

Electrical Instrumentation and Hazards*

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Electric current is both valuable and hazardous in cardiac therapy. Small amounts of electric current are enough to electrocute the patient, especially if the current is delivered through a catheter in the heart. It has been demonstrated that currents as low as 10–15 microamperes are capable of inducing ventricular fibrillation. This minute amount of current is actually a thousand times less than what you can barely feel with your hand; nevertheless, this amount of current, internally, can cause many problems. Therefore, electrical equipment, when used, must be used carefully. We must be careful of the amount of current induced by capacitive coupling, or other sources of leakage.

The problem becomes further complicated in a hospital where electrical equipment is used with inadequate maintenance. The most desirable situation would be to have an electrical technician on the staff to maintain the equipment, making certain that the equipment has been installed correctly. Both the technician and the physician should have the responsibility of insuring proper use of the electrical apparatus. The manufacturer designs the equipment to work in a certain environment; if it is used properly within this environment, it is usually safe.

Presently, there is no perfect solution to the problems of electrical hazards in cardiac therapy. Although electrical hazards are continually occurring due to improper wiring, it would be an enormous expense to have all hospitals suitably rewired. Committees and workshops have been created to study these problems. In 1970, the National Academy of Sciences published an excellent report on *Electrical Hazards in Hospitals*. However, the complexity of the problem remains with no universal solution.

What can be done and what can the physician do? One recommendation is proper grounding; but for this to be effective, proper grounding would have to correlate directly with the design of the equipment. Some

equipment is designed to be used without ground. Should the patient touch ground or any surface at a different potential, a dangerous current may flow through the patient.

Although solutions to individual problems are usually found as each situation arises, there does not appear to be, as yet, a universal solution.

PANEL DISCUSSION

Questioner: How are the devices for recognition of electrical hazards in coronary units?

Mr. Berkovits: If you have a system that is designed to be grounded, a testing circuit may detect when you have a malfunction.

Questioner: What about the use of an electric bed?

Mr. Berkovits: As long as it functions properly you have no problem. The question is whether or not the convenience of an electric bed justifies the risk of a potential danger. The electrical equipment in a coronary care unit should be kept to a minimum. When functioning properly, the high isolation impedance of this system will improve your reliability and safety. However, capacitive currents and currents induced magnetically in a magnetic field can be hazardous.

Dr. Zoll: I think it is important to mention that there is a risk of electrical fibrillation not only in the coronary care unit, but in the operating room at the time of implantation of pacemaker replacement. Several of us have talked about the means to measure threshold at the time of operative manipulation at the end of the catheter electrode. At this time, we attach the electrode to a variable voltage source and a measuring device, usually an oscilloscope which is powered by alternating current. Although some oscilloscopes are now battery powered, every time one is connected, we risk inducing alternating current ventricular fibrillation. However, in experienced hands, like those of Dr. Parsonnet, this is a safe procedure. Before we attach these instruments to the patient's catheter, we routinely test for AC interference. With a quickly breakable

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connection we then attach the instruments. In this way, if any ectopic interference activity is produced, we can disconnect the instruments properly. Extreme caution must be exercised when a low resistance pathway to the heart is exposed to the environment.

Mr. Berkovits: I would like to point out that in order to avoid confusion in an emergency situation, there should not be wires hanging in all directions. Whenever you work in this type of situation, you should have a clear vision of everything that is happening.

Questioner: What is the value of a voltmeter?

Mr. Berkovits: If you have a battery-powered voltmeter, you can measure voltage, milliamperes, and resistance, but because the leakage currents are minute (10–15 microamps), no conventional voltmeter will detect them.

Questioner: Can AC-powered voltmeters be used?

Mr. Berkovits: AC-powered voltmeters do not offer appreciable increased sensitivity in resistance measurements, and you run the risk of inducing dangerous leakage currents.

Questioner: Concerning the usage of electrical instruments, how can you provide for maximum safety?

Mr. Berkovits: Because each hospital has a different wiring system, there is no single solution. A number of recommendations have been made for the formation of committees. The National Academy of Sciences has formed a committee on safety and hazards. Although they have not found a solution that would apply to all electrical hospital equipment, they do agree that the AC current delivered to the heart should be kept below 10 microamps.

Questioner: Is the battery-powered oscilloscope safe?

Mr. Berkovits: It is safer than a conventionally powered oscilloscope, but there are external conditions that may create a danger regardless of whether an AC- or DC-powered oscilloscope is used. Because electric currents can be inductively or capacitively induced, any wire near the heart can act as an antenna and induce more than 10 microamps.

Questioner: What about the hazards of static electricity?

Mr. Berkovits: Static electricity gives only a single discharge and will appear as a single stimulus.

Questioner: Dr. Zoll, please make additional comments on external shock therapy for cardiac standstill in a straightline EKG with arrest.

Dr. Zoll: External electrical stimulation, properly applied, will provide an effective and adequate stimulus to produce an electrical and mechanical response if the heart is capable of responding. If one acts quickly, within a matter of seconds after the onset of arrest, the resuscitation from ventricular standstill by external electric stimulation is an effective emergency measure that should be successful no matter what the background of the arrest may be. It is most commonly done in patients with Stokes-Adams disease with A-V blockage because these patients are most commonly affected with ventricular standstill. But, it is also effective in patients who have reflex vagal stimulation and arrest, in patients who have arrest due to drugs of one sort or another, in patients who have so-called "unexpected arrest" in the operating room while under anesthesia, and in patients with acute myocardial infarction. Because of the availability of this method of resuscitation and the availability of intravenous drug therapy, which can also be used to maintain and restore cardiac rhythmicity, we are less eager to introduce all the complications, risks, and troubles involved by the use of temporary cardiac pacing in many patients with acute myocardial infarction. I agree that there is an important place for temporary pacing in acute myocardial infarction, but I strongly maintain that if one is careful with patients with acute myocardial infarction, uses drugs properly, and stands by with emergency resuscitation, the need for catheter electrodes and the corresponding risk can be greatly diminished. I say that one must balance the various factors involved with one's clinical judgment and that one doesn't need to use temporary pacing quite as often as might be suggested today.