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## Electrosurgical Burns at Skin Temperature Probes

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Improperly grounded electrosurgical machines can burn the skin at the sites of monitoring electrodes. Several recent articles have emphasized this danger and suggested various equipment, cable or electrode modifications to minimize it.<sup>1,2</sup> Burns produced at the sites of other monitoring transducers have been reported, but are less common and have been less completely described.<sup>3</sup> Third-degree burns produced at the site of a cutaneous temperature probe placed to monitor skin temperature during total hip replacement for which an electrosurgical machine was used prompted us to examine this problem more completely.

Three pieces of electrical equipment were in use during the surgical procedure. A CSV Bovie electrosurgical machine with a 36 × 23 cm stainless steel return electrode was used for both cutting and coagulation. A Datascope 865 C physiologic monitor using 3 M Red Dot disposable monitoring electrodes and a Yellow Springs type 709 temperature probe was used to display pulse rate, skin temperature and lead II of the electrocardiogram. The electrocardiogram electrodes were applied to the suprasternal notch and the lateral surfaces of the thorax. The temperature probe was placed in the left axilla. The patient's temperature was supported with a water mattress through which warmed fluid was circulated. During the 2½-hour operation no difficulty was encountered except that the CSV Bovie required slightly higher settings than usual for adequate coagulation. The physiologic monitor displayed heart rate on the digital output during almost the entire operation. No unusual reading was seen when the digital display was briefly switched to display temperature.

At the termination of the operative procedure, circular areas of tissue carbonification were found where the temperature probe had touched both surfaces of the skin of the axilla. No damage to the skin that lay underneath the electrocardiogram electrodes could be detected.

No electrical abnormality could be found on subsequent examination of the heating mattress. The

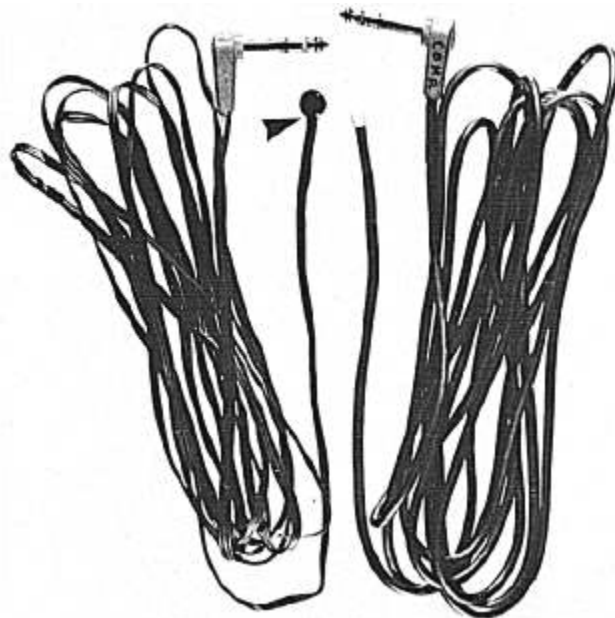


FIG. 1. Yellow Springs type 709 (left) and type 701 (right) temperature probes. Arcing, under conditions described in the text, occurred at the point indicated by the arrow on the left probe. The metal surface of the terminal button of the type 709 probe is turned away from the camera.

temperature probe was found to have sustained damage to the insulation of the three-conductor wire where the wire entered the metal-capped terminal button of the probe (see fig. 1). The Datascope 865-C was tested for leakage currents and circuit isolation with and without a temperature probe connected. Without a temperature probe the isolation was within normal ranges, but when the temperature probe was connected the isolation was reduced by a factor of 30. The Datascope was returned to the manufacturer for calibration and repair. The nickel-cadmium batteries, the voltage regulators, and the pulse sensor were found to have been destroyed. It is very probable that the current from the Bovie unit first broke down the temperature probe insulation and then damaged the Datascope. The CSV Bovie proved to be in working order except that the capacitor, which is attached between the distal end of the double-wired return electrode cable and the return plate itself, was mechanically damaged. This damage is thought to have resulted in high impedance in the normal return

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pathway and higher radiofrequency currents in alternate paths to ground.

The grounding cord of the CSV Bovie is a two-conductor coaxial cable, the outer conductor of which is provided to conduct a safety (circuit sentry) current from the machine to the grounding plate to be, in turn, returned to the machine through the central grounded conductor.<sup>4</sup> Unless this safety circuit is completed, the radiofrequency generator cannot be activated. A capacitor (placed as shown in figure 2) completes the safety circuit but tends to prevent passage of the safety current into the patient. The radiofrequency current of the actual cutting or coagulating currents passes the capacitor with relative ease. Operating room oscilloscopic tracings in which the electrocardiogram is superimposed upon a 60-cycle interference pattern when such an electro-surgical unit is used suggest that considerable electrical energy from the safety circuit is passing through the patient to the electrocardiogram electrodes and that the capacitor may be defective (shorted).

In our case, the capacitor failed in such a way (opened) that the safety circuit was maintained but the integrity of the central grounded conductor was destroyed. The safety current could pass from one conductor of the cable to the other but a high impedance was provided in the grounding path for the coagulating current of the electro-surgical machine. The temperature probe provided an alternate path to ground for the radiofrequency current.

We tested 30 such capacitors that had been in clinical use and found that ten of them were open. All external capacitors were discarded. At our request internal modifications were carried out on the appropriate CSV Bovies, those with serial numbers below 11,000, by the manufacturer's representative so that internal capacitors could be installed.

In an effort to determine whether the damage to the insulation at the end of the temperature probe existed before the operation in which the patient was burned or was produced by the electro-surgical unit, the following tests were carried out: The direct-current impedances (metal probe cap to phono-jack connections) of four new Yellow Springs type 709 temperature probes were determined using a Keithley (Model 160) Volt-Ohm Meter. The impedance found was greater than 1,000 megohms in all cases.

Three type 709 temperature probes were destroyed by further testing. The first probe was connected in series with a .012-megohm one-watt carbon resistor and placed across the radiofrequency output of a CSV Bovie unit set at a cutting current of 40 and a waveform of 2. Obvious arcing took place at the junction between the metal backing of the probe button and the cable at the

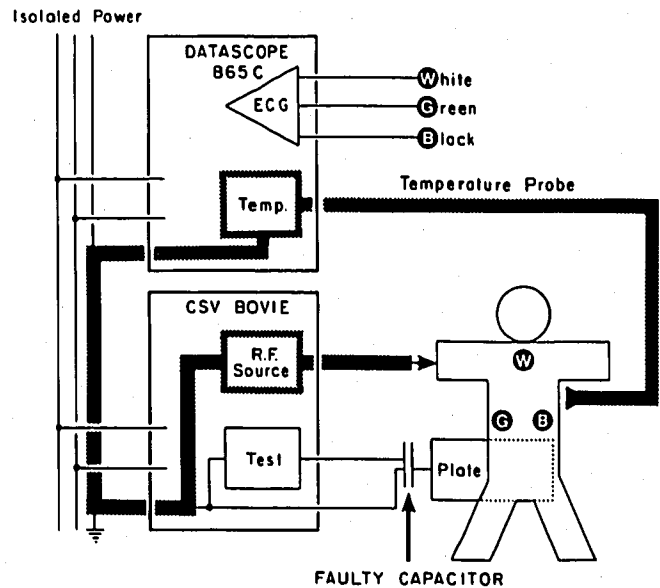


FIG. 2. Diagram of conditions under which skin burns occurred. Because of the faulty (open) capacitor, radiofrequency current passed from the CSV Bovie through the temperature probe and Datascope. The current loop thought to be responsible for the burns is shown with a stippled overlay. White, green and black electrocardiogram leads were connected to the patient as indicated.

point where the cable enters the terminal button of the probe. The resistance of the probe, measured as described above, was then found to be 100 megohms. Two additional probes were taped to the surfaces of beefsteaks with the metal surface down and the electro-surgical machine was used to cut the beef at a point about four inches from the probes. Similar Bovie settings were used; the ground plate was not used. Again, an obvious arcing took place at the junction and the insulation damage could be seen. Resistance of these probes was subsequently measured to be .024 and 4.5 megohms.

The resistances of 16 probes (type 709 or nearly identical type 409) removed from clinical service and tested in this manner were greater than 1000 megohms from the terminal button to the jack in every case but one. One type 409 probe had button-to-jack sleeve resistance of 100 ohms and button-to-jack tip resistance of 190 megohms. Probes without metal buttons on the ends and designed for temperature measurement within the rectum or esophagus (Yellow Springs 701) were also tested. The mean resistance of four new 701 probes was found to be greater than 1,000 megohms. After being placed in the radiofrequency circuit of a CSV Bovie in series with a .012-megohm one-watt carbon resistor these probes still had resistances greater than 1,000 megohms.

It is interesting that the burns produced in this

particular case were in the area of the temperature probe and not in the areas of the disposable monitoring electrodes. It has been suggested that the electrical isolation of the electrocardiogram electrodes produced by the physiologic monitors is only on the order of a few hundred ohms under radiofrequency conditions.<sup>3</sup> Apparently, in this case, this isolation was sufficient to prevent burns.

The temperature circuits of most physiologic monitors are not isolated. Presumably, isolated input circuitry would have prevented this problem. We believe that additional modification of physiologic monitors is necessary and that isolated inputs for signals other than electrocardiogram should be seriously considered. Battery operation of this equipment does not seem to be the answer to the problem because of the possibility of accidental chassis grounding and high power consumption

during long operations and prolonged schedules. Improved alarm circuitry on electrosurgical machines also seems necessary.

The decreased resistance found in one type 409 probe that had been in clinical service for an unknown period of time suggests that reesterilization, handling, and mechanical abuse may weaken the insulation.

#### REFERENCES

1. Aronow S, Bruner JMR: Electrosurgery (editorial). *ANESTHESIOLOGY* 42:525-526, 1975
2. Finlay B, Couchie D, Boyce L, et al: Electrosurgery burns resulting from use of miniature ECG electrodes. *ANESTHESIOLOGY* 41:263-269, 1974
3. Hall SV, Malhotra IV, Hedley-Whyte J: Electrosurgery burns (correspondence). *ANESTHESIOLOGY* 42:641-644, 1975
4. Health Devices: Electrosurgery. 2:183-226, 1973

#### Cerebral Circulation

**N<sub>2</sub>O AND CEREBRAL BLOOD FLOW** The effect of substituting nitrous oxide for nitrogen during halothane anesthesia was evaluated in four healthy women undergoing elective surgical procedures. Anesthesia was induced with halothane and tracheal intubation accomplished after administration of pancuronium. Controlled ventilation was instituted (average Pa<sub>CO<sub>2</sub></sub> 32.6 torr, average Pa<sub>O<sub>2</sub></sub> 168.4 torr, average pH 7.44) and 0.84 per cent halothane administered in 60 per cent N<sub>2</sub>/40 per cent O<sub>2</sub>. The arterial-venous difference in oxygen content was used as an index of cerebral blood flow (CBF). After three determinations of CBF had been made, nitrous oxide was substituted for nitrogen and CBF determined at 5, 15, 30 and 60 minutes. Thereafter, nitrogen was substituted for nitrous oxide and CBF again determined after the same time intervals. Following substitution of nitrous oxide for nitrogen, CBF rapidly increased, reaching a plateau value 67 per cent greater than control 15 minutes later. Following withdrawal of nitrous oxide, CBF progressively decreased and returned to con-

trol values 60 minutes thereafter. There was no significant change in arterial blood-gas values or cerebral perfusion pressure at any time. Marked slowing of the electroencephalogram was observed when nitrous oxide was added to halothane. Upon substitution of nitrogen for nitrous oxide, the EEG reverted to control pattern. These data indicate that nitrous oxide has a significant effect upon cerebral blood flow and the electroencephalogram in man anesthetized with halothane. (*Sakabe T, and others: Cerebral responses to the addition of nitrous oxide to halothane in man. Br J Anaesth* 48: 957-962, 1976.) **ABTRACTER'S COMMENT:** The authors have demonstrated that substitution of nitrous oxide for nitrogen results in a cerebral blood flow that exceeds cerebral metabolic requirements. This has been shown for a number of volatile anesthetics. One must wonder whether the authors would have shown the same results had the concentration of halothane been diminished when nitrous oxide was substituted (thus keeping the anesthetic potency the same in both situations).