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Title: A NEW JET VENTILATION CATHETER

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Introduction: Humidification is difficult during jet ventilation (JV). Pneumothorax is a hazard of JV, if airway outflow is obstructed. A coaxial JV catheter is described. It can deliver adequate inspired humidity (IH) during low and high frequency JV (LFJV and HFJV) and minimize consequences of airway obstruction.

Methods: A 40cm long (ID=4mm, OD=6mm) tube (Fig 1) was the outer channel. A Y piece was inserted at one end. One limb of the Y was connected to a humidifier by a tube bearing a one way valve. Through the third limb, a 40cm long (ID=2mm, OD=3mm) jet delivery tube was inserted into the outer tube, 2.5cm short of the outer end. The humidifier air inlet tube reached below water surface. The jet entrained humidified air through the space between inner and outer tubes. The space also served as a vent during glottic occlusion. During obstruction gases escaped at the valve, preventing backpressure in the humidifier. Ventilation was done with a Bird Mark II ventilator[1]. LFJV parameters: tidal volume 500ml, rate 12, inspiratory time 1 sec. HFJV values: 95ml, 104/min and 0.12 sec. The catheter was tested in dogs and patients. Under pentobarbital anesthesia, the catheter was inserted 5cm into dog trachea. Tracheal temperature, blood gas tensions, entrainment pressure (EP) and entrained air volume (EV) were measured. The humidifier temperature T was 30°C. After 1 hour of ventilation, condensed water in the system was drained into the humidifier. Water loss from the humidifier was taken as the difference between initial and final water levels. IH (mg H_2O/L) was derived by dividing minute water loss by respiratory minute volume. IH was also derived at 40, 50 and 60°C. In group A dogs (n=5), LFJV was studied for 4 hours and in B (n=5), HFJV. In group C (n=5), cuffed tracheal tubes were inserted. The JV catheter and a pressure measuring catheter were inserted into the trachea through the tube and snugly wedged into the tube lumen. Airway obstruction was produced during LFJV by inflating the tube cuff. Exhaled gases escaped only through JV catheter vent. Ten obstructive episodes were studied per dog. Each episode lasted 30 min. Measurements listed in the table were made. Lungs were exposed and examined for air leaks at 40 torr airway pressure. In group D (n=2) the vent was also clamped during obstruction. The clinical study was approved by the Human Study Committee of the New York University Med. Ctr. Patients gave informed consent. Anesthesia was maintained with methohexital and succinycholine. Twenty patients (4 equal groups) received JV for 2 hours through the catheter inserted 5cm into the trachea. The first group received unhumidified LFJV, the second unhumidified HFJV, the third humidified LFJV and the fourth humidified HFJV (T=60°C). Blood gas tensions were measured. Tracheal secretions were obtained at the beginning and end. Tracheal smears were examined to assess the structural integrity of tracheal epithelium by a point scoring system[2]. Results were expressed as mean ± 1 SD.

Results: IH was 30±2 mg H_2O/L during LF and HFJV at T of 60°C. $IH = 1.03 \times e^{0.056 \times T}$ (r=0.99). LFJV and HFJV produced an EV of 100 and 10ml respectively at EP of -75 and -8 torr. At all T, dog and human tracheal temperatures remained below 36°C. No group C dog suffered lung damage or air leaks. Group D dogs lost systemic pressure and cardiac output and developed surgical emphysema within 70 sec. Peak airway pressures (PAP) exceeded 80 torr. Human tracheal cellular score (TCS) decreased 34±5% (p<0.01, paired t-test) after dry LF or HFJV but only 6±1% after humidified JV. Blood gas tensions were normal in dogs and humans during both modes.

Discussion: The TCS decreased after unhumidified JV signifying epithelial damage[2]. It decreased minimally after humidified JV, indicating adequate IH. Despite smaller EP, HFJV delivered the same IH as LFJV because of faster rate. Airway obstruction (with vent clamped) produced rapid cardiovascular collapse and pulmonary barotrauma. With vent open, the PAP stabilized at 40 torr because lungs deflated (Fig 2). Dogs maintained perfusion and pulmonary gas exchange (table). The vent was ineffective during obstructed HFJV due to short expiratory pause.

References:

1. Ramanathan S, et al: Anesthesiology 55:A 352, 1981
2. Chalon J, et al: Anesthesiology 37:338-343, 1972

TABLE: GLOTTIC OBSTRUCTION IN GROUP C DOGS

Measurement	Preocclusion	Postocclusion
Peak airway pr	8 ± 1 (torr)	40 ± 1 (torr)
End exp. pr	0	15 ± 1 (torr)
Cardiac output	3.5±1 (L/min)	1.8±0.4 (L/min)
Mean BP (torr)	115±14	88 ± 17
PaO_2 (torr)	373±75	385±51
$PaCO_2$ (torr)	29 ± 4	32 ± 5
pH	7.42±0.1	7.37±0.1

Post occlusive measurements were made after 30 min of obstructed ventilation. All changes are statistically significant except PaO_2.

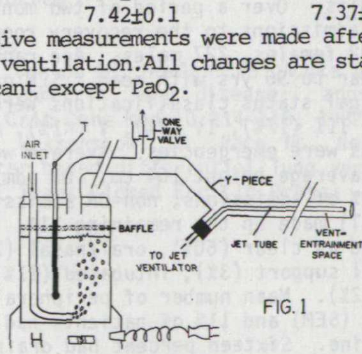
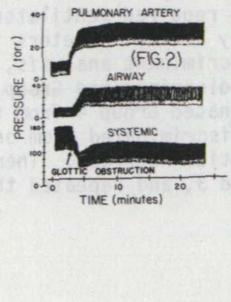


FIG.1



(FIG.2)