Higher Humidity, an Additional Benefit of a Disposable Anesthesia Circle

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Disposable anesthetic circles have been advocated to prevent cross-contamination during anesthesia.[1] Acceptance of these units requires, however, that they match or exceed the standards of existing reusable units. This paper investigates one facet of this problem—that of the humidity produced by a particular disposable circle compared with the humidity reported for reusable large carbon dioxide absorber units.

METHOD

The Disp CO_2 sorb† was selected for this comparison because of the way in which it introduces fresh gases into the circuit. The fresh gas inlet is so positioned that all fresh gases are forced through the carbon dioxide absorber canister before they reach the patient. Conventional units, on the other hand, introduce fresh gases at the inspiratory valve or at a shunt above the carbon dioxide absorber, so that fresh gases bypass the humidity of the absorber and dilute the humidified gases from the reservoir bag.

The study was conducted in eight adult patients free of overt pulmonary disease who required endotracheal anesthesia of more than one hour's duration. Anesthesia consisted of halothane, enflurane, or nitrous oxide, with intravenous agents as necessary. Ventilation was performed manually. A conventional reusable anesthesia circle was used to establish anesthesia and then immediately replaced by the disposable circle. An endotracheal tube was inserted into the trachea of each patient. This procedure prevented any contribution of oronasal breathing into the disposable circuit before the start of the controlled study. Fresh gas flow was maintained at 4.5 l/min.

Measurements of humidity‡ and temperature§ of inhaled gases were recorded at 5-minute intervals until plateaus were reached. The measurements of humidity were taken on the inhalation side at the Y-piece, the hygrosensor being separated from the Y-piece by a unidirectional valve that prevented contamination by exhaled gas in the sensing chamber.

Ambient temperatures were recorded at 20-minute intervals; to exclude the effects of the chill factor, the thermistor measuring room temperatures was placed in a large paper cup that faced away from dominant air currents. Esophageal or rectal temperatures were also recorded.

RESULTS

With the disposable circle, the humidity of inhaled gases rose from 0 to 70 per cent relative humidity (RH) at ambient temperature in approximately ten breaths. It reached 100 per cent RH at ambient temperatures of 23.6 ± 1.8 C in 25 minutes (fig. 1). This humidity represented 21 ± 1.5 mg/l of water vapor. The patients' temperatures averaged 35.6 ± 1 C. There was no significant difference between inspiratory temperatures at the Y-piece and ambient temperatures; any heat gain from the soda lime reaction was lost as the gas passed through the 40-inch inhalation hose.

DISCUSSION

The addition of humidity to anesthetic gases has been advocated to protect ciliary morphology,[2] ciliary function,[3] and pulmonary mechanics.[4,5] It has been suggested that while 60 per cent RH at ambient temperatures (14 to 17 mg/l water vapor) protects ciliary activity,[2] 100 per cent RH at 20 to 30 C (17 to 30 mg/l water vapor) is necessary to

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† Disp CO_2 sorb™ (401-1001), Dryden Corporation, 5835 North Tacoma Avenue, Indianapolis, Indiana 46220. This unit is charged with soda lime, USP.

‡ Wide-Range Hygrosensor (15-2012), American Instrument Company, 8030 Georgia Avenue, Silver Spring, Maryland 20910.

§ Yellow Springs Thermistors (401), Yellow Springs Industries Company, P.O. Box 279, Yellow Springs, Ohio 45387.

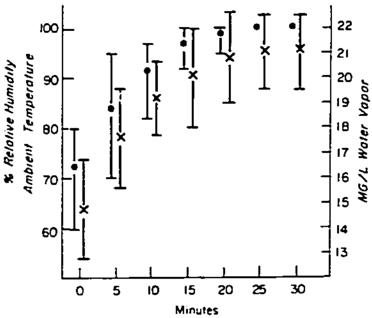

FIG. 1. Relative humidity (•) and milligrams of water vapor per liter gas (×) are presented as mean and range against time. N = 8.

protect against atelectasis, increase in alveolar–arterial oxygen tension difference, and alterations in compliance.[4,5] Therefore, humidity of 22 ± 8 mg/l water vapor should be protective during anesthesia.

Previous reports indicate that reusable standard carbon dioxide absorber canisters are able to generate 60 to 80 per cent relative humidity at ambient temperatures (14 to 17 mg/l water vapor).[6–8] If such systems are dry at outset, however (with 5 l/min fresh gas flow), these minimum levels cannot be reached in less than an hour's time.[7] If fresh gas flows introduced in the conventional fashion at the inhalation valve are greater than 5 l/min, there is further delay in the attainment of peak humidity in the inhalation side of the circle in proportion to the dilution of the gases carrying humidity from the soda lime canister by the fresh dry gas. On the other hand, the Disp CO_2 sorb, because of its unique introduction of fresh gases, is able to reach 80 per cent relative humidity in three minutes and 100 per cent relative humidity at ambient temperatures in 25 minutes (21 ± 1.5 mg/l water vapor).

The rapid increase of humidity in the Disp CO_2 sorb is possible because all gases, both fresh and reservoir effluent, must pass through the soda lime compartment.[9] Soda lime contributes humidity both by the presence of water (14 to 19 per cent by weight) and from the reaction of soda lime with carbon dioxide (18 ml water/g molecular weight of carbon dioxide neutralization).[6,10]

In conclusion, freshly charged reusable canisters with fresh gases introduced just proximal to the inhalation valve at fresh gas flows of 4 to 5 l/min barely satisfy the criteria of safe humidification[2–5] until after an hour of use.[6–8] The Disp CO_2 sorb disposable unit provides minimum acceptable levels of humidification at outset and reaches acceptable levels after 25 minutes. The patient's respiratory system, then, is not only protected from cross-contamination, but is also given more humidity earlier from this particular disposable circle than from standard reusable circle units that introduce fresh gases on the inspiratory side distal to the carbon dioxide absorber.

The data in this paper, as well as other data,[11] indicate that further investigation of fresh gas introduction in standard, reusable soda lime canisters is warranted. The placement of the fresh gas inlet between the reservoir bag and the soda lime does not appear to violate rules of carbon dioxide rebreathing.[12] This arrangement should provide the rapid attainment of humidity described here and in Barry and Hugh-Davies' report on pediatric circles.[9]

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Simplified Delivery of Volatile Anesthetics for Bronchoscopy

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The Sanders bronchoscopic attachment is a safe and simple means of ventilation with oxygen-enriched air when general anesthesia for bronchoscopy is provided with intravenous agents. If it had an ability to deliver volatile anesthetics, this attachment would be more valuable. Thus, bronchoscopies in which volatile agents seem preferable or advantageous could easily be performed. This paper describes the use of a standard Sanders attachment to deliver volatile anesthetic agents by the same Venturi principle on which it was founded.

METHODS

A standard Sanders bronchoscopic ventilating attachment was placed on an 8 × 40-mm Pilling ventilating bronchoscope. The ventilating sidearm of the bronchoscope was then attached directly to the gas outflow tubing of a Foregger model E anesthesia machine as shown in figure 1. Utilizing a Finnigan mass spectrometer, the concentrations of halothane vapor were measured within the gas outflow tubing of the anesthesia machine, and at the distal end of the bronchoscope while air was being entrained with the Sanders apparatus. Oxygen pressures from 20 to 50 psi were used for entrainment of room air into the bronchoscope. A 5-l/min flow from the anesthesia machine was used.

Measurements were made proceeding from low to higher concentrations of halothane to alleviate any problem of background or room accumulation of vapor. The anesthesia machine and bronchoscope were flushed with 100 per cent oxygen preceding each new determination. Data were analyzed and a line constructed using a least-squares regression.[1]

A direct relationship was established between the concentration delivered and that entrained (see table 1 and figure 2). Admixture of entrained air through the proximal opening of the bronchoscope and of halothane vapor via the sidearm resulted in a marked dilution of the delivered halothane concentration, as expected. The relationship between concentration delivered and that entrained was not affected by varying oxygen pressures delivered to the Venturi aperture. Therefore, all data from all pressure measurements were pooled. Furthermore, prolonged entrainment did not progressively deplete or dilute the concentration being emitted from the end of the bronchoscope.

DISCUSSION

Examination of the tracheobronchial tree during general anesthesia has long been

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