Electrical Safety Revisited: A New Wrinkle

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BUILDING codes for operating rooms are continually in a state of evolution due to advances in construction techniques, equipment design, and surgical requirements. As the following reports suggest, it behooves anesthesiologists to be aware of changes in these codes that may affect their working environment.

During the past year our hospital's anesthesiology department was informed of four instances in which operating room personnel received electric shocks in the course of their duties. In none of these cases was an alarm activated, indicating the presence of a ground fault, nor were any circuit breakers tripped. No serious injuries occurred.

Case Reports

Case 1

An audiovisual technician was investigating an intermittent color problem in a neurosurgical video recorder and television. He noted that every time he touched the television screen the color would improve, and he believed that this was caused by a "ground" problem. While unlatching the cabinet containing the power supply, an electric arc jumped from the cabinet to the key, shocking the technician, who was not injured. No specific fault was identified in this equipment, which subsequently operated properly. No wet surfaces were involved.

Case 2

A member of the housekeeping staff received a shock while using a Hydro-vac (Advanc Machine Company, Plymouth, MN) to clean a wet floor. Examination of the equipment showed a frayed power cord.

Case 3

An operating room technician received a shock when plugging an electrosurgery unit into the wall outlet. Investigation revealed a loose wire in the electric outlet. It is not known if wet conditions were present.

Case 4

An operating room technician received a shock while adjusting the dimmer switch of the surgical field lights. The dimmer switch had been recently changed from a 2-V controller to a 240-V dimmer switch. Examination of the switch has found no abnormality to account for this shock. No wet surfaces were involved.

Discussion

The initial response to these incidents was to suspect that the line-isolation monitors were not working properly. To our surprise, we found that the isolated power system (including the line-isolation monitors) had been removed during a recent renovation of the operating suite. Although the department of anesthesia had been informed about the general nature of the renovation during its planning stages, we were neither consulted nor informed about any changes to the electric system and remained unaware that they had been made. Approximately 50 staff anesthesiologists, residents, and nurse anesthetists had worked in this particular suite since the time of the renovation. None of them, however, seems to have noticed the removal of the line-isolation monitors, despite presentation to the department, after completion of the renovation, of a lecture on electrical safety that included a discussion of the virtues of isolated power systems.

Isolated power systems were originally required to be installed in all operating rooms by the National Electrical Code beginning in 1971 to help prevent sparks from igniting flammable anesthetics. However, after much debate, this requirement was dropped from the Code in 1984, with the condition that the hospital must have a written prohibition against the use of flammable anesthetic agents.1 (Standards for operating room electric systems are set by the National Electrical Code and by the Standard for Health Care Facilities of the National Fire Protection Association.2 Adherence to the requirements of both of these documents is generally mandated by local laws and by the Joint Commission for the Accreditation of Health Care Facilities.)
Where installed, isolated power systems serve the additional function of helping to protect patients and personnel from serious macroshock, \textit{i.e.}, shock through intact skin. The isolation transformer greatly reduces the amount of leakage current that can flow through a fault pathway, for instance from the "hot" side of the electric wiring, through a victim's body, to ground. (However, isolated power systems do not eliminate the hazard of microshock, \textit{i.e.}, shock from very small leakage currents that theoretically could cause ventricular fibrillation if passed directly into the heart through a cardiac pacing wire or catheter.) Because the safety advantage conferred by an isolated power system would be defeated if a faulty piece of equipment were to allow current effectively to connect either side of the isolated line to ground, an alarm device, the line-isolation monitor, is included to alert personnel should this situation occur. The alarm may also serve to call attention to electric equipment problems that might otherwise go undetected.

An alternative way to prevent macroshock is the use of ground fault circuit interrupters (GFCIs). These devices are designed to shut off the electric power within a few milliseconds of the occurrence of a ground fault, thereby preventing serious electric shock, including ventricular fibrillation. Because serious electric shocks are much more likely in the presence of wet conditions (because of enhanced electric conductivity of skin or reduced resistance of insulation), the National Electrical Code has for many years required installation of GFCIs in wet locations such as bathrooms, outdoor receptacles, and swimming pools in homes and public buildings. In the hospital, the current (1993) Code allows for grounded electric systems, without GFCIs, in locations where only routine shock hazards are present. However, it requires either GFCIs or isolated systems to be installed in patient care areas designated as "wet locations," defined in the Code as those patient care areas that are normally subject to wet conditions while patients are present. These include standing fluids on the floor or drenching of the work area, either of which condition is intimate to the patient or staff. Routine housekeeping procedures and incidental spillage of liquids do not define a wet location.\textsuperscript{4}

The designation of a patient care area as a wet location is to be made by the hospital governing body. Without formal designation, architects and engineers may not know that a particular area can become wet and needs special electrical protection, as in the situation described above. Because not all anesthetizing locations qualify as wet locations, it may be reasonable to avoid the extra expense of installing protection where it is not needed. General-purpose operating rooms and obstetric delivery rooms, however, appear to meet the definition of a wet location and should be designated as such, thereby requiring installation of either GFCIs or an isolated power system, depending on whether or not temporary loss of electric power would be tolerable. Either of these devices could also help to identify faulty pieces of equipment before shocks occur and thereby help prevent electric shocks similar to those reported here, whether or not wet conditions are present.

In summary, anesthesiologists should be aware that under the current National Electrical Code, unprotected, grounded electric power systems may be installed in new or remodeled locations in which anesthesia is provided. Formal designation by the hospital's governing body of the wet locations among them will help to ensure that either an isolated power system or GFCIs are installed where necessary. The choice between these two types of protection probably should be determined by the particular local conditions and practices.

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References