Advances in acute coronary care

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THE first description of the intensive care of patients suffering from acute myocardial infarction was published by Day in 1963. This was followed by the widespread development of intensive care units, some devoted entirely to coronary care. Results from these units have demonstrated clearly, that it is possible to obtain a significant improvement in the mortality rate of patients suffering from myocardial infarction who are cared for in these units as opposed to those in the general wards of the hospital.

However, in spite of this improvement in hospital mortality, the overall mortality rate from the disease has not been appreciably affected. The vast majority of patients dying from the disease, do so outside hospital, either before medical aid can reach them, or while under the care of the general practitioner, or at some stage during their transfer from the site of their initial attack to the intensive care unit.

This study was conducted to discover whether any of the principles of treatment developed in intensive care units could reasonably be applied to treatment of patients either at home, or before admission to the CCU, and to attempt some evaluation of attempts made to bring intensive care out of hospital to the patient.

Experience in intensive care units has brought about a complete reorientation of the management of patients suffering from acute myocardial infarction. Fifteen to twenty years ago treatment was limited to three well established traditional methods:

1. The relief of pain by opiates
2. Complete physical rest
3. Treatment of congestive heart failure by digitalis and diuretics.

This passive approach has persisted to a considerable extent in general practice, and many patients recover from the disease, under the care of the general practitioner, with no more treatment than the initial relief of pain and good nursing by the relatives. Prior to the development of intensive care units, hospital treatment remained basically the same as that given in general practice, the principal difference being the skilled nursing care throughout the 24 hours.

The ability to prevent and treat lethal cardiac arrhythmias by the use of drugs and DC shock introduced a completely new factor. The development of intensive care units and the attempts to bring this care to the patient, have changed a passive to an active programme of treatment for the coronary patient.

Initially, the care of the patient suffering from an acute myocardial infarction in an intensive care area of a hospital was characterized by:

1. Continuous electrocardiographic monitoring of the patient by a team of specially-trained nurses
2. The immediate treatment of cardiac arrest by electrical conversion by a resident medical officer.

In 1967 Lown from the Peter Bent Brigham Hospital in Boston, and Killip from Cornell University Medical College, New York, published important papers reporting disappointing results of treatment based on these principles. Their experience led them to suggest the need for a shift in emphasis from the treatment of cardiac arrest to its prevention. "It is our thesis that in the majority of instances, the occurrence of sudden cardiac arrest from derangement in heart rhythm presents an avoidable catastrophe."

(Lown 1967). This approach produced an immediate fall in hospital mortality and has become standard practice in coronary care units.

Essentially the emphasis has been altered from the treatment of cardiac arrest when it occurs, to a programme designed to prevent cardiac arrest, by the early identification and the treatment of dangerous premonitory arrhythmias.

Intensive coronary care now consists of:

1. The continuous electrocardiographic monitoring of the patient by a team of nurses trained to recognize and report sinister alterations in the ECG—particularly the occurrence of certain identifiable arrhythmias
2. The active and vigorous treatment of these arrythmias when they are observed
3. The immediate treatment of cardiac arrest by the trained nursing staff—using a defibrillator—without waiting for the arrival of the medical officer. This is particularly valuable when the shortage of medical staff makes the continual presence of a doctor in the unit throughout the 24 hours impracticable.

At the same time the coronary care units have provided an opportunity for the intensive study of the pathological processes of myocardial infarction—by conitnuous clinical observation, electrocardiography, and frequent biochemical estimations.

Finally there is continual assessment and critical evaluation of the treatment given in the units.

The three major causes of death following coronary occlusion are:

1. Rhythm disturbances, particularly ventricular fibrillation
2. Pump failure resulting in decreased cardiac output and cardiogenic shock
3. Acute congestive cardiac failure.

Probably the majority of patients dying in the acute phase of a coronary occlusion do so from ventricular fibrillation. This is particularly true of the early deaths i.e. those occurring immediately or in the first few minutes of the attack. "There are two especially dangerous periods during which ventricular fibrillation may occur. The first ten minutes after infarction takes place are critical. If ventricular fibrillation does not take place during this period—a period of relative safety may follow—with a second period of extreme cardiac instability beginning three to five hours after the occlusion and lasting for another five to six hours." (Guyton 1960). The work of the Belfast mobile unit casts some doubt on this 'period of relative safety'—but all workers agree that the period of maximum risk is immediately after the infarct has occurred, and during the following 24 hours.

At least three factors enter into the tendency of the heart to fibrillate. First, acute ischaemia of the cardiac muscle causes rapid depletion of the intracellular potassium ions, and a corresponding increase in the potassium ion concentration in the extracellular fluid. Experiments in which the extracellular potassium has been raised have demonstrated an increase in the irritability of the cardiac muscle. Secondly, the ischaemic muscle cannot repolarise its membranes and remains negative with respect to the surrounding normal cardiac muscle, so that a current of injury flows from the ischaemic muscle to the normal area and can initiate an abnormal impulse leading to fibrillation. Thirdly, powerful sympathetic reflexes develop after a major occlusion, increasing the irritability of the cardiac muscle, thereby predisposing to fibrillation. Similar sympathetic stimulation may take place as a result of fear and operate in the same manner.

Cardiac arrhythmias

In a series of 300 patients studied in a CCU, 90 per cent of the patients showed some form of arrhythmia during the first 72 hours.

Various classifications of arrhythmias have been suggested, commonly depending on the anatomical site of origin i.e. atrial, atrioventricular junctional, or ventricular.

Lown (1969) has suggested that a more appropriate classification is one based on the underlying physiological disorder, and this both relates the findings to the clinical situation and provides guide lines for therapy. Under this classification arrhythmias are divided into:

1. *The arrhythmias reflecting the primary electrical instability of the heart*
   (a) Ventricular tachycardia
   (b) Ventricular extrasystoles
   (c) Ventricular fibrillation
2. *The bradyarrhythmias*
   (a) Sinus bradycardia
   (b) Nodal rhythm
   (c) Heart block
3. *The arrhythmias associated with pump failure*
   (a) Sinus tachycardia
   (b) Atrial extrasystoles
   (c) Atrial and nodal tachycardia
   (d) Atrial flutter
   (e) Atrial fibrillation.

The arrhythmias of primary electrical instability

Ventricular extrasystoles constitute the most frequent arrhythmia in myocardial infarction. In each unit visited, the frequency of extrasystoles was recorded by the nurse watching the monitor. Prophylactic treatment was instituted if:

1. The frequency exceeded six per minute
2. If runs of two or more extrasystoles occurred
3. If they were multifocal in origin
4. If they showed the phenomenon of R on T, i.e. if the R wave of the ectopic beat falls on the T wave of the preceding ventricular complex. This combination is liable to induce ventricular fibrillation.

In hospital these conditions can be observed on the electrocardiograph and prophylactic treatment instituted. Experience in the mobile coronary care unit suggests that the prophylactic treatment of ventricular ectopic beats is an important factor in the prevention of ventricular fibrillation during transit to hospital. Unfortunately ventricular fibrillation can develop very rapidly, either immediately after a short burst of extrasystoles, or with no premonitory signs at all. If no ECG is available the presence of frequent ectopic beats may be detected by prolonged auscultation of the heart or constant palpation of the radial pulse. Ventricular tachycardia, which produces a ventricular rate greater than 100 beats per minute, is of sinister import, being frequently followed by ventricular fibrillation.

Fortunately, in the majority of cases, both these arrhythmias can be controlled by the use of intravenous lignocaine. Given slowly intravenously as a 'bolus' of 50–100 mg it is effective within 15–30 seconds. The duration of action is only 20–30 minutes. It is metabolized in the liver, only ten per cent of the drug appearing in the urine, so that it may be used even in the presence of oliguria.

Lignocaine has few adverse effects on the circulation. The cardiac rate, blood pressure, peripheral resistance and cardiac output remain unchanged. In 88 per cent of patients it is effective in controlling both ventricular extrasystoles and ventricular tachycardia, but in a small number of cases the arrhythmia may be made worse. Ideally the heart's action should be monitored visually on an oscilloscope, during the administration of intravenous lignocaine. Under the usual domiciliary conditions the best that can be achieved is constant observation of the apex beat, or radial pulse, while the injection is being given. Vomiting and epileptiform convulsions occur in a small percentage of patients, and respond to intravenous chlorcyclizine hydrochloride 50 mg (Valoid).

In view of the transitory effect of a single dose of lignocaine, further prophylaxis

is achieved in hospital practice by a continuous transfusion of lignocaine in five per cent dextrose adjusted to run at 1 mg/minute. It is virtually impossible to use this treatment in domiciliary practice, unless some trained person is travelling in the ambulance to supervise the rate of transfusion. However, it has recently been shown that a dose of 200 mg lignocaine given intramuscularly produces an effective plasma level of 1 microgram per ml after 15 minutes, persisting for two hours.

This offers an effective and theoretically safe method of control of premonitory arrhythmias, which can be used in domiciliary practice, before patients are transferred to hospital. So far there has been no large scale trial of this method.

Patients who have shown extrasystoles, or ventricular tachycardia, controlled by lignocaine, are particularly prone to develop further episodes of arrhythmia during the following 48 hours. In the majority of units, procaine amide 250 mg qds orally is given as a prophylactic, and continued in this dose for a minimum period of six weeks. Procaine amide may be given intravenously to patients not responding to lignocaine. A total of 1G is given in divided doses. However, procaine amide exerts a profound depressive effect on the myocardium, accompanied by systemic hypotension, and its parenteral use is only safe under conditions of intensive care.

The anticonvulsant drug, phenytoin sodium, has also been shown to have marked antiarrhythmic properties, 250 mg intravenously in divided doses being given. Myocardial depression and hypotension restrict the use of phenytoin sodium also to hospital practice. It is reasonable and safe for the practitioner to initiate antiarrhythmic therapy, in any patient exhibiting signs of ventricular irritability, before the patient is sent to hospital. A 'bolus' intravenous injection of 50 mg lignocaine in one per cent solution, followed by an intramuscular injection of 200 mg lignocaine would provide adequate prophylaxis for a period of at least two hours.

Bradyarrhythmia

Bradyarrhythmia is more common, of more serious significance, and more readily corrected, than is generally realized. In a series of patients studied by the Belfast mobile team, 61 per cent of the patients suffering from posterior myocardial infarction, who came under intensive care within one hour, were found to have bradyarrhythmia. In 43 per cent this dysrrhythmia was present at the time of the initial examination.

Patients are considered to have bradyarrhythmia if the pulse rate is less than 50 per minute. It is particularly dangerous if associated with ventricular ectopic beats or hypotension. Excessive vagal discharge, manifested by bradyarrhythmia, is thought to be an important precursor of ventricular fibrillation, and an important factor in the early high mortality from myocardial infarction. Abolition of this excessive vagal activity by intravenous atropine is a valuable method of treatment. Several cardiologists believe that atropine is often used in inadequate dosage. It is usually given in a dose of 0.6 mg intravenously, but 1.2 mg is often required to obtain a significant increase in the cardiac rate, and doses as large as 3 mg have been given. Most patients suffering from sinus bradycardia show an increase in cardiac rate, and an increase in systolic blood pressure, within five to ten minutes of administration of the drug. Extrasystoles associated with the bradycardia may be abolished by atropine. In a few cases, the increase in cardiac rate is accompanied by the development of ventricular extrasystoles.

Nodal bradycardia and heart block are frequently temporary phenomena, resulting from ischaemia of the atrioventricular node and conducting tissues.

First degree heart block, shown by a prolongation of the P-R interval over 0.2 second requires no treatment. Usually no further degree of heart block develops. Stable second degree heart block, e.g. 2:1 heart block, often associated with diaphrag-

matic infarction, may require treatment. Again this is assessed by the ventricular rate. If the pulse is below 50 per minute intravenous atropine is indicated, and frequently a good response results from its use. Occasionally patients suffering from second degree heart block require electrical pacing. In Belfast, such patients are paced electrically at 90 beats per minute. If, however, the patient is *in extremis* from second degree or complete heart block, particularly if accompanied by Stokes-Adams attacks, the heart can be paced mechanically by thumping the precordium. It is important to make sure that this form of pacing produces good peripheral pulses.

If a good circulation is not rapidly restored, provided that frequent extrasystoles are absent, an infusion of isoprenaline 2 mg in 500 ml of 2.5 per cent sodium bicarbonate solution is set up, and given cautiously at 10–30 drops per minute. This treatment carries a high risk of inducing a fatal ventricular fibrillation, and is only safe under constant ECG control, with a ready-charged defibrillator at the patient's bedside. The aim here is to speed the ventricular rate to 55–65 beats per minute.

The arrhythmias of pump failure

Atrial arrhythmias, particularly atrial fibrillation, develop most commonly in patients suffering from large infarcts, who show clinical signs of left ventricular failure and cardiogenic shock. They are associated with a more grave ultimate prognosis than ventricular arrhythmias, although ventricular arrhythmias offer a more immediate threat to the patient's life. They can be regarded as secondary phenomena of a failing myocardium.

Digitalization and diuretics remain the principal methods of treatment. In this country intravenous digoxin remains the drug of the first choice. Lown and other American workers have pressed the claim of ouabain as being both more rapid in action and more rapidly excreted. Peak effective levels after an intravenous dose of 0.2 mg are achieved in 30 minutes, and persist for four to six hours. In urgent cases 0.2 mg is given intravenously every 30 minutes for three doses. The fear that the use of intravenous digoxin early in myocardial infarction may initiate ventricular fibrillation has caused some clinicians to suggest that cardioversion is the optimal treatment for atrial as well as ventricular arrhythmias, but this is by no means agreed.

Intravenous frusemide (Lasix) holds first place as the diuretic of choice in a dosage of 40–80 mg intravenously. All patients on long continued oral or parenteral diuretics received oral potassium supplements in the form of Tabs Slow K 2 tds.

The physical signs of dyspnoea and basal crepitations remain the standard clinical criteria for the diagnosis of left ventricular failure.

In hospital portable chest radiography provides a more accurate estimate of pulmonary venous congestion. Full biochemical studies, particularly serum potassium estimations, were carried out daily as a routine. The maintenance of adequate serum potassium levels was regarded as of extreme importance.

Ventricular fibrillation and ventricular asystole

Ventricular fibrillation and ventricular asystole together account for the majority of early deaths in myocardial infarction. The prognosis of the two conditions is completely different. Ventricular asystole, characterized by small, infrequent, ineffective, ventricular contractions carries a poor prognosis. Ventricular fibrillation on the other hand is treatable provided a person trained in external cardiac massage and mouth-to-mouth resuscitation is able to commence resuscitation within four minutes. The work of the mobile units has shown that life can be maintained for a period of up to 30 minutes, but the underlying arrhythmia cannot be rectified without electrical defibrillation. A shock of 200–400 watt seconds is administered using paste-coated

electrodes applied at the cardiac apex and the substernal notch.

"The specific treatment of ventricular fibrillation is electrical defibrillation. This catastrophic arrhythmia rarely converts spontaneously. Instances have been reported in which doctors worked heroically for hours using closed chest resuscitation, finally to be defeated because they did not realize that the heart must be electrically defibrillated" (Corday 1967).

Inflation of the lungs with oxygen or air from an Ambu bag before commencing closed chest massage is a valuable measure in reversing the inevitable hypoxia accompanying cardiac arrest.

All units used prophylactic lignocaine after electrical defibrillation and the transfusion of bicarbonate to rectify acidosis. Cerebral oedema was treated by infusions of mannitol.

Cardiogenic shock

Some degree of shock, as manifested by pallor, sweating, restlessness, tachycardia and falling blood pressure is inseparable from myocardial infarction. In the majority of patients this condition is reversible, and adequate relief of pain and the administration of oxygen lead to a steady improvement.

There remains a group of patients who, in spite of treatment, steadily deteriorate. They exhibit profuse sweating, a blotchy cyanosis of the skin, and confusion leading to unconsciousness. The blood pressure drops and the systolic blood pressure stays below 80 mm Hg.

There have been few detailed studies of the haemodynamic state of patients suffering from cardiogenic shock. Methods of treatment have been instituted based on hypovolaemic shock following blood loss, or surgical shock associated with sepsis, particularly peritonitis. Recent studies of patients in intensive care units have shown that a common clinical picture may result from widely divergent circulatory disorders. Persistent hypotension and shock is not necessarily accompanied by the signs of peripheral vasoconstriction.

The most common haemodynamic findings are:

1. A precipitous fall in cardiac output, particularly in stroke volume.
2. A systolic blood pressure below 80 mm Hg. This pressure is critical in the maintenance of adequate coronary perfusion. Below this level the myocardium suffers from a vicious circle of steadily increasing ischaemia leading to further deterioration in cardiac output.
3. Sweating, pallor and mottling of the skin are manifestations of intense peripheral vasoconstriction. Initially a result of adrenergic reflexes leading to redistribution of blood into the vital areas of the cerebral and coronary circulation, its persistence results in a vicious circle of tissue hypoxia. Constriction of the pre- and post-capillary sphincters causes capillary stagnation with resultant tissue oxygen deficit, anaerobic tissue metabolism, and the development of metabolic acidosis.
4. This capillary stagnation is well marked in the lungs. There is closure of many alveoli with the development of arteriovenous shunts, and the transudation of an albumen-rich fluid into the alveoli. The resulting deficient oxygenation in the pulmonary circulation, further decreases the amount of oxygen available to the damaged myocardium.
5. In the kidney, similar vasoconstriction leads to a decrease in filtration, and oliguria or anuria.

A variety of agents have been suggested in cardiogenic shock in an endeavour to rectify the abnormal haemodynamic state. Their effective use is limited by lack of accurate information of the circulatory abnormality in each particular case.

Pressor Agents. Noradrenaline, aramine and dopamine, increase the arterial pressure and improve cardiac contractility. Unfortunately this effect is only temporary, and is accompanied by an increased peripheral vasoconstriction, and a subsequent increase in the 'work load,' placed on an already failing myocardium.

Vasodilators. Phenoxybenzamine and chlorpromazine block the effect of cate-

cholamines on the alpha receptors in the pre-and post-capillary sphincters. It is claimed that the use of these drugs achieves a more equitable blood flow to all tissues. The tissues are perfused more evenly but at a lower perfusion pressure. Total blood flow through the tissues is enhanced, and the risk of anuria is lessened.

Phenoxybenzamine is given by intravenous infusion one mg per kilo in 100 ml of five per cent dextrose over a period of two to four hours. A number of patients receiving phenoxybenzamine develop intense bronchospasm. Chlorpromazine (Largactil) effects a weaker alpha blockade, and can be given intravenously slowly over ten minutes. The resulting vasodilatation carries the risk of reducing the 'effective' circulating blood volume, thus lowering the central venous pressure to a dangerous level.

Steroids. Dietzmann and Lillehei (1967) in America, have shown that extremely large doses of steroids may be effective in reducing the intense peripheral vasoconstriction, so lowering the peripheral resistance. There is also a possible cellular effect in sparing the integrity of the cell membranes. The doses of glucocorticoid used are far larger than those in normal clinical use.

Methylprednisolone sodium succinate is given in doses of 1.5 gm intravenously. Hydrocortisone is given in doses of 150 mg per kilogram, and Dexamethasone six mg per kilo. Improvement should be obvious in five minutes. This method has the advantage of being a single intravenous injection, requiring no elaborate continuous transfusion, and of producing a smooth vasodilation.

Isoprenaline. This agent has a beta adrenergic stimulating effect on the myocardium, and a weak vasodilator effect. It increases the force of the ventricular contraction with a coincident rise in oxygen consumption, dilates the coronary vessels producing improved myocardial oxygenation and also dilates the vessels of muscle, skin and gastro-intestinal tract. It has a bronchodilator effect. It is given by intravenous infusion at one to eight micrograms per minute. If given too rapidyl, sweating, tachycardia and further ischaemic pain result, probably from sudden increase in the left ventricular oxygen requirements.

Intravenous fluids

In an attempt to increase the cardiac output by raising the central venous pressure 100 mls of five per cent dextrose in water have been given. When effective, the jugular venous pressure rises steeply by up to ten cm. After a few minutes it drops, and as it does so the arterial pressure rises. Further small volumes of fluid are given, and the process repeated until a stable and adequate circulation is established.

In those patients in whom this treatment is unsuccessful, the central venous pressure is raised, and remains raised at this level, without any improvement in the patient's condition. Low molecular weight dextran has also been given in a similar manner. The principal danger lies in the risk of precipitating acute pulmonary oedema.

Few, if any, of these drugs are suitable for use in general practice, although they may be of value under conditions of mobile intensive care.

The domiciliary management of the severely shocked patient appears to be limited to:

1. Adequate relief of pain by the cautious use of heroin
2. The administration of oxygen
3. Elevation of the lower limbs to improve the venous return
4. The correction of arrhythmias
5. Possibly the use of large doses of steroids
6. A trial of the continuous use of intravenous fluids in the patient *in extremis* from cardiogenic shock, would appear to be justified.

Analgesics in myocardial infarction

The majority of patients suffering from acute myocardial infarction experience intense chest pain accompanied by acute anxiety, dyspnoea and restlessness. The effective relief of pain is not only valuable in itself, but also may prevent the development of cardiogenic shock, and lessen the incidence of arrhythmias. In all the units visited heroin (diamorphine hydrochloride) had superseded all other analgesic drugs. In general practice, morphine, omnopon and pethidine are still in use.

In 1967 Dr Alexander Muir analysed the circulatory effects of the analgesic drugs in common use. He compared the pain relieving, haemodynamic and subjective effects of 5 mg heroin, 10 mg morphine and 100 mg pethidine hydrochloride.

The majority of patients receiving five mg heroin intravenously fell asleep or became drowsy, and made no complaint of unpleasant side effects. There was a transitory fall in mean aortic pressure of five mm Hg but no alteration in cardiac rate or output.

Morphine 10 mg intravenously gave adequate pain relief, but the mean aortic pressure fell significantly by up to 20 mm Hg within five minutes of the injection. There was a compensatory increase in cardiac output. Patients who are either propped up in bed, or carried downstairs in the semi-upright position in a stretcher chair, after an intravenous dose of morphine may exhibit a marked vasovagal response. This may result in faintness, unconsciousness and sometimes death caused by the precipitous fall in blood pressure.

Approximately half the patients who received pethidine hydrochloride 100 mg intravenously, while admitting adequate relief of pain, felt dizzy and nauseated. This was accompanied by profuse sweating. After a transitory rise the mean aortic pressure fell by 20 mm Hg, cardiac output was diminished and peripheral vascular resistance increased.

It follows that heroin is the most effective analgesic, produces the least unpleasant side effects, and causes minimal changes in the circulatory state.

(To be concluded.)

At length an advertisement headed "Apprentice wanted," met his father's eye; and George was offered, and accepted to fill the vacant station at Wickham-Brook, a small village near Bury St Edmunds. He left his home and his indulgent mother, under the care of two farmers, who were travelling across the country; with whom he parted within about ten miles of the residence of his future master, and proceeded, with feelings easily imagined in a low-spirited, gentle lad, to seek a strange, perhaps a severe, home. Fatigue also contributed to impart its melancholy; and the reception augmented these feelings to bitterness. Just as he reached the door, his master's daughters, having eyed him for a few moments, burst into a violent fit of laughter, exclaiming " La! here's our new 'prentice." He never forgot the deep mortification of that moment; but justice to the ladies compels me to mention, that shortly before that period he had had his head shaved during some illness, and, instead of the ornamental curls that now embellished the shorn, he wore, by his own confession, a very ill-made scratch-wig. This happened when he was in his fourteenth year, in 1768 . . .

Whether my father complained of the large portion of agricultural tuition he received gratis, I know not; but, not being bound by indenture, he was removed, in the year 1771, to a more eligible situation, and concluded his apprenticeship with a Mr Page, surgeon at Woodbridge, a market-town seventeen miles from Aldborough. Here he met with companions suitable to his mind and habits, and, although he never was fond of his destined profession, began to apply to it in earnest . . .

The life of George Crabbe by his son, 1834.