the successful application of epidural anesthesia of obstetric patients.* Any safe method which reduces requirements for drugs during labor and delivery has merit, and whether acupuncture has this desirable effect has still to be established. Our experience suggests that it will not displace, and is unlikely at present to augment, conventional methods of anesthesia.

In summary, acupuncture analgesia, administered by a trained Chinese acupuncturist, was evaluated during labor and delivery in 21 volunteer parturients. Nineteen of the 21 patients regarded acupuncture treatment as unsuccessful in providing analgesia for labor and delivery; sixteen patients requested alternative methods of analgesia. None of the patients was regarded by the investigators as having adequate analgesia during acupuncture treatment. Acupuncture did not appear to influence the progress of labor or the condition of the fetus or neonate. There was no complication as a result of acupuncture treatment. This study suggests that acupuncture analgesia alone will not supplant traditional forms of obstetric analgesia.

The authors thank the acupuncturist, Dr. Shui Wan Wu, for her skillful and competent assistance and for her cooperation throughout the study.

REFERENCES

Humidification of Anesthetic Gases with an Inexpensive Condenser-Humidifier in the Semiclosed Circle

D. B. WEEKS, M.D.*

Alterations in ciliary cellular morphology and activity and in pulmonary mechanics during endotracheal anesthesia with arid gases have been established. Recent reviews have discussed pulmonary morbidity and presented various humidification systems for supplementing inspired moisture. Most of these systems require electricity or external pressure sources for producing humidity. This paper confirms the suggestion made by Boys and Howells that condenser-humidifiers, or heat and moisture exchangers (HME), produce sufficient humidity during anesthesia without the necessity for electricity or external pressure sources.

MATERIALS AND METHODS

The Garthur Vapor Condenser was selected for this study because it has been demonstrated to be superior to other HME's available. It is readily adaptable to existing anesthesia circuitry, one end accepting 22-mm male fittings and the other, 22-mm female or 15-mm male fittings. For use in this study during general anesthesia with a semiclosed circle, it was placed between the endotracheal tube and Mackow connector (fig. 1). The HME was evaluated during routine

---

* Assistant Professor in Anesthesia.

Received from the Department of Anesthesia, Bowman Gray School of Medicine of Wake Forest University, Winston-Salem, North Carolina 27103. Accepted for publication July 8, 1974.
surgical procedures. Twenty-eight adult patients free of overt pulmonary disease and requiring endotracheal anesthesia for at least one hour were chosen. No direct consent was requested of the patient. Premedication, including belladonna alkaloids, was allowed. Halothane, enflurane, nitrous oxide, and oxygen with intravenous anesthetics were used as indicated. Fresh gas flow rate was 5 l/min. Ventilation was performed manually as needed.

In order to measure the inspiratory phase of the HME, which is a to-and-fro instrument, a previously described experimental circle was used with the following modifications (fig. 2). The expiratory limb was warmed with a heat tape to maintain an external temperature of 34°C and an internal gas temperature of 32°C proximal to the HME. An insulation-backed mirror was added to reflect any radiant heat away from the humidity sensor housing. Measurements of temperatures in the expiratory limb and humidity sensor housing in the absence of gas flows showed that the housing acquired no heat from the heat tape. Temperatures were measured with matched thermistors in the humidity sensor housing, in the expiratory limb of the experimental circle, in the inspiratory limb of the semiclosed circle, and in the patient’s esophagus. Ambient temperatures were also measured. Humidity was measured by a Hygro sensor placed in the inspiratory limb of the experimental circle (fig. 2). The chill-factor of each operating room was qualitatively noted but not measured.

Temperature and humidity measurements were taken immediately after endotracheal intubation and then at 10-minute intervals until a plateau was reached. The HME was added to the circle 10 minutes after endo-

---

1 Heat tape, 110 volts; temperature controlled by a servo-box made to specification by the Biomedical Engineering Department, Bowman Gray School of Medicine, Winston-Salem, N.C. 27103.

2 Yellow Spring thermistor (401), Yellow Springs Industries Company, P. O. Box 279, Yellow Springs, Ohio 45387.

3 Wide-Range Hygro sensor (15-2012), American Instrument Company, 8030 Georgia Avenue, Silver Spring, Maryland 20910.

* The effect on exposed body tissue of a given combination of temperature and wind (or draft).
tracheal intubation to allow for the determination of baseline conditions. The measuring devices and experimental circle were cleansed with Cidex™ after each use.

Four studies were done, each with and without the HME: Group I, Measurement of mean airway temperature and inspired temperature (ten subjects). Group II, Measurement of temperature and humidity under extremely dry conditions (four subjects). Group III, Measurement of temperature and humidity under moderately dry conditions (four subjects). Group IV, Measurement of temperature and humidity under clinical conditions (ten subjects).

Group I was devised to determine mean airway temperature conservation by the HME and to verify again the lack of heat gain from the expiratory limb of the experimental circle. Measurements were made with a thermistor inserted between the endotracheal tube and the HME or the connector. Airway temperature at this point and the temperature of the inspired gases were measured to calculate the temperature of the expired gases at the endotracheal tube outlet.

In Groups II and III, measurements were made while the circle contained fresh soda lime and completely dry reservoir bag and hoses. However, in Group II, the circle valves were moved to the Y-piece so that there was only minimal mixing of inspired and expired gases. Group IV patients received anesthesia through soda lime that could have been used recently (and therefore might have been damp) and hoses and reservoir bag that contained various amounts of water from the rinse phase of the Cidematc cleansing. All of the anesthesia machines provided fresh gas input on the inspiratory side of the carbon dioxide canister.

RESULTS

Group I. Mean airway temperature was 26.9°C without the HME and 29.5°C with the HME. Thus, there was a net gain of 2.6 ± 0.4°C heat conservation. The temperature of the expiratory gas was calculated at 32°C.

The results in Groups II, III, and IV are shown in Figure 3. Total temperature and humidity gains were dependent upon pre-existing circle humidity, soda lime reaction, ambient temperature, and chill factor. The range of ambient temperature was 22 ± 2°C; the range of esophageal temperatures was 36 ± 0.5°C.

Without the HME, humidities at ambient temperature ranged from 20 per cent relative humidity in Group II to 100 per cent in Group IV, the value depending upon the amount of residual moisture in the circle system. The HME increased the temperatures of the inspired gas in Groups II, III, and IV to 3.0 ± 0.5°C above ambient temperatures present in the inspiratory side of the circle system. The HME increased humidity in all three groups, the amount depending on the pre-existing conditions. Relative humidity reached 100 per cent after several breaths in all of the patients in Group IV and after 10 minutes in the patients in Group III. In Group II,
the humidity of inspired gases reached 90 per cent or more, but did not always reach 100 per cent during observation periods as long as 90 minutes. Temperature lagged behind relative humidity by approximately 20 minutes, reaching a plateau at 30 minutes in all patients. The average humidity of inspired gases from all three groups when the HME was used was 24.3 mg/l ventilation or 100 per cent relative humidity at 26 C. There were no signs of the usual water condensation in the expiratory valve and dome when the HME was in use, indicating a decrease in contamination of the soda lime by exhaled water.

DISCUSSION

Guidelines from previous reports suggest that 22 ± 8 mg/l humidity affords protection during endotracheal anesthesia.1,2,4 Anesthesia circle systems with fresh gases introduced on the inspiratory side may barely satisfy these requirements; however, more humidity is needed to approach physiologic replacement. This study suggests that the HME fulfills this need.

The Garthor-HME provides approximately 20 mg/l while the patient breathes ambient air by conserving 60 per cent of normal water loss.5 Recently, such conservation (13.8 to 16.5 mg/l) during endotracheal anesthesia with a nonbreathing system was demonstrated to protect ciliary morphology.7

The present study demonstrates that the Garthor-HME with the semiclosed circle provides 22–27 mg/l (100 per cent relative humidity at 3 C above ambient temperature). This level approaches normal laryngeal humidity and not only protects cilia but also prevents alterations in pulmonary mechanics due to drying.3

Possible precautions in the use of the HME relate to deadspace and resistance. Although hyperventilation of the lungs can overcome the problem of mechanical deadspace (17 ml) and carbon dioxide accumulation, children weighing less than 10 kg should probably receive humidity from heated water-bath humidifiers rather than from an HME.9 The screens within the HME offer little resistance unless plugged with mucus, which may occur when the HME is used in an awake patient or in a patient who has “coughed” during anesthesia.

The HME can be recommended for use in most instances during endotracheal anesthesia when a semiclosed circle system is used. In those cases requiring more than physiologic replacement of humidity, a hot-water-bath humidifier rather than an HME should be considered.10

The Garthor HME requires no external power source, is adaptable to existing anesthesia circle systems and provides fully saturated gases at 26 C in a semiclosed circle at low initial costs. I have used this condenser-humidifier in a semiclosed circle for five years and have found its function to be completely satisfactory.

REFERENCES