The Acute Coronary Attack

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Foreword

By Richard S. Crampton, MD, FACP, FACC, Professor of Medicine, University of Virginia

In the genesis of the U.S.A. the ethnic group most concerned in pushing the frontiers westward was the Scots-Irish. The spirit of those energetic, pragmatic, and fiercely independent Ulstermen persists in Northern Ireland to this day.

The pioneering efforts of Pantridge and his team have revolutionised emergency medical care. Mobile coronary care units modelled on the Belfast plan or adapted from it operate in all States of the Union. The spin-off from the operation of the pioneer unit has been as significant as its introduction. The Belfast workers have shown that sudden coronary death is usually due to ventricular fibrillation. They have documented the high incidence of dysautonomia and demonstrated that early acute atrioventricular block complicating myocardial infarction is usually vagogenic and responsive to atropine. They have also made the fundamental observation that early intensive care of patients with coronary thrombosis and immediate correction of the dysautonomias and rhythm disturbances may limit the amount of myocardium destroyed and reduce the incidence of cardiogenic shock and pump failure.

The introduction of the mini-defibrillator has been among the important contributions. It is likely that this will become as ubiquitous as the fire extinguisher. We will not continue to regard life as less important than property.

It is estimated that each day nearly 1,000 Americans die from acute heart attacks before they reach hospital. Commenting on this in the House of Representatives during the second session of the 92nd Congress, a distinguished American scientist said that, 'if Professor J. Frank Pantridge and his group at the Royal Victoria Hospital, Belfast, had not initiated the sequence of events they did in 1966, we might all still be largely ignorant of

the all-important early minutes after the onset of an acute heart attack. Worse yet, we would probably still not know how little we knew'.

This book is a record of the Belfast experience. I commend it to all who have any responsibility for the care of the coronary patient.

Richard Crampton,
Charlottesville.
4th July 1975.

Preface

True progress in the management of any medical or surgical emergency may be said to have occurred only when the advances in knowledge can be applied to the care of the patient. Important advances in hospital management of the acute coronary attack have occurred in the past ten years. However, the majority of coronary deaths occur before the victim reaches hospital. Thus, unfortunately, there is still in most areas a wide gap between what is being done and what is possible.

Prehospital coronary deaths now constitute one of the major problems in medicine. It is salutary to remember that in his book *Observations on Some of the Most Frequent and Important Diseases of the Heart*, published in Edinburgh in 1809, Allan Burns wrote, 'where however, the cessation of vital action is very complete, and continues long, we ought to inflate the lungs, and pass electric shocks through the chest: the practitioner ought never, if the death has been sudden, and the person not very far advanced in life, to despair of success, till he has unequivocal signs of real death'. Nevertheless, 158 years were to elapse before the first successful resuscitation from ventricular fibrillation occurring outside hospital was reported by Pantridge and Geddes.

The management of the patient in the hospital coronary care unit has been dealt with in many publications. Therefore, in this book no attempt has been made to cover all aspects of coronary care. The authors have concentrated on the organisation of the delivery of intensive care to the stricken individual and on the clinical problems of the acute phase of myocardial infarction. These problems frequently differ from those encountered in the hospital coronary care unit.

Observation of patients immediately after the onset of the coronary attack has proved pertinent to the understanding of the mechanism of sudden death. Early observation has also indicated the possibility of limiting the size of the infarct and thus diminishing the incidence of shock and pump failure.

The operation of a mobile coronary care unit in Belfast since 1966 has shown the need for reorientation of the approach to the management of the

coronary episode towards the early initiation of prehospital coronary care, and early discharge from hospital of patients no longer at risk.

The book may be of interest to those responsible for the care of the patient with acute myocardial infarction and, in particular, to personnel involved in prehospital coronary care schemes. It is hoped that it may come to the attention of administrators concerned with emergency medical services.

J. F. Pantridge

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1

Introduction

The Executive Board of the World Health Organisation (1969) has stated that, 'coronary heart disease has reached enormous proportions, striking more and more at younger subjects. It will result in coming years in the greatest epidemic mankind has faced unless we are able to reverse the trend by concentrated research into its cause and prevention' (Stamler, 1973). While the logic of primary prevention is irrefutable, it appears unlikely that much progress will be made in this direction in the immediate future. The U.S. Inter-Society Commission for Heart Disease Resources reported in 1970 that there was little convincing evidence that control of known risk factors, apart from correction of the cigarette smoking habit, reduces the incidence of coronary artery disease. Furthermore, coronary artery disease is frequently established at an early age. Approximately two-thirds of children aged five have abnormal coronary arteries and normal coronary vessels are rare after the age of fifteen (Osborn, 1963). An autopsy study of American servicemen killed in Korea showed that three-quarters of these men, average age 22, had 'some gross evidence of coronary disease' (Enos *et al.*, 1953).

More than one-quarter of a million individuals in Britain suffer from acute myocardial infarction each year. The community mortality is of the order of 40 per cent (Fulton *et al.*, 1969) so that there are over 100,000 deaths from this cause annually. The Registrar-General's Statistical Review in 1972 indicated that nearly 60,000 coronary deaths occurred among individuals under the age of 70. Coronary artery disease causes more than one-third of all deaths in the United States. There are over 600,000 coronary deaths in that country each year (Vital Statistics of the United States for 1969). Forty-one per cent of deaths among American males twenty years of age or older result from coronary artery disease (Spiekerman *et al.*, 1962).

Epidemiological data indicate that the majority of the deaths from the coronary attack are sudden. Heberden, two centuries ago, noted that patients with symptoms of ischaemic heart disease might die suddenly. McWilliam in 1889 postulated that ventricular fibrillation was the

mechanism of sudden death. The clinical features and many of the complications of coronary occlusion were documented by Dock (1896), Obrastzow and Straschesko (1910), Herrick (1912), and by Parkinson and Bedford (1928). The electrocardiographic signs were described by Smith (1918) and by Pardee (1920).

In 1899, Prevost and Battelli observed that a strong electrical current over a short period stopped experimental ventricular fibrillation. The experimental work of Hooker *et al.* (1933) and of Wiggers (1940) indicated the constant effectiveness of alternating current in defibrillating the exposed heart. Nevertheless, the therapeutic implications remained unrecognised. Indeed, when in 1939 a patient with anterior infarction was shown to die from ventricular fibrillation, Smith wrote 'the probability of being able to revive a patient with coronary occlusion from ventricular fibrillation by such means seems extremely remote'. However, in 1947, Beck *et al.* successfully defibrillated a human heart. Successful open chest resuscitations of patients with ventricular fibrillation complicating acute myocardial infarction were reported in 1956 by Reagan *et al.*, by Beck *et al.* and by Celio. In the same year, Zoll *et al.* showed that transthoracic defibrillation was possible in the clinical situation. The remarkable demonstration by Kouwenhoven *et al.*, in 1960, that blood flow to vital organs might be maintained simply by compressing the lower end of the sternum, revolutionised the concept of cardiac resuscitation. The findings of Gurvich and Yuniev in 1946, that direct current or capacitor discharge was preferable to alternating current for the correction of ventricular fibrillation, were confirmed (Lown *et al.*, 1962).

When cardiac resuscitation had become a practical proposition, Julian (1961) suggested that, 'all medical, nursing, and auxiliary staff should be trained in the techniques of closed-chest cardiac massage and mouth to mouth breathing . . . patients known to be at risk from ventricular fibrillation or asystole could have their cardiac rhythm constantly monitored'. Reports of the establishment of coronary care units soon appeared (Day, 1963; Brown *et al.*, 1963; Julian *et al.*, 1964; Meltzer, 1964; Robinson *et al.*, 1964). Within a few years the coronary care unit had become 'an integral, essential part of customary hospital practice' (Meltzer, 1969). While the initial concept of the hospital coronary care unit involved the immediate detection and prompt correction of ventricular fibrillation, attention was soon directed to the possibility of preventing ventricular fibrillation by the administration of antiarrhythmic agents. However, since some two-thirds of the deaths occur outside hospital, the reduction of hospital deaths from 30 to 20 per cent had only a small impact on the community mortality. Indeed, even if all patients with coronary thrombosis were admitted to coronary care units it would be impossible to reduce the community mortality by more than 4·5 per cent (Pantridge, 1970). The hospital coronary care unit did not influence the incidence of shock or

pump failure nor did it have a significant effect on the mortality from these complications.

The study of McNeilly and Pemberton (1968) showed that the majority of deaths from acute myocardial infarction occurred soon after the onset of symptoms. The data of Yater *et al.* (1948) and those of Bainton and Peterson (1963) indicated that sudden coronary death was more likely to occur among the younger individuals. It was found that among males 50 years and younger, 63 per cent of the deaths from acute myocardial infarction occurred within one hour of the onset of symptoms. That the majority of deaths occurred soon after the onset of symptoms was confirmed by the studies of Fulton *et al.* (1969) and those of Gordon and Kannel (1971).

Since nearly two-thirds of premature deaths occur within one hour of the onset of symptoms and since the median delay in hospital admission may be eight hours or more (Mittra, 1965; McDonald, 1968; McNeilly and Pemberton, 1968), the majority of patients with acute myocardial infarction die unattended at or near the place where they are stricken. Their predicament is somewhat similar to that of battle casualties in the eighteenth century. In 1792, Larrey, a young French army surgeon, noted the plight of the wounded. French army regulations at that time dictated that the medical personnel should remain one league (2·42 miles) behind the battle area. The wounded reached the surgical depots usually after a delay of some 24 hours and were frequently moribund or dead. Larrey devised a light vehicle that transported the surgeons and their equipment to the front line and thus revolutionised military surgery (Fig. 1.1). Napoleon

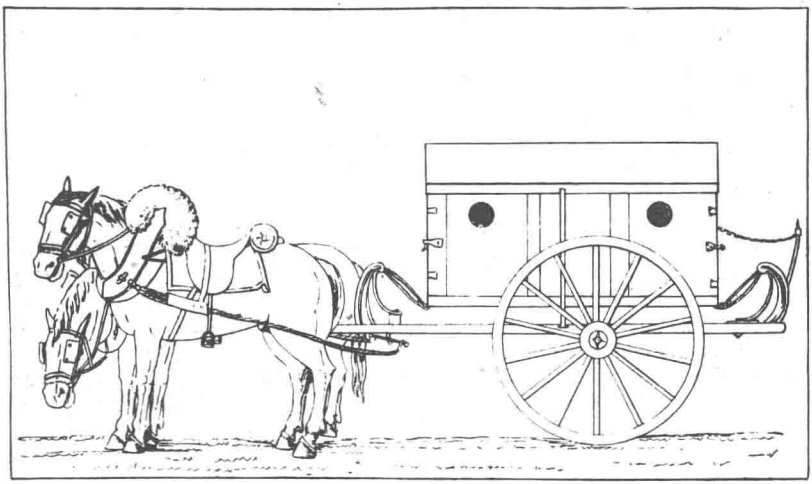

FIGURE 1.1. Larrey's Mobile Unit, 1792

described the mobile unit as one of the finest conceptions of his time. One hundred and seventy-four years later, a mobile unit to deal with coronary casualties was initiated in Belfast.

The mobile coronary care unit enables personnel trained in coronary care to reach the patient at the site of the heart attack (at home or elsewhere) as soon as possible after the onset of symptoms to start emergency treatment immediately and to continue monitoring and therapy during transport to hospital.

Attempts had been made in the U.S.S.R. to provide prehospital coronary care (Moiseev, 1962). These were limited to the treatment of shock and pump failure by a special team summoned after the personnel from the usual emergency service had reached the patient. This approach was clearly unrewarding.

Although the high incidence of early preventable deaths from acute myocardial infarction is one of the major problems in medicine in the Western World, there are still, unfortunately, many areas in which no attempt has been made to provide prehospital care.

REFERENCES

Bainton, C. R. and Peterson, D. R. (1963) Deaths from coronary heart disease in persons 50 years of age and younger. *New England Journal of Medicine*, **268**, 569.

Beck, C. S., Pritchard, W. H. and Feil, H. S. (1947) Ventricular fibrillation of long duration abolished by electric shock. *Journal of the American Medical Association*, **135**, 985.

Beck, C. S., Weckesser, E. C. and Barry, F. M. (1956) Fatal heart attack and successful defibrillation: New concepts in coronary artery disease. *Journal of the American Medical Association*, **161**, 434.

Brown, K. W. G., Macmillan, R. L., Forbath, N., Mel'grano, F. and Scott, J. W. (1963) Coronary unit: An intensive-care centre for acute myocardial infarction. *Lancet*, **ii**, 349.

Celio, A. (1956) Cardiac arrest associated with coronary occlusion: Successful resuscitation. *Journal of the International College of Surgeons*, **25**, 299.

Day, H. W. (1963) Preliminary studies of an acute coronary care area. *Journal Lancet*, **83**, 53.

Dock, G. (1896) In *Notes on the Coronary Arteries*. Ann Arbor, Michigan: The Inland Press.

Enos, W. F., Holmes, R. H. and Beyer, J. (1953) Coronary disease among United States soldiers killed in action in Korea. *Journal of the American Medical Association*, **152**, 1090.

Fulton, M., Julian, D. G. and Oliver, M. F. (1969) Sudden death and myocardial infarction. *Circulation*, **40**, Suppl. IV, 182.

Gordon, T. and Kannel, W. B. (1971) Premature mortality from coronary heart disease. *Journal of the American Medical Association*, **215**, 1617.

Gurvich, N. L. and Yuniev, G. S. (1946) Restoration of regular rhythm in the mammalian fibrillating heart. *American Review of Soviet Medicine*, **3**, 236.

Heberden, W. (1772) Some account of a disorder in the breast. *Medical Transactions of the College of Physicians, London*, **2**, 59.

Herrick, J. B. (1912) Clinical features of sudden obstruction of the coronary arteries. *Journal of the American Medical Association*, **59**, 2015.

Hooker, D. R., Kouwenhoven, W. B. and Langworthy, O. R. (1933) The effect of alternating electrical currents on the heart. *American Journal of Physiology*, **103**, 444.

Julian, D. G. (1961) Treatment of cardiac arrest in acute myocardial ischaemia and infarction. *Lancet*, **ii**, 840.

Julian, D. G., Valentine, P. A. and Miller, G. G. (1964) Routine electrocardiographic monitoring in acute myocardial infarction. *Medical Journal of Australia*, **1**, 433.

Kouwenhoven, W. B., Jude, J. R. and Knickerbocker, G. G. (1960) Closed-chest cardiac massage. *Journal of the American Medical Association*, **173**, 1064.

Lown, B., Neuman, J., Amarasingham, R. and Berkovits, B. V. (1962) Comparison of alternating current with direct current electro-shock across the closed chest. *American Journal of Cardiology*, **10**, 223.

McDonald, L. (1968) The London hospital. In *Acute Myocardial Infarction:* Proceedings of a Symposium (Ed. Julian, D. G. and Oliver, M. F.), p. 29. Edinburgh: E. and S. Livingstone.

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.

McWilliam, J. A. (1889) Cardiac failure and sudden death. *British Medical Journal*, **1**, 6.

Meltzer, L. E. (1964) The concept and system for intensive coronary care. *Bulletin of the Academy of Medicine of New Jersey*, **10**, 304.

Meltzer, L. E. (1969) The present status and future direction of intensive coronary care. In *Coronary Heart Disease, Cardiovascular Clinics*, Volume 1, Number 2 (Ed. Brest, A. N.), p. 177. Philadelphia: F. A. Davis Company.

Mittra, B. (1965) Potassium, glucose and insulin in treatment of myocardial infarction. *Lancet*, **ii**, 607.

Moiseev, S. G. (1962) The experience of rendering first aid to myocardial infarction patients in Moscow. *Sovetskaya Meditsina*, **26**, 30.

Obrastzow, W. P. and Straschesko, N. D. (1910) Zur kenntnis der thrombose der koronararterien des herzens. *Zeitschrift für Klinische Medizin*, **71**, 116.

Osborn, G. R. (1963) The problem of coronary disease: Methods of investigation. In *The Incubation Period of Coronary Thrombosis*, p. 5. London: Butterworths.

Pantridge, J. F. (1970) Mobile coronary care. *Chest*, **58**, 229.

Pardee, H. E. B. (1920) An electrocardiographic sign of coronary artery obstruction. *Archives of Internal Medicine*, **26**, 244.

Parkinson, J. and Bedford, D. E. (1928) Cardiac infarction and coronary thrombosis. *Lancet*, **i**, 4.

Prevost, J. L. and Battelli, F. (1899) La mort par les courants électriques: Courants alternatifs a haute tension. (Death by electric currents alternating

at high tension). *Journal de Physiologie et de Pathologie Générale*, **1**, 427.
Reagan, L. B., Young, K. R. and Nicholson, J. W. (1956) Ventricular defibrillation in a patient with probable acute coronary occlusion. *Surgery*, **39**, 482.
Registrar-General's Statistical Review (1972) London: Her Majesty's Stationery Office.
Robinson, J. S., Sloman, G. and McRae, C. (1964) Continuous electrocardiographic monitoring in the early stages after acute myocardial infarction. *Medical Journal of Australia*, **1**, 427.
Smith, F. J. (1939) Ventricular fibrillation as a cause of sudden death in coronary artery thrombosis. *American Heart Journal*, **17**, 735.
Smith, F. M. (1918) The ligation of coronary arteries with electrocardiographic study. *Archives of Internal Medicine*, **22**, 8.
Spiekerman, R. E., Brandenburg, J. T., Achor, R. W. P. and Edwards, J. E. (1962) The spectrum of coronary heart disease in a community of 30,000. *Circulation*, **25**, 57.
Stamler, J. (1973) Epidemiology of coronary heart disease. *Medical Clinics of North America*, **57**, 1, 5.
U.S. Inter-Society Commission for Heart Disease Resources (1970) Report on primary prevention of the atherosclerotic diseases. *Circulation*, **42**, A-55.
Vital Statistics of the United States for 1969 (1973) Volume II–Mortality, Part B. United States Department of Health, Education and Welfare. Public Health Service. National Centre for Health Statistics. Rockville, Maryland.
Wiggers, C. J. (1940) The physiologic basis for cardiac resuscitation from ventricular fibrillation—method for serial defibrillation. *American Heart Journal*, **20**, 413.
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: Report of 866 cases, 450 with necropsy examinations. *American Heart Journal*, **36**, 334, 481, 683.
Zoll, P. M., Linenthal, A. J., Gibson, W., Paul, M. H. and Norman, L. R. (1956) Termination of ventricular fibrillation in man by externally applied electric countershock. *New England Journal of Medicine*, **254**, 727.

2

Prehospital Coronary Care Schemes

Mittra found that in Belfast, in 1965, the hospital admission of a large proportion of patients with acute myocardial infarction was delayed more than twelve hours. Many factors were concerned in the delay. Some patients did not seek medical help immediately. Others were unable to contact their family doctor. Practitioners were not all aware of the high risk of sudden and preventable death. The ambulance service was not always able to deal with the call immediately and patients with myocardial infarction were frequently unnecessarily delayed in casualty departments. It was reasoned that it should be possible to eliminate the causes of delay apart from that due to the patient's procrastination in seeking medical help (Pantridge and Geddes, 1966, 1967). It was hoped that public awareness might result in reduction in the patient delay.

The prototype mobile coronary care unit was initiated in Belfast in 1966. The Royal Victoria Hospital, the major teaching hospital, seemed geographically well situated for the operation of such a unit since it was near the centre of the city, the population of which was 550,000, of whom 100,000 lived within a one mile radius of the hospital. The ambulance depot for the city was in the hospital grounds some 300 yards from the coronary care unit. Thus, it was possible to integrate a mobile coronary care unit into the existing emergency service. The family doctors in Belfast were acquainted with the facts regarding the risk of unnecessary death immediately after the onset of symptoms suggesting acute myocardial infarction. A training scheme in the technique of resuscitation was arranged for medical practitioners, for some paramedical workers, and for appropriate lay individuals. The family doctors were given a special telephone number which enabled them to reach the coronary care unit directly. Delays at the hospital telephone exchange were thus avoided. The scheme initiated in 1966 continues to operate without significant modification.

A short-wave radio system enables the duty doctor in the coronary care unit to receive immediately the call for the mobile unit. A signalling system facilitates the rapid activation of ambulance control and an ambulance proceeds from the depot, *A* (Fig. 2.1) to the rendezvous point, *R*, where the

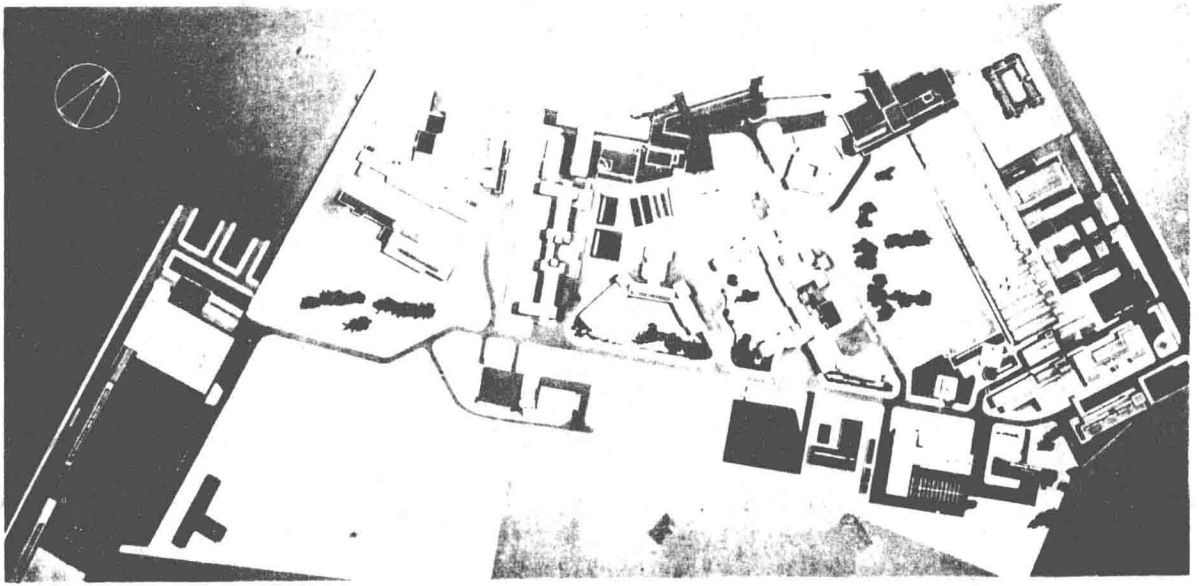

FIGURE 2.1. Plan of hospital area
A = ambulance depot; R = rendezvous point; T = telephone exchange; W = ward

coronary care unit personnel, a doctor and a nurse or medical student, are waiting. The team is on its way within two minutes of the receipt of the signal from the family doctor or member of the public. It proceeds with all possible speed to the patient.

The ambulance carries—

1. A battery-operated portable direct current defibrillator.
2. Oxygen, Ambu bags, endotracheal tubes, and suction apparatus.
3. A battery-operated monitoring oscilloscope and tape recorder.
4. Drugs and intravenous solutions normally available in a coronary care unit, including atropine and beta-blocking agents.

All the equipment is portable. The hardware is robust and, as far as possible, foolproof. Since the apparatus must, on occasions, be carried some distance and possibly in haste up several flights of stairs, the monitoring equipment and defibrillator are light and compact. It is unnecessary to use clumsy, expensive, and heavy defibrillators since small models are available.

When the team reaches the patient he will be under the same intensive care conditions as obtain in a hospital coronary care unit (Fig. 2.2). Fifty per cent of the patients are reached within ten minutes of receipt of the call from the family doctor or lay individual and nearly threequarters are reached within fifteen minutes.

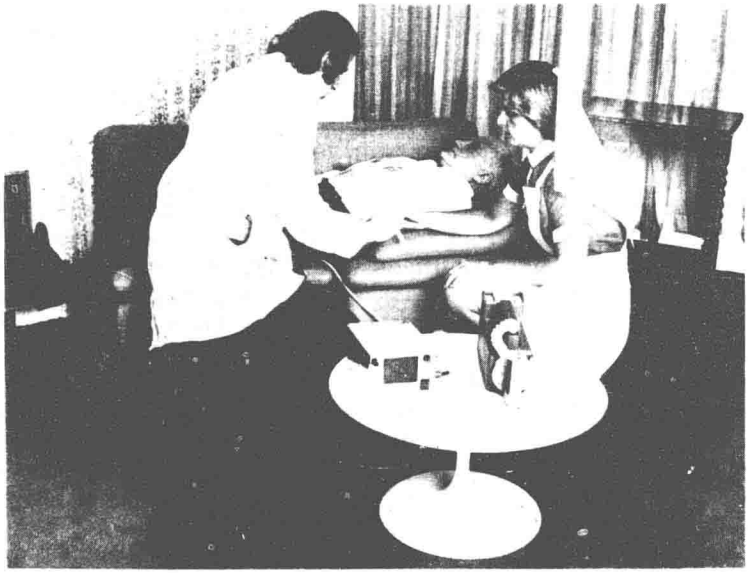

FIGURE 2.2. Initiation of monitoring and therapy in patient's home

FIGURE 2.3. Monitoring during transport

If the message the family doctor receives suggests a myocardial infarction he will summon the mobile unit immediately and before he has seen the patient. A proportion of calls necessarily come from the general public, who dial '999' when unable to contact the general practitioner. Selected calls are referred to the coronary care unit personnel for screening. If the family doctor should, because of geographical proximity, reach the patient before the mobile unit, he may improve the patient's chance of survival by initiating immediately therapy for the relief of pain and for the control of autonomic disturbance or dysrhythmias. When the mobile team arrives, therapy is initiated or that of the general practitioner continued. Pain is relieved by intravenous heroin. Stabilisation of the rhythm may require anti-arrhythmic agents, atropine, beta-blocking agents, or a combination of these drugs. Pain relief, stabilisation of the rhythm, and correction of the autonomic disturbance are considered mandatory before movement. Monitoring and therapy are continued during transport (Fig. 2.3). Haste or fuss during transport is most carefully avoided. The patient is transferred directly from the ambulance to the hospital coronary care unit, monitoring continuing during this transfer (Fig. 2.4).

Since the ambulance depot for the City of Belfast is in the grounds of the Royal Victoria Hospital and the mobile coronary care unit operates through the ordinary emergency system, employment of ambulance