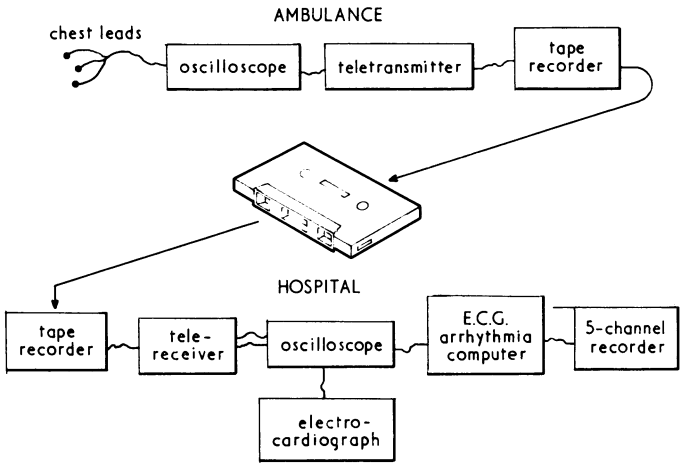

FIG. 1—Manner in which electrocardiogram is displayed, stored, and subsequently analysed. Signal passes from monitoring oscilloscope through a "tele-transmitter" frequency modulation system and on to a domestic tape recorder. The tape cassette is brought to the hospital and the signal is demodulated and analysed using another oscilloscope, an arrhythmia computer, and a paper recorder for permanent preservation of records.

All the equipment (fig. 1) was commercially available and only minor modifications were necessary to obtain an integrated system. In addition to specialized electronic instruments the coronary ambulances carry all standard equipment including Entonox (50% nitrous oxide and 50% oxygen), which can be administered by facemask or mouthpiece, and suction apparatus. All requirements for intubation and infusion are also immediately to hand on special panels, but their use is limited at present to medical personnel.

Referral and Admission Policy

The area covered by the scheme forms a semicircle within about a 10-mile (16-km) radius from the main hospital. Co-operation with the East Sussex Ambulance Service enables us to include all the population usually served by the Brighton and Lewes Hospital Group, between 300,000 in the winter and 500,000 in the summer.

General practitioners in the area were informed that the service is available for any patient who may have had a myocardian infarction or acute coronary insufficiency. A coronary ambulance is also sent in response to 999 (emergency) calls from patients, relatives, or police if the ambulance control suspects from the message that this might be appropriate. Both vehicles are used for routine duties when necessary, including transfer of acutely ill patients between hospitals, but our policy is to hold at least one in readiness for emergency use.

Every effort is made to reach patients with myocardial infarction with the least possible delay. The general practitioner is not expected to visit the patient before referral if a message leads him to suspect that a patient has had a coronary attack. In order to save more time an "open-house" admission policy is used for patients aged 55 and under (the age limit will be raised when facilities permit). The practitioner need only call for the ambulance; the hospital is notified by the control room while the vehicle is in transit. A senior house officer attached to the coronary care unit is informed of the expected time of arrival of the ambulance and whenever possible will meet the patient as he arrives. The admission of older patients is arranged in the usual way by contact with the admitting house officer or the emergency bed service. Cardiac patients collected in response to 999 calls are always assessed in the accident and emergency department.

All patients with suspected acute myocardial ischaemia are admitted to the unit regardless of age, provided a bed is available. Otherwise patients are taken to a general medical ward in the main hospital or occasionally in one or two other hospitals situated near by. Defibrillators and limited monitoring facilities are available in the medical wards as well as in the unit. During the first 12 months of the scheme 90% of all patients admitted with suspected coronary pain were accepted in the main hospital, and 68% in the four-bedded coronary care unit.

Origin of Coronary Calls

Over the first 12-month period the ambulance control received a total of 1,497 calls arising from emergencies which were considered possibly "cardiac." Of these 1,017 (68%) were made through the 999 service and 464 (31%) by general practitioners. The remaining 16 journeys involved the transfer of seriously ill patients between hospitals. The ambulance men themselves were able to rule out any cardiac emergency in 415 (41%) of the "999" cases. A total of 1,082 patients were therefore monitored as possible cardiac emergencies. This includes patients who were already pulseless before the ambulance arrived. In addition to

emergency calls the two ambulances performed routine duties, and their joint total was 3,461 journeys during the year.

Ischaemic Heart Disease in Monitored Cases

The final hospital diagnosis was checked for each patient monitored in the ambulance over the study period. Forty-one per cent. were shown to have suffered a recent myocardial infarction, and 15% to have had either acute coronary insufficiency or angina pectoris. A further 20% were found in either ventricular fibrillation or asystole. Assuming that most of these patients developed their arrhythmias as the result of myocardial infarction, the proportion with suspected ischaemic heart disease in whom the diagnosis was confirmed was 76%.

If all calls on the coronary ambulance are taken into account, including the cases in which monitoring was considered unnecessary, 55% of patients were suffering from proved ischaemic heart disease.

Delay before Hospital Admission

For nine months of the study period a record was kept for each patient of the delay between onset of principal symptoms and the events leading to hospital admission. The median times are shown in fig. 2. Understandably a marked difference was found between patients admitted as a result of 999 calls and those who were referred by general practitioners. For the 999 calls the ambulance was sent for after a median interval of eight minutes, the ambulance reached the patient after 16 minutes, and the hospital was reached after 33 minutes. The corresponding intervals for general-practitioner cases were 92, 121, and 160 minutes. Fifty per cent. of the patients subsequently known to have suffered a myocardial infarct were being monitored within 20 minutes of the onset of severe symptoms if 999 calls had been made, but for other cases the corresponding median delay was 125 minutes.

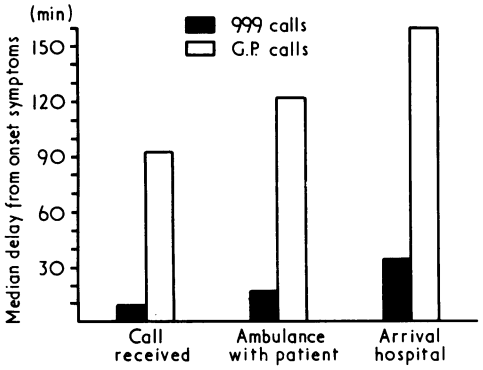

FIG. 2—Median delays between onset of symptoms and stages leading to hospital admission. Most 999 calls were obvious emergencies, and consequently the patients reached hospital with less delay than those referred through general practitioners.

For the group as a whole much of the additional delay when the general practitioners were involved was due to the patients themselves, for a median time of 43 minutes elapsed before they reported their symptoms. This was usually because the significance of chest pain was not immediately realized. Moreover, the figures given for 999 calls include patients who had collapsed and were found by the ambulance crew to be in ventricular fibrillation or asystole. The interval between the onset of illness and calling for help was shorter for this group than for those suffering less dramatic symptoms, as was the time taken for the ambulance crew to reach the patients. For the cases in which the general practitioner was alerted after an obvious collapse the additional delay due to his subsequently having to call an ambulance was on average less than eight minutes, and in only one instance did it seem possible that the outcome could have been influenced adversely.

Arrhythmia Recognition in the Ambulance

The patient's heart rhythm was not only monitored by the ambulance men using a conventional oscilloscope but also recorded during transit on magnetic tape for analysis in the coronary unit by one of us (N.M.W.). This system for checking the accuracy of diagnoses in the ambulance was available for nine months of the year under study but it was not used for patients in whom resuscitative efforts were felt to be pointless.

The ambulance men's diagnosis for all the recorded rhythms is compared in fig. 3 with the cardiac registrar's diagnosis.

Ambulance Mens' Diagnosis

Registrar's Diagnosis	S.R.	S.B.	S.V.T.	A.F.	V.T.	A.S.	V.F.	V.E.	S.V.E.	1°	2°	3°	J.R.	O
S.R.	**309**	2	8	2										1
S.B.	2	**12**										1		1
S.V.T.			**31**	1	1									1
A.F.	1		3	**44**										
V.T.					**1**									
A.S.					1	**61**	3							
V.F.							**19**							
V.E.								**41**						4
S.V.E.								3	**18**					1
1°										**11**			1	1
2°				1							**2**	1	1	
3°												**15**		
J.R.			2										**2**	
O				1	1			5	2	2				

Total diagnoses 620 Correct diagnoses 566 (91%)

FIG. 3—Comparison of ambulance men's diagnoses for heart rhythms observed during transit and cardiac registrar's diagnoses for same electrocardiograms when analysed subsequently after storage on magnetic tape. Bold figures represent line of identity.

S.R. = Sinus Rhythm. S.B. = Sinus bradycardia. S.V.T. = Supraventricular tachycardia. A.F. = Atrial fibrillation. V.T. = Ventricular tachycardia. A.S. = Asystole. V.F. = Ventricular fibrillation. V.E. = Ventricular extrasystoles. S.V.E. = Supraventricular extrasystoles. 1° = 1st-degree A.V. block. 2° = 2nd-degree A.V. block. 3° = 3rd-degree A.V. block. J.R. = Junctional (nodal) rhythm without evidence of block. O = Rhythm reported by ambulance men but not confirmed, or seen during analysis of tapes but not reported by ambulance men.

Ninety-one per cent. of a total of 620 diagnoses were judged to be correct; if sinus rhythm is excluded from this assessment the diagnostic accuracy was 86%. Some of the few incorrect diagnoses resulted from technically poor tracings—for example, supraventricular tachycardia was suspected on several occasions when the rhythm was sinus tachycardia but P waves were not clearly discernible. No mistakes were made when the correct diagnosis was ventricular fibrillation, but the ambulance men labelled three cases of asystole with baseline artefact as ventricular fibrillation and treated the arrhythmia accordingly. In seven cases in which ventricular fibrillation was present when the team reached the patient a D.C. shock was given before the tape recorder was switched on in order to avoid delay. The diagnoses could not therefore be checked in these instances.

Ventricular Fibrillation and Asystole

A total of 216 patients were pulseless when the ambulance arrived in response to emergency calls, and in most instances the

patients had clearly been dead for an appreciable time. Asystole was present in 159 instances. Resuscitative efforts (external cardiac massage and artificial ventilation) were attempted whenever it seemed appropriate but none of these patients survived. Fifty-seven patients showed evidence of some residual electrical activity on the oscilloscope, indicating ventricular fibrillation. One of these patients had been given cardiac massage and artificial ventilation in a chemist's shop while waiting for the ambulance to arrive. Defibrillation was successful (fig. 4) and the patient was admitted to hospital conscious, to be discharged in good health three weeks later. Resuscitation should have been possible in a similar case but failed because of a fault in the defibrillator. Spontaneous effective circulation could not be restored in the other 56 cases with prolonged periods of arrest, though in 16 of them D.C. shock was followed by a transient return to co-ordinated rhythm.

FIG. 4—Electrocardiogram showing successful defibrillation in ambulance. Record was preserved on magnetic tape which was delivered to the hospital with the patient for subsequent analysis. Permanent paper record was made of this and all other arrhythmias.

Eight patients developed ventricular fibrillation after the ambulance team had arrived, three after monitoring had started and a further five before or during movement to the ambulance. One of this group was pulseless before he developed a terminal arrhythmia, and despite temporary restoration of co-ordinated electrical activity after D.C. shock he died before reaching hospital. The remaining seven patients all reached hospital alive, and four survived to be discharged home.

Thus from both groups a total of eight patients with primary ventricular fibrillation were successfully resuscitated in the ambulance, but three of them died later in hospital. One of the remaining five unfortunately died at home shortly after discharge from further infarction, but four survived for periods up to 18 months.

Discussion

So far as we are aware the coronary ambulances in Brighton were the first in the country to be manned entirely by ambulance personnel. Some months after we had started our initial training programme we learnt of similar experiments both in Dublin[5] and in Oregon[6] which had been operating successfully since 1969.

Systems of this type have advantages and disadvantages when compared with conventional coronary ambulances. The principal disadvantage concerns the problems of drug administration. Up to the time of writing our ambulance men have been restricted to the use of Entonox for pain relief and defibrillation in emergency situations. On the other hand, the low cost of the scheme is a major advantage. An ambulance can be fitted with the basic equipment for monitoring and recording the electrocardiograms and for defibrillation for about £1,400 (June 1973, V.A.T. not included). Tape facilities can now be added for a little more than £100 per vehicle, with a similar outlay for the coronary care unit, which may also require an additional oscilloscope and recorder. In Brighton no new ambulances have been required and no additional staff employed.

The total cost of the service was therefore the capital outlay for the electronic equipment and the negligible maintenance charges. The lectures given to the ambulance men by one of us (D.A.C.) were neither an additional burden nor an extra expense, for the six-monthly series was already provided on a regular basis for the nurses' course in coronary and intensive care. We recognize that in other areas the organization of similar schemes may not be so convenient, and the costs would then be correspondingly greater. Speed of operation is also important. The ambulances do not have to collect or liaise with medical staff, a factor which causes delay with some of the conventional systems in use.

The ambulance men were trained to a high degree of proficiency, not only in resuscitation techniques but also in all aspects of coronary artery disease and in the recognition of arrhythmias. This gave them confidence that they would understand any problem which might arise. We considered but rejected the use of radio facilities to transmit electrocardiograms to the coronary unit on the grounds that a doctor may not always be immediately available and valuable time may be lost. The correct identification in a moving ambulance of 86% of rhythm disturbances provides impressive evidence of the expertise the ambulance men were able to acquire. The retrospective analysis of tracings recorded in the ambulance disclosed only one occasion when defibrillation was too long delayed and the presence of experienced medical personnel would have been advantageous. This resulted from a failure to stress in training that respiratory efforts usually persist after fibrillation has supervened; the attendant therefore hesitated before diagnosing and correcting the circulatory arrest. The instruction was improved as a result of this experience,and no further difficulties were encountered in the prompt recognition of fibrillation. We doubt if ambulance men should carry the responsibility of recognizing and treating life-threatening arrhythmias without comprehensive training and first-hand experience in a coronary unit.

We aim to maintain a pool of about 20 trained men, so that at least one is available for each of two ambulances at all times. This allows some latitude for holidays and sickness, yet guarantees each man sufficient specialized work to maintain proficiency.

The true value of a coronary ambulance system cannot easily be assessed. Only effective defibrillation in transit provides tangible evidence of success, but relief of pain and the treatment of dangerous bradycardia and ventricular arrhythmias may *prevent* some instances of ventricular fibrillation which would otherwise occur. Adgey *et al.*[1] found a higher mortality in patients first seen three or more hours after the onset of symptoms than in those treated early. It may not be unreasonable in the future for ambulance men to stabilize heart rhythm by administering relatively safe drugs such as atropine and lignocaine under carefully defined conditions.

Another important advantage of the system lies in the new sense of urgency which is gradually created in the community as a result of the existence of the ambulance and the publicity it inevitably receives. In Belfast over a four-year period from 1966 to 1969 the proportion of patients who were treated within one hour of the onset of symptoms increased from 13% to over 27%. For the same period the median delay before patients came under intensive care was reduced from more than eight hours to only 100 minutes. Impressive evidence of the favourable effect on mortality accruing from early coronary care has been reviewed by Pantridge and Adgey.[7] In Brighton the median

delay for all patients admitted with myocardial infarction has fallen from nearly eight hours to less than three hours following the introduction of the coronary ambulances, and the trend toward earlier referral is continuing.

We found a very great difference between the median delay for patients presenting after 999 calls and those referred from general practitioners. The type of case tended to be quite different from the two sources, for most of the 999 calls were made after patients had collapsed or been taken ill in the street. The additional delay for patients referred from home was due in large measure to the patients themselves, either because they did not appreciate the significance of the symptoms or because they wished to avoid calling a doctor at night.[8] This problem cannot easily be overcome without the risk of creating misplaced anxiety in the community and possibly overloading the medical services with unnecessary calls. We therefore face a dilemma because most potentially reversible cases of ventricular fibrillation occur within an hour or so of the onset of symptoms. The problem would be resolved at least to a small degree if patients with *diagnosed* ischaemic heart disease were advised by their general practitioners to seek help at once if cardiac pain at rest persisted for more than 10 minutes without relief from trinitrin.

We do not claim that a coronary ambulance manned only by ambulance personnel can be as successful as a conventional system. Nevertheless, our experience over a 12-month period of operation leads us to believe that it offers a worth-while and inexpensive alternative for the many areas in which a shortage of skilled medical and nursing staff has so far precluded the advantages of mobile coronary care.

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Medicine in Old Age

Cardiovascular Disease in the Old

J. WEDGWOOD

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In many cases cardiovascular disease in the old is similar to the disease in the young and middle aged, except that its pathology is weighted towards conditions such as ischaemic heart disease rather than congenital or rheumatic heart disease. This point, though perhaps obvious, needs to be made to emphasize that most forms of heart disease in the young which do not cause early death may be found in old age.

In other cases, particularly those presenting to the geriatric physician, and in patients over 75 or 80 years, the aetiology, symptoms, course, and response to treatment are all considerably modified, and need separate consideration. The present paper is concerned with this group of patients and will deal with the commoner conditions in which the differences are most appreciable, and which present particular problems to the general practitioner. Congestive heart failure is a common condition covering most aspects of heart disease, and so this paper will be limited to a discussion of this condition.

The most outstanding feature of congestive heart failure is the ease with which elderly patients develop it and the relatively good response to treatment.[1] Congestive failure may develop in patients with less clinical evidence of heart disease than would be expected in younger patients. Though there is usually evidence of myocardial or valvular heart disease, precipitating factors are particularly important and need to be recognized before the condition can be adequately treated.

The Middlesex Hospital, London W1N 8AA
J. WEDGWOOD, M.D., F.R.C.P., Consultant Physician in Geriatrics

Precipitating Factors

CHEST INFECTION

Chest infection is a particularly important factor to bear in mind. Signs of bronchopneumonia may be difficult to detect, and relatively slight infection is often sufficient to precipitate failure. The combination of chest infection and heart failure in which it is difficult to decide the relative contribution of pulmonary and cardiac factors is common.

ATRIAL FIBRILLATION

Atrial fibrillation is common in the elderly, and may be paroxysmal. When the ventricular rate is rapid it is a common cause of failure. A more serious arrthymia is atrial flutter or atrial tachycardia with atrioventricular block. This condition is difficult to detect clinically except by inspection of the venous pulse. When atrioventricular block is present with a 2 : 1 ventricular response the ventricular rate may be relatively slow and regular. It is particularly likely to occur in a patient who is being treated with digitalis for atrial fibrillation. It is a serious complication of digitalis toxicity, easily missed, and liable to be fatal.[2]