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Title: TEMPERATURE GRADIENTS WITHIN ANESTHESIA BREATHING CIRCUITS WHEN HEATED HUMIDIFICATION IS USED.

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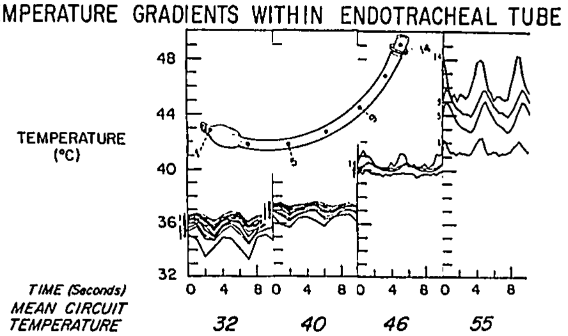
Introduction. Heated humidification (HH) of anesthetic gases is advocated to minimize intraoperative hypothermia. Estimates of net caloric benefit from HH vary over 15 fold (22-360 kcal/hr).[1,2] We hypothesized that previous research overstated the benefits of HH because it used only inspiratory limb temperatures for respiratory heat gain calculations, and ignored temperature gradients within the circuit, the heat exchange function of the endotracheal tube (ETT), and heat transfer through the walls of the ETT to the environment, and to the oropharynx.

Methods. Anesthesia circuit temperatures were monitored in 5 consenting, intubated patients under general anesthesia without HH and with HH at low, medium and high settings. Institutional approval of the study protocol was obtained. Thermistors with rapid (0.1 sec) time constants were located at the intratracheal end of the ETT, at the junction between the y-connector and the ETT, and 55 cm proximal to the trachea in the inspiratory limb. For each humidifier setting, intratracheal mean inspiratory and mean expiratory temperatures were calculated from measured end-inspiratory and end-expiratory temperatures and entered into the respiratory heat loss equation.[3]

In a companion study, temperature gradients along the length of the endotracheal tube were examined at the same humidifier settings in an anesthetized, intubated dog using a 30 cm long probe with 14 thermistors spaced 2.5 cm apart, suspended intraluminally within the ETT. Continuous temperature traces were plotted simultaneously.

Results. Large temperature gradients were found in the breathing circuit whenever HH was used. With a Cascade humidifier at maximum output, water bowl temperature was 75°C and peak inspiratory temperatures were 60°C in the circuit, 55°C at the elbow, and 45°C at the tracheal orifice of the ETT. There was a 5-8°C variation in circuit temperature within each respiratory cycle. The amplitude of temperature variation with respiration, measured with the multi-thermistor probe (see figure) was always greater at the elbow than at the intra-tracheal end of the ETT. There was also a gradient of up to 8-10°C between average temperatures at the elbow and at the trachea. Thus the ETT served both a heat exchange, and a heat transfer function. Calculations of respiratory heat flux suggested losses (assuming 70%[4] relative humidity in inspired gas without

TEMPERATURE GRADIENTS WITHIN ENDOTRACHEAL TUBE



humidifiers) of 5-7 kcal/hr when humidifiers are not in circuit. When they were used at high output, respiratory heat gain was 2.5-3.5 kcal/hr depending upon degree of hyperventilation. Another 2-3 kcal/hr is transferred through the walls of the ETT (in part to the patient via the oropharynx, in part to room air). The net caloric 'benefit' to the patient (compared to circuits without humidifiers) totals 9-13 kcal/hr.

Discussion. Heated humidifiers work in three ways: they reduce evaporative and convective losses from the respiratory tract; add heat to the body through the walls of the ETT; and add heat via the respiratory tract whenever inspiratory temperatures and absolute humidities are greater than expiratory temperatures and humidity. As used clinically, HH has an hourly net caloric benefit equivalent to infusion of 500-750 ml of crystalloid at body temperature rather than at room temperature. We conclude that previous research has overestimated heat gain from HH, but suggest that design improvements (better insulation of delivery hoses, servo-control of output to end-ETT sensors) would allow far more effective minimization of intraoperative thermal stress.

References.

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