Emergency Management of Pacemaker Failure*

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The purpose of this report is to describe the more common problems encountered with permanent pacemakers and their management.

One of the serious recurring problems is loss of output from the pacemaker. As a result, no pacemaker impulse whatsoever is seen on the electrocardiogram and the heart rate appears slower than the fixed rate of the pacemaker. In such a situation, if a patient is pacemaker dependent, whereby he will become symptomatic without the pacemaker, a temporary pacemaker electrode must be inserted immediately as an emergency procedure. On the other hand, if the patient can get along for a while without the pacemaker, then the pulse generator can be replaced electively under local anesthesia. In taking care of any patient, it is extremely important to decide whether or not the patient is pacemaker dependent. This information must be readily available; thus, by providing the patient with some type of identification bracelet or by labeling the chart with a specific tag, the patient will be treated appropriately and without delay.

Another problem that appears frequently is change of pacemaker rate. The most common cause for a change in rate is the drop in output of the battery. This can usually be determined by the exclusion of two other possibilities: competition and change in impedance. If the patient is "competing," the pulse at the wrist may be considerably slower than the rate seen on the electrocardiogram. An electrocardiogram will demonstrate whether or not the pacemaker is behaving normally, and if the pulse deficit is a result of an inability to palpate early coupled beats. A change in the impedance of the electrode, as seen when the tip of an electrode breaks, can also change the pacemaker rate if that particular model is load sensitive. However, most of the time if there is a real change in the rate, as measured on the electrocardiogram or any suitable interval counter, the usual cause is a drop in battery voltage and pulse generator output, which is treated by the replacement of the unit.

A noncompetitive pacemaker firing at a fixed rate indicates that the sensing circuit has failed. Sensing failure causes difficulties in making a proper diagnosis by external examination, X ray or electrocardiograms alone. Many judgments can only be made by operating on the patient and exposing the pulse generator and electrodes. However, an X ray, both PA and lateral, may reveal malposition of the electrode or perforation of the heart. There is also the possibility that scarring has occurred in the area of the electrode with a drop in the amplitude of the intracardiac signal to which the pacemaker no longer responds. With the pacemaker surgically exposed, the amplitude of the R wave and the output of the pacemaker should be measured. If pacemaker output has dropped, failure to sense has been caused by battery exhaustion. If a new pacemaker does not behave properly in its sensing mode, something has happened at the electrode myocardial interface; consequently, a new electrode position must be found or a more sensitive pacemaker implanted. When sensing failure has occurred after the 20th month, a safe assumption may be made that battery exhaustion was the cause.

If a pacemaker fails to elicit a ventricular response and the rate is the same as it was when the pacemaker was inserted, there is probably something wrong with the electrode position. Either the electrode is dislodged or the threshold for excitation exceeds the pacemaker output. High threshold occurs most commonly from sepsis along the electrode, scarring of the myocardium, or a break in the wire within the insulating sheet. Short circuits can also occur, shunting some of the current away from the heart; this is usually due to a set screw on the sur-

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face of the pacemaker that is not properly insulated, leaving a path between the anode and the cathode. Short circuits occur at other areas in the same way, but most of these problems are detected on the operating table. If careful analysis reveals a problem that can be easily corrected, such as splicing a broken wire or repairing broken insulation, it is wrong to replace the pacemaker.

If there is failure to capture and the rate of the pacemaker has also changed, a safe assumption would be that the output is down. The possibility that something has happened to the impedance must also become a consideration; however, the former is by far the more common reason. Exposure of the pacemaker and testing of the threshold for stimulation and output of the unit will solve this problem.

Runaway pacemakers, unfortunately, continue to present a problem. In runaway cases, modern pacemakers have been constructed to ensure a simultaneous drop in output to avoid capture of the heart. In other words, when the rate increases, the output will fall below threshold. Removal of a runaway pacemaker is urgent even if the rate is only slightly increased. This will help prevent further increases that may occur within a short period of time. The treatment for a runaway pacemaker is either rapid incision to cut the wire, pacing on that wire, or removal of the pacemaker from its pocket to disconnect it. The latter is preferable if time is available. Pacing can be continued with an external unit on the same electrode, thereby preserving it; a new pulse generator can then be implanted using the original wire.

Pacemaker extrusion is another complication that may be encountered. Causes of extrusion are pressure necrosis of the skin overlying the pacemaker, acute or chronic infection and hematomas. Whatever the mechanism, once the pacemaker erodes through the skin, several therapeutic options can be considered. The first is not to do anything, because once the pacemaker appears through the skin, enlargement of the hole often occurs slowly. There will be a draining sinus that can be covered with a bandage through the full 20 to 24 months of pacemaker life, if the patient is willing to put up with the inconvenience. Whether the unit is changed at once or at the end of the battery life, the surgical technique for replacement is the same; an incision is made on the opposite side, isolating the field from the infected side. By sewing drapes to the skin after the new pacemaker electrode is inserted, the infected unit can then be removed by a separate surgical team. Once the old pacemaker electrode has been withdrawn, the new one is definitely positioned and, if necessary, used for temporary pacing. When the clean operation is finished, the wound on the original side is drained and closed. Another option may be irrigation of the infected wound with antibiotics. On rare occasions, this method has been successful in aborting infection and pacemaker extrusion. Veins are always available for permanent transvenous pacing. If the cephalic vein on one side has been used, other veins will still be acceptable at a later date, including the subclavian vein, or its tributaries, and the external and internal jugular vein.

Another troublesome complication is twitching of the diaphragm. This is uncommon, but when present it is usually a sign of trouble; such as perforation of the heart or malposition of the epicardial electrodes. Occasionally, a transvenous electrode may have pulled back into the atrium where it would stimulate the right phrenic nerve. Once in a while the diaphragm can be stimulated through the intact ventricle, especially if the ventricle is very thin. All of these possibilities must be corrected by repositioning the electrode. If there are two epicardial electrodes near the left phrenic nerve, the problem can be corrected by converting it to a unipolar system. Upon determining which electrode produces the twitch, it should be used as the indifferent electrode, using the other one as the stimulating electrode. In this way, implantation of an entirely new system can be avoided.

There have been instances in which pacemakers have been seen jumping back and forth in their pockets. When these pectoral muscles near the pulse generator twitch, some form of correction should be made. If it is a bipolar pacemaker with both electrodes in the heart, obviously there must be a bared wire or an uninsulated set screw. These defects produce direct stimulation of a somatic muscle. A break in the insulation is a more common problem, but is often difficult to fix. The broken Silastic sheath must be reinsulated and shifted to a unipolar system, or a new system must be installed.

Twitching in unipolar electrodes can be caused by various other factors. There have been cases in which an electrode has been pulled out entirely, wrapping around the pacemaker so that the cathode was in the subclavian vein against the pectoralis major muscle. The pacemaker can also turn over with the anode facing the muscle rather than the skin. Although this does not always cause twitching, a twitch is less likely to occur when the pacer is plate up rather than plate down. Since a twitch can occur in any position, it is important not to use muscle relaxants on those occasions when general anesthesia is required during insertion of the pacemaker. If a pacemaker has flipped over, it can be recognized by palpating the pacemaker, observing if it is loose in the pocket and then flipping it to the proper position. In unipolar pacing systems there are other kinds of leaks around the electrode connector, par-

ticularly around the Silastic collar or the set screw, that can produce short circuit, high current density paths to somatic muscles.

There has been some recent discussion about electrical interference. An unusual example of this occurred with a patient who had an external Medtronic pacemaker with a bipolar electrode in the heart and an EKG telemeter attached to his chest. Several times he had experienced complete asystole. Thinking that the cause might be electrode malposition or that the pacemaker was defective, he had been taken to the catheterization laboratory. After trying many different external pacemakers, all of which showed the same problem, the telemeter was removed, revealing that the radio frequency transmission from the telemeter had been blocking the external pacemaker. Such interference with pacemaker function is rare, but is something to be aware of in coronary care units. If a telemeter is used in a patient with a pacemaker, the telemeter should be kept far away from the pacemaker. Better still, a different type of monitoring system should be used.

Another problem encountered is the handling of a patient who complains of dizzy spells, yet the electrocardiogram reveals that the pacemaker is functioning normally. To decide what is the problem, a series of exclusions must be considered. Is the output of the pacemaker dropping? This is likely if the pacemaker is 22 months old and there is also a change in rate. Is there a high threshold so that pacemaker output is just borderline? Is there intermittent malposition of the electrode? This is difficult to diagnose, but often can be suspected by the X-ray configuration of the leads. Is there intermittent contact of a broken wire within its insulation? Does the patient have intermittent bursts of ventricular arrhythmias? This must be suspected if in a long rhythm strip frequent ventricular premature contractions are seen.

"Pacemaker syndrome" is still another area that causes problems. This is characterized by the symptomatic fluctuation of the blood pressure, usually in a patient with a fixed-rate pacemaker, from atrial and ventricular asynchrony. The diagnosis can be confirmed only by ruling out all other causes of weakness and by recording wide blood pressure fluctuations. What about electromagnetic interference? Did the patient do anything unusual preceding the weak spells? When all of these ruminations have been considered and all causes of weakness have been discarded, it must be assumed that the patient is right; something is wrong with his pacemaker system. If you cannot make a definitive diagnosis, the pacemaker should be exposed and its output and excitation threshold should be tested. Nine times out of ten, the patient is right and it is necessary to adjust the pacemaker.