

is inverted. The tip of the tube may tend to catch on the epiglottis or other structures at the laryngeal inlet, but use of a smaller tube (e.g., 32 Fr for an adult), good lubrication, and a rotary motion overcome this difficulty.

The soft distal end of the guide reduces the risk of perforation of the trachea to an absolute minimum. Properly performed, the technique is atraumatic, safe, and can be of great help in orotracheal intubation of patients in whom usual methods fail. Thorough practice in using the mirror and the technique in a manikin or cadaver is essential before using it in a patient.

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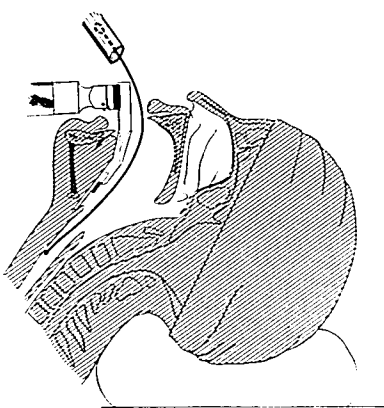


FIG. 2. Diagram showing the stylet in place and the endotracheal tube being guided over it into the trachea.

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Fire in an Ultrasonic Nebulizer

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Ultrasonic nebulizers (fig. 1) convert electrical energy at 50 or 60 Hz into high-frequency acoustic energy in the order of 1.3 megahertz (MHz).¹ The acoustic energy is

transmitted to the agent to be nebulized and physically disperses it into a large volume of small particles of uniform small size (0.5 to 1.0 μ).² Although it is not generally recognized, the power levels required for high-rate nebulization constitute a potential fire hazard. The following incident may be the first such fire to be reported in the literature.

REPORT OF INCIDENT

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The fire occurred in the General Intensive Care Unit of Cook County Hospital during aerosol therapy, using an ultrasonic nebulizer. The patient being treated was a 24-year-old man who had

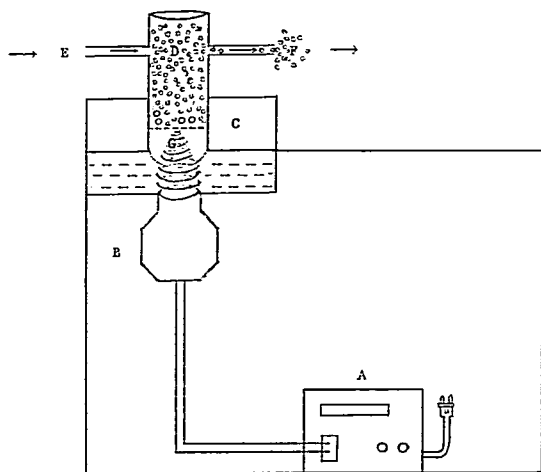


FIG. 1. Diagram of components of an ultrasonic nebulizer. A, 1.3-megacycle ultrasonic generator; B, transducer head; C, couplant fluid in couplant chamber; D, disposable polyethylene nebulizing chamber and fluid (Bendix); E, fresh gas flow or a blower; F, gases and nebulized particles to the patient; G, fountain of ultrasonic waves "geyser."

sustained a bullet injury of the thoracic spine, which caused a lower motor neuron lesion extending to the level of the second dorsal segment. The patient had acute respiratory failure and was managed by controlled ventilation through a tracheostomy tube utilizing an Emerson P.O. volume ventilator delivering 800 ml/stroke, at a rate 16 rpm and an inspiratory/expiratory ratio of 1:2. The recorded peak inspiratory pressure was 30 cm H₂O and the inspired oxygen concentration was 50 per cent. The patient was to have ultrasonic nebulization of 30 ml of 0.45 per cent saline solution with 1 ml of racemic epinephrine every eight hours, at a rate of 1 ml/min.

On the morning of the incident the respiratory therapist in the unit prepared the medication, the solution, and the ultrasonic nebulizer and connected the nebulizer to the inspiratory side of the ventilator. Fifteen minutes after the treatment had started, the nurse in charge of the patient saw whitish-orange flames (like a flash of lightning) originating from the disposable cup of the nebulizer and rapidly spreading to the disposable hoses. The nurse immediately disconnected the patient from the ventilator and alerted the respiratory therapist, who unplugged the nebulizer and ventilator from the electric outlet and ventilated the patient manually using a self-inflating bag. The fire extinguished itself spontaneously after the nebulizer was unplugged and the ventilator was then reconnected to the patient.

The nebulizer (fig. 2) was a Bendix model. § The surface of the couplant chamber (fig. 1 C) showed numerous scorched and blistered marks in certain areas, the location of which suggested that the sonic energy was concentrated in these regions. (Later, marks of the same nature, obviously of long standing, were found on the other Bendix nebulizers.) The lower half of the polyethylene cup (fig. 1 D) and an estimated 2 inches of the end of the output disposable hose (fig. 1 F) had been destroyed by burning and melting. The hoses were properly connected and the electrical outlets, plugs, and connecting cables were properly connected and grounded. The couplant chamber (Fig. 1 C) contained 1,575 ml of fluid, indicating that an adequate level was present. The couplant fluid was red from the racemic epinephrine in the cup that had spilled into it.

Efforts were made to duplicate the fire using the same equipment with a new cup. None to various amounts of fluid were placed in the cup. The cup was maneuvered in its holder to simulate accidental misplacement in the

§ Model SNB-713-A-1, S†N 429A.

couplant chamber. The oxygen level was varied from 20 to 100 per cent. No fire occurred and nothing unusual was found in the several components of the equipment. The temperature in the medication cup increased 5 degrees C above ambient and in the couplant chamber water was 7 degrees C above ambient, both changes being in agreement with prior reports.²

DISCUSSION

An ignition source, an ignitable substance, and oxygen are necessary for ignition and fire to occur. In an ultrasonic nebulizer, the geyser or fountain of ultrasonic waves (Fig. 1 G) has the potential for producing the heat necessary for ignition, depending on the wavelength of the energy and the thickness and molecular makeup of the transmitting medium. The water in the couplant chamber allows the transmission of these waves to the medication cup with minimal generation of heat, and the equipment used is fitted with a device to turn off the power if the level of the couplant water decreases below a certain level. The polyethylene disposable cups (fig. 1 D) which transmit the energy to the liquid to be nebulized are flammable. Although polyethylene readily transfers high levels of ultrasonic energy with very little generation of heat within itself, considerable heating can occur if the thickness exceeds a fourth of the wavelength of the acoustic energy. For an ultrasonic frequency of 1.3 MHz, the appropriate maximum thickness is 0.016 inch (personal communication, Mr. R. Johnson. The Bendix Corporation). The same source stated that the heating of the polyethylene can be aggravated by the operation of the nebulizer with insufficient liquid to cover the upper inner surface of the cup. Under these conditions the energy cannot be transmitted completely through the wall of the cup. Instead, it may be reflected back at the polyethylene-air interface, reinforce the transmitted waves, and form "standing waves" in the body of the plastic, which increase heat dissipation and raise the local temperature. Obviously, the use of 50 per cent oxygen and the prolonged inspiratory-expiratory ratio contributed to the development of the fire.

We conclude that the fire was the result of excessive heating of the polyethylene cup by



FIG. 2. The ultrasonic nebulizer, the nebulizing cup, and the inspiratory hose which were in use when the fire started.

the acoustic energy in the presence of an augmented concentration of oxygen. This is supported by the previous finding by the respiratory therapy staff of "scorched spots" in the centers of the bottom of the polyethylene cups after use. Also, the nursing staff reported that during use of the Bendix nebulizer they frequently detected the smell of "burning candles," which probably was associated with scorching and blistering of the walls of the couplant chamber. In addition, after the accident, the manufacturer investigated the thickness of the walls of the disposable cups and found that frequently they were thicker than the intended maximum thickness of 0.016 inch.

High generation of power by the equipment in use may have contributed to causing the fire. The power output of the Bendix nebulizer is greater than those of other models in common use. This would explain why the scorching and other heating effects reported to us by the respiratory therapy staff and the nurses were not observed when the Bendix disposable cups were used with a DeVilbiss nebulizer. We could not find evidence to suggest that there was inadvertent internal maladjustment of the power output, which is known to be possible in such a unit.

Several changes have been made in the Bendix nebulizer to avoid repetition of this accident. All disposable polyethylene cups are manufactured to a maximum bottom-wall thickness of 0.016 inch; the couplant chamber cover has been redesigned to prevent localized heating; and a stainless steel "chimney" has been added to confine the acoustic energy to

the couplant water. Despite these changes, it should be remembered that ultrasonic energy has great potential for localized heating and a fire hazard exists when such heating occurs in an oxygen-enriched atmosphere. Users of ultrasonic equipment should be apprised of this hazard, be instructed in the early recognition of malfunction, and be supported by technical specialists who can perform routine checks of the efficiency and safety of equipment.⁴

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Respiratory Excretion of Halothane after Clinical and Occupational Exposure

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Corbett and Ball¹ reported levels of methoxyflurane between 2 and 10 ppm in the inhalation zone of the anesthesiologist under usual working conditions, and measurable levels of methoxyflurane in end-expired air of anesthesiologists for as long as 30 hours following exposure. Patients had detectable levels of methoxyflurane in end-expired air for as long as 18 days after anesthesia. These findings prompted us to perform similar studies with halothane.

METHODS

The rates of excretion of halothane were determined by measuring concentrations in the end-expired air of the subjects at random intervals following exposure. Samples were col-

lected in bags impermeable to diffusion of halothane. Subjects were instructed to inhale, exhale about two thirds, and then breathe into the bag.

Halothane concentrations were measured in parts per million (ppm). Patient breath levels were determined using a Beckman GC-2A gas chromatograph equipped with a column of 10 per cent diisodecyl phthalate on 50/60 mesh Chromosorb P and a flame ionization detector. The limit of detection was 40 parts per billion (ppb). Anesthesiologist breath levels and environmental concentrations were determined using a Beckman GC 72-5 gas chromatograph with a similar column and a flame ionization detector. The limit of detection was 4 ppb. At low levels care was taken to avoid contamination of the syringe by previous samples injected into the chromatograph.

Under clinical conditions it was not possible to determine separately the contributions of concentration and length of exposure to the decay curves, as is done in experiments on human volunteers.² Although differing exposure times were chosen, patients' inspired concentrations changed during clinical anesthesia. To facilitate comparison of exposures, halothane

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