

THE TREATMENT OF TOTAL HEART BLOCK BY IMPLANTABLE PACEMAKER*

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«. it is reported that a child, three years old, fell from a one pair of stairs window upon the pavement, and was taken up without signs of life. A medical practioner being sent for, declared that nothing could be done, and the child was irrevocably dead; but a gentleman having proposed a trial of electricity, the parents consented. At least twenty minutes elapsed before he could apply the shock, which he gave to various parts of the body without any appearance of success. On directing a few shocks through the *chest* (italics are in the original), a small pulsation became perceptible, and soon after the child began to sigh, and to breathe though with great difficulty: in about ten minutes it vomited. A kind of stupor remained for some days; but it was restored to perfect health and spirits in about a week.» (1)

These sentences, taken from the Register of the Royal Humane Society for the year 1774, were quoted by John Aldini, a nephew of Galvani, in a report on the use of electrical shock in resuscitation. It is hardly possible to believe that this child was dead for twenty minutes, since it recovered without any evidence of central nervous system damage. However, the report is of historical interest in that it shows a recognition of the possible use of electricity in cases of cardiac arrest, as early as the late 18th Century.

One hundred and seventy eight years elapsed before electrical stimulation would be used for the treatment of heart disease. Zoll (2) treated heart block and cardiac arrest by external electrodes in 1952. This method has not been used widely because of the discomfort of the pectoral contractions and the skin burns. In 1957, Lillehei (3) used direct stimulation of the myocardium for the treatment of surgical heart block. The morbidity and mortality using this method was quite high, due to the incidence of dangerous infections. At last Chardack (4) was able to use the first implantable pacemaker on

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April 18, 1960. This method greatly reduced the danger of infection and the patients found it more suitable psychologically.

Under normal conditions the cardiac rate is controlled by the sino - auricular node, located at the junction of the superior vena cava and the right atrium. This node is the «pacemaker» of the heart. However, in some cardiac arhythmias, this function is taken over by the atrioventricular node, or ventricles. The result is total or partial heart block. The rate of the atrioventricular node is much slower than that produced by the sino-auricular node — about 40 beats per minute. Cardiac output can be made adequate, even at this slower beat, by increasing the cardiac stroke volume. However, if the heart rate drops below 25 beats per minute, output can not be made adequate. If cardiac asystole is longer than ten seconds, the result is syncope, convulsions, or even death due to acute cerebral anoxia. These terrible attacks are called the Stokes - Adams syndrome.

Total heart block may be the result of a number of conditions. It may be either congenital or acquired; of traumatic origin (the result of operation or accident), or due to disease (myocardial infarction, neoplasms or digitalis intoxications). There is no need for an implantable pacemaker if the Stokes - Adams syndrome is absent or the cardiac output is sufficient. A definite indication for its use is in surgical or post - operative heart blocks. Stokes - Adams syndrome usually limits the patient's life from a few months to two years at the most. In these cases, the implantable pacemaker is definitely indicated. (5)

Case History

The patient was a 66 year old male who had had two myocardial infarctions in the past and had developed total heart block with a heart rate of 28 to 32 beats per minute. He had several Stokes - Adams attacks every month for ten months. On December 4, 1962, he was operated on and an implantable pacemaker was installed. This was the first such operation performed in Turkey.

Surgical technique : To inhibit cardiac arrest during the induction of anesthesia or during the thoracotomy, the electrodes of the external pacemaker should be attached to the patient's chest prior to anesthesia. The electrocardiograph should be followed closely by oscilloscope before and during the operation. These initial preparations completed, the left chest was entered by left anterolateral incision, exposing the myocardium. Next, a second incision was made in

the left upper abdomen, immediately below the left costal margin, and a pocket, seven to eight cm. in diameter, was made between the fascia and the subcutaneous tissue. A tunnel was made between this pocket and the thorax. A second tunnel was made between the pocket and the eleventh rib, ending blindly. The pacemaker itself was placed in the pocket, the emergency extension lead was inserted through the blind tunnel, and the electrodes to the myocardium were inserted in the passage between the pocket and the thorax. It is most important not to kink or perforate the siliconized rubber around the electrodes during this process. The next step was to make two small incisions in an avascular region of the ventricle, near the apex. The spiral platinum electrodes were sutured into the myocardium through these incisions. As soon as this was completed, the patient's heart rate increased to 62 to 66 beats per minute. There were no postoperative complications, and the patient was dismissed within two weeks, in normal condition.

The pacemaker used in this operation was one of the latest models produced by the Med - Tronic Company. It is five and one half cm. in diameter and weighs 160 grams. This pacemaker produces two millisecond stimulations approximately 60 times per minute. Its electrical power is ten milliamperes and it can overcome 1,000 Ohms resistance. Normal myocardial resistance is about 350 Ohms. The life of the pacemaker is about five years. The manufacturer claims that the battery will probably last ten years, but they do not guarantee it for more than five. Because the time cyclor operates even though the pacemaker is not in use, there is about a ten per cent power loss. Therefore, if the instrument is not used within ten or twelve months after purchase, it should be returned to the manufacturer for replacement. Two to three weeks before the battery expires the pulse rate will increase by about fifteen per cent. Within those weeks the battery must be replaced. There is no need to make any changes in the myocardial electrodes. The latest pacemakers are provided with an emergency extension, giving the surgeon a greater margin of safety in the event of sudden complications. Since it is necessary to work at low temperatures in order to maintain sterilization, either gas sterilization or Warexin (which contains clor-pactin) may be used.

Although the operation reported here was without incident, some of the complications which may arise are briefly outlined below.

If the expected changes do not occur after the pacemaker has been implanted, the circuits must be checked by the following method. (6) First, it should be noted whether or not the signals of the pacemaker are being recorded on the electrocardiograph. If they are, the battery is operating properly and the difficulty lies in a malfunctioning electrode. However, if the electrocardiograph is not recording any signals from the pacemaker, either the pacemaker itself is defective, or there has been a short circuit. In this case, the emergency extension must be used. This is done by entering the end of the blind tunnel near the eleventh rib by a short incision, and breaking the tip of the emergency extension wire, to expose the three inner wires, A, B, and C. If there is no signal when B and C are attached to an oscilloscope, the difficulty lies in the battery and, if possible, the entire apparatus should be replaced. If there is no other available, it is possible to attach wires A and C to an external pacemaker and stimulate the heart in this way temporarily.

If, however, there is a square, approximately eight volt pulsation when B and C are attached to the oscilloscope, the pacemaker is functioning properly, but there is a short circuit. Most probably one of the electrodes is out of place or not functioning properly. In this case a monopolar stimulation can be produced using the one functioning electrode. (All of the early pacemakers were unipolar; bipolar units are fairly recent and much superior. (7))

If the malfunction is due to increased myocardial resistance, the electrocardiograph will show a small pulsation, but no ventricular complex will follow. To correct this problem, the wires B and C should be tied together, thus by-passing the resistor in the pacemaker and increasing the battery power. Increased myocardial resistance may occur following a two-stage operation or after temporary use of an external pacemaker, and is usually due to an infection. Although Chardack's original operation required two stages, it is usually done now in one operation, and this type of complication is becoming rare.

Because the pacemaker is sensitive to heat, the pulse rate will increase slightly within a few weeks of implantation, slowing down to normal after two or three months. However, it will never produce a rate greater than 90 beats per minute. In our patient, the pulse rate was increased to 64 beats per minute immediately, and rose to 70 after the operation. Three months later it was back down to 64 per minute. After five years, if the pulse rate increases, it will be necessary to re-operate to replace the battery.

The implantable pacemaker plays an especially important role in pediatric surgery since most of the open heart operations are performed on children. It is absolutely necessary to have an implantable pacemaker available whenever open heart surgery is performed in order to prevent the complications of surgical heart block, with its high mortality rate.

Summary

An implantable pacemaker was first used by Chardack on April 18, 1960. The first such operation in Turkey was performed on December 4, 1962, at Hacettepe Medical Center. This paper presents the history and physiopathology of this case, as well as the general clinical application and electro-dynamics of the pacemaker. The writer believes it is essential to have an implantable pacemaker available whenever open heart surgery is done, in order to overcome the common complications of surgical heart block.

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