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Respiratory effects of tracheal gas insufflation in spontaneously breathing COPD patients

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Abstract *Objective:* To evaluate the effect of tracheal gas insufflation (TGI) in spontaneously breathing, intubated patients with chronic obstructive pulmonary disease (COPD) undergoing weaning from the mechanical ventilation.

Design: A prospective study in humans.

Setting: Polyvalent intensive care unit (14-bed ICU) in a 700-bed general university hospital.

Patients: Twelve patients with chronic obstructive pulmonary disease (COPD) who required intubation and mechanical ventilation were studied. All patients met standard criteria for weaning from mechanical ventilation. Seven patients (group 1) had been transorally intubated during episodes of acute respiratory failure. Five patients, all men (group 2), had previously undergone tracheostomy and had a transtracheal tube in place.

Interventions: Intratracheal, humidified, O_2-mixture insufflation (TGI) was given via a catheter placed in distal or proximal position. Gas delivered through the intratracheal catheter was blended to match the fractional of inspired gas through the endotracheal tube. Continuous flows of 3 and 6 l/min in randomized order were used in each catheter position. Prior to data collection at each stage, an equilibration period of at least 30 min was observed, and thereafter blood gases were analyzed every 5 min. A new steady state was assumed to have been established when values of both P_aCO_2 and $\dot{V}\,CO_2$ changed by less than 5% between adjacent measurements. The last values of blood gases were taken as representative. The new steady state was confirmed within 35–50 min. Baseline measurements with zero $\dot{V}_{cath}$ were made at the beginning and end of the experiment.

Results: This study shows that V_T, MV, P_aCO_2, and V_D/V_T are reduced in a flow-dependent manner when gas is delivered through an oral-tracheal tube (group 1). The distal catheter position was more effective than the proximal one. In contrast, when gas was delivered through tracheostomy (group 2), TGI was ineffective in the proximal position and less effective than in group 1 in distal position.

Conclusion: Under the experimental conditions, tracheal gas insufflation decreased dead space, increased alveolar ventilation and possibly reduced work of breathing. From the preliminary data reported here, we believe that TGI may help patients experiencing difficulty during weaning.

Key words Weaning · Work of breathing · Dead space · Alveolar ventilation

Introduction

Reduction of dead space through conventional tracheostomy has been used to help in weaning patients with CO_2 retention [1, 2]. Transtracheal insufflation of O_2 has also offered some advantages to patients with chronic obstructive pulmonary disease (COPD), including decreased dyspnea and improved exercise tolerance [3–6]. Reported benefits of transtracheal insufflation of O_2 may be related to reduced work of breathing [7–9]. Transtracheal oxygenation appears to be an effect of the reduction in dead space and possibly to enhance gas mixing. Insufflation of gas directly into the trachea [tracheal gas insufflation (TGI)] results in a reduction in dead space at least as great as that following tracheostomy. Two mechanisms may contribute to this effect. First, a portion of the inspired tidal volume is delivered by the catheter tip, thereby bypassing the dead space in the upper airways (inspiratory bypass). Second, the catheter delivers O_2 mixture during the expiratory phase of the respiratory cycle, thereby decreasing dead space by diluting the CO_2-laden gas in the volume proximal to the catheter tip (expiratory washout) [10–12]. Because tracheal gas insufflation has the potential for decreasing the anatomical dead space, it may also facilitate weaning from mechanical ventilation in patients with ventilatory failure. To test this hypothesis, the respiratory effect of TGI through an endotracheal tube (oral-tracheal or transtracheal) was studied in spontaneously breathing, hypercapnic patients with COPD undergoing weaning from mechanical ventilation.

Methods

Subjects

Twelve patients with chronic obstructive pulmonary disease (COPD) who required intubation and mechanical ventilation were studied. They were divided into two groups. Seven patients (group 1), one woman and six men, aged 55–77 years (mean 68 ± 7 years), had been transorally intubated during episodes of acute respiratory failure. Five men (group 2), aged 49–75 years (mean 64 ± 10 years), had previously undergone tracheostomy and had a transtracheal tube in place. The tracheostomy had been performed in order to facilitate weaning from mechanical ventilation. The clinical characteristics of the patients and the based ventilatory pattern while they were being ventilated in pressure support mode are shown in Table 1. Inclusion criteria consisted of clinical diagnosis of COPD with CO_2 retention. All patients in both groups met standard criteria for weaning from mechanical ventilation [13, 14]. Patients were able to tolerate spontaneous ventilation for a period at least 2 h while breathing humidified O_2 mixture (F_iO_2: 0.3–0.5) delivered by a T-piece tube. Patients were also in a steady metabolic state; $\dot{V}CO_2$ did not change more than 5% during the period of the experiment. Patients accepted into the study were clinically stable without fluctuations in hemodynamic status or body temperature. Patients who developed hemodynamic instability or whose CO_2 production increased by more than 5% during the experiment were excluded from the protocol. The study was approved by the scientific committee of the hospital, and informed consent was obtained from all patients and/or closest family members.

Breathing circuit

To facilitate passage of the 2-mm intratracheal (Vygon, intravenous catheter, Ecouen, France), patients were breathing through an endotracheal tube connected with the angled adapter containing a rubber diaphragm (15M swivel elbow plus seal cap, intersurgical, Twickenman, Middesex, UK). The catheter was connected to an oxygen blender (Sechrist Sarns, air-O_2 mixer, Mich., USA). Inspiratory and expiratory flows were measured with pneumotachograph (Fleisch #2 Lausanne, Switzerland) mounted between the adapter and Y-piece. Low-volume, one-way valves (Hans Rudolph, Kansas City, Mo., USA) attached to the Y-piece separated the inspiratory from the expiratory line. Expired air was directed to a mixing chamber (~10 l) to facilitate continuous monitoring of mixed expired CO_2 concentration (Datex capnograph 103-23-01, Multicap, Sweden). The inspiratory line was connected to a humidified oxygen-mixture supply tube (Venturi system). The dead space added by this circuit was ~15 ml (Fig. 1).

Protocol

The subjects were studied seated at a 45° angle. An arterial catheter was inserted in the radial artery, and arterial blood gas samples were analyzed at 37 °C (Radiometer ABL, Copenhagen, Denmark). Blood gases, inspiratory and expiratory flow, respiratory rate and mixed expired CO_2 ($P\bar{E}CO_2$) were measured. Inspired and expired tidal volumes were obtained by numerically integrating the signal from the pneumotachograph. Corrected $P\bar{E}CO_2$, V_D/V_T, effective tidal volume (V_{Teff}), $\dot{V}CO_2$, and minute ventilation (MV) were calculated by the measured parameters. Inspiratory and expiratory flow and inspired and expired tidal volumes were recorded on an 8-channel recorder (Gould ES 1000, Oxaio, USA). The first blood gases were collected just before the patient was connected to the standard aforementioned circuit, while patients were breathing the oxygen

Table 1 Characteristics of patients studies (*ARF* acute respiratory failure, *COPD* chronic obstructive pulmonary disease, *PSV* pressure support ventilation, *MV* minute ventilation, *RR* respiratory rate, *APF* acute respiratory failure)

	Patient no.	Age/Sex (years)	Mech. vent. (days)	Mode PSV (cmH_2O)	PEEP (cmH_2O)	VT (ml)	MV (l/min)	RR (B/min)	Vd/Vt	PCO_2 (mmHg)	Cause of ARF
Group 1	1	55/F	5	5	4	400	5.6	14	0.64	70	Exacerbation of COPD
	2	67/M	6	4	4	510	8.16	16	0.56	61	Post-operation
	3	77/M	5	4	4	420	5.04	12	0.48	52	Exacerbation of COPD
	4	68/M	10	3	5	490	7.35	15	0.50	58	Pneumonia
	5	69/M	8	5	5	600	9.6	16	0.56	79	Exacerbation of COPD
	6	72/M	7	5	3	520	9.36	18	0.52	63	Post-operation
	7	74/M	8	5	4	630	8.82	14	0.63	67	Exacerbation of COPD
	Mean	68	7	4.43	4.8	510	7.2	15	0.56	64	
	SD	7	1.8	0.8	0.9	84	1.5	1.9	0.06	9	
Group 2	1	49/M	16	3	5	410	4.92	12	0.52	50	Pneumonia
	2	66/M	14	5	5	450	7.2	16	0.45	56	Pneumonia
	3	71/M	11	3	5	450	6.3	14	0.52	56	Exacerbation of COPD
	4	59/M	18	4	5	410	6.56	16	0.44	50	Exacerbation of COPD
	5	75/M	23	3	5	500	7.5	15	0.47	55	Exacerbation of COPD
	Mean	64	16.4	3.6	5	444	6.496	14.6	0.48	53	
	SD	10	4.5	0.9	0	37	1.2	1.7	0.04	3	

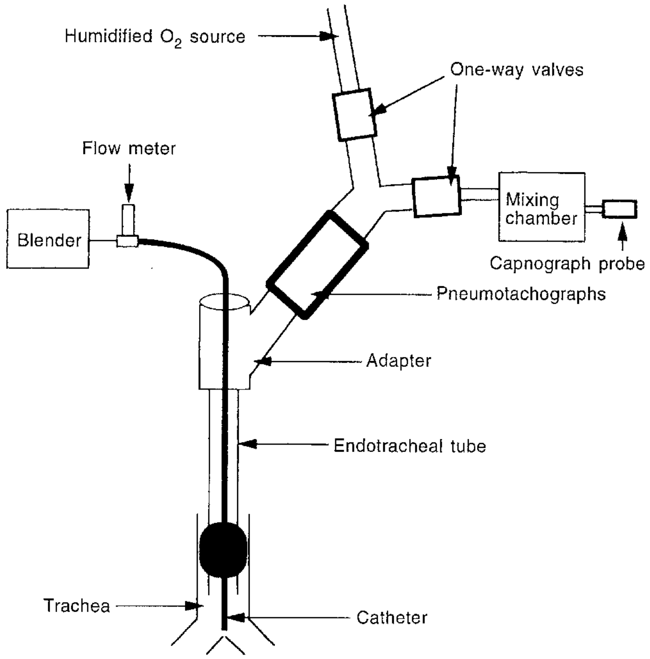

Fig. 1 Diagram of the breathing circuit: catheter and monitoring set-up

mixture through a T-piece. Then the breathing circuit was connected to the endotracheal tube, and the intratracheal catheter (2 mm ID) was placed randomly in either the proximal position (at the level of the cricoid cartilage in the transorally intubated patients and 3–4 cm into the tracheostomy tube of tracheotomized patients) or the distal position (1 cm above the carina), under bronchoscopic guidance. The correspondence of the level of cricoid cartilage into the endotracheal tube was calculated by a chest X-ray film. Baseline measurements were made over a 45-min period while patients were breathing an inspired O_2 fraction (FiO_2) of 0.3–0.5 through the standard circuit with zero catheter flow. Intratracheal, humidified O_2-mixture insufflation was then begun via the catheter placed within the endotracheal tube. Gas delivered through this intratracheal catheter was blended (Sechrist Sarns, air-oxygen mixer) to match the fraction of inspired gas through the circuit. A continuous flow of 3 and 6 l/min in randomized order was used in each catheter position. The flows from the blender were stable, as confirmed by the pneumotachograph. Prior to data collection at each stage, a minimum of 30 min was allowed to transpire for equilibration; thereafter, blood gases were analyzed every 5 min. We assumed that a new steady state had been established when both P_aCO_2 and $\dot{V}\,CO_2$ changed by less than 5% between adjacent measurements. The new steady state was confirmed within 35–50 min. The last blood gas values taken were regarded as representative. A second series of baseline measurements with zero V_{cath} were made at the end of the experiment while the patients were connected to the circuit.

Calculations

Tidal volume

Effective tidal volume (V_{Teff}) was determined from the integration of the expiratory flow signal ($\dot{V}_E$) minus the catheter flow ($\dot{V}_{cath}$) multiplied by inspiratory time (T_E):

$$V_{Teff} = \int \dot{V}_E \, dt - \dot{V}_{cath} \cdot T_E$$

Minute ventilation

Minute ventilation (MV) was calculated by the formula:

$$MV = V_{Teff} \cdot 60/T_T, \quad T_T = T_I + T_E$$

Carbon dioxide output

The carbon dioxide output ($\dot{V}$ CO_2) was calculated by the following equation:

$$\dot{V}\, CO_2 = \dot{V}_{EXP} \cdot [\text{measured } P\bar{E}CO_2/(PB\text{-}47)] \cdot$$
$$\text{(BTPS to STPS correction factor)}$$

where measured $P\bar{E}CO_2$ is the partial pressure of mixed expired CO_2, without correction for the catheter flow ($\dot{V}$ cath), delivered during expiratory time (T_E), and where $\dot{V}_{EXP}$ is the expired volume per minute measured by the numerically integrating signal from pneumotachograph. This volume comprises MV plus the catheter flow during expiration:

$$\dot{V}_{EXP} = (V_{Teff} + \dot{V}_{cath} \cdot T_E) \cdot 60/T_T.$$

Dead space

The dead space fraction V_D/V_T was calculated by the Enghoff modification of the Bohr equation:

$$V_D/V_T = P_aCO_2 - P\bar{E}CO_2/P_aCO_2$$

where corrected $P\bar{E}CO_2$ is the mixed expired CO_2 concentration corrected for the catheter flow ($\dot{V}_{cath}$). $\dot{V}_{cath}$ remained constant throughout the respiratory cycle, forming part of V_T during the inspiratory phase. During exhalation, however, $\dot{V}_{cath}$ diluted the $P\bar{E}CO_2$ measured in the mixing chamber. $P\bar{E}CO_2$ measurement was adjusted to represent only the CO_2 concentration V_{Teff}:

$$\text{corrected } P\bar{E}CO_2 = \dot{V}_{EXP} \cdot \text{measured } P\bar{E}CO_2/MV.$$

Statistical analysis

Results are expressed as mean ± SD. A paired *t*-test was used to determine the reproducibility of baseline values recorded at the beginning and end of the study. The significance of each variable's differences and

Table 2 The effects of catheter flow rate and catheter position on ventilation and gas exchange

Catheter position	Group 1					Group 2				
	Baseline	Proximal		Distal		Baseline	Proximal		Distal	
Catheter flow (l/min)	0	3	6	3	6	0	3	6	3	6
pH	7.39 ± 0.02	7.39 ± 0.01	7.40 ± 0.01	7.40 ± 0.01	7.43 ± 0.01	7.41 ± 0.02	7.41 ± 0.01	7.42 ± 0.02	7.41 ± 0.01	7.42 ± 0.01
$PaCO_2$ (mmHg)	67.7 ± 10	64.6 ± 9*	62.3 ± 9.5*	62.5 ± 11*	47 ± 11*	56 ± 4	54.4 ± 3	54.4	53 ± 4.8	52.6 ± 4.7*
Tidal volume (ml)	476 ± 77	467 ± 73	456 ± 74*	433 ± 68*	423 ± 55*	386 ± 34	384 ± 28	390 ± 29	376 ± 22	354 ± 25*
MV (l/min)	7.8 ± 0.6	7.6 ± 0.7*	7.2 ± 0.4*	7 ± 0.4*	7.8 ± 0.4	6.58 ± 0.8	6.62 ± 0.77	6.6 ± 0.9	6.5 ± 0.7	6.3 ± 0.7*
RR (breaths/min)	17 ± 4	17 ± 4	16 ± 3	17 ± 4	16 ± 4	17 ± 2	17 ± 2	17 ± 2	17 ± 2	18 ± 3
Vd/Vt	0.59 ± 0.06	0.55 ± 0.06*	0.54 ± 0.04*	0.51 ± 0.06*	0.46 ± 0.06*	0.5 ± 0.06	0.5 ± 0.06	0.5 ± 0.06	0.5 ± 0.07	0.49 ± 0.07
$\dot{V}CO_2$ (ml/min)	260 ± 30	266 ± 38	263 ± 32	267 ± 35	246 ± 34	212 ± 40	213 ± 40	213 ± 45	204 ± 22	203 ± 29
P_aO_2 (mmHg)	69 ± 7.9	71 ± 11	73 ± 9	71 ± 10	73 ± 7	71 ± 7	70 ± 4	70 ± 5	72 ± 5	72 ± 6

*Statistically significant difference from the baseline values baseline value were tested using a paired t-test. Internal comparisons were made using the t-test. Correlations between values were analyzed by linear regression, using a standard software package (Statview 512+). The level of significance was $p < 0.05$.

Results

Patient stability and complications

Carbon dioxide output remained practically unchanged throughout the experiment in both groups of patients. $\dot{V}\ CO_2$ decreased at high catheter flow rates and with distal position, but the differences from the baseline values were not statistically significant. Arterial blood pressure and heart rate were unaffected by the catheter flow. Baseline measurements of pH, $PaCO_2$ and PaO_2 prior to connection with the circuit, taken at the beginning and end of the protocol, showed no significant changes.

Many patients experienced a mild increase in cough or minimal discomfort for a few minutes when the catheter was placed in distal position. None developed bronchospasm, which would have necessitated catheter removal.

Effect of TGI on gas exchange

Group 1: Arterial carbon dioxide partial pressure decreased from baseline values (which are reported as the mean values of both baseline measurements at the beginning and end of the protocol) at both catheter flow rates and in both positions. The flow was more effective in the distal position (1 cm above carina) than in the proximal position (at cricoid level). TGI decreased $PaCO_2$ more effectively at the higher (6 l/min) than at the lower (3 l/min) flow rate (Table 2, Fig. 2a). The reduction of $PaCO_2$ from the baseline was statistically significant at both catheter positions and flows (proximal position: catheter flow = 3 l/min, $p < 0.01$; proximal position: catheter flow = 6 l/min; distal position: catheter flow = 3 and 6 l/min, $p < 0.0001$).

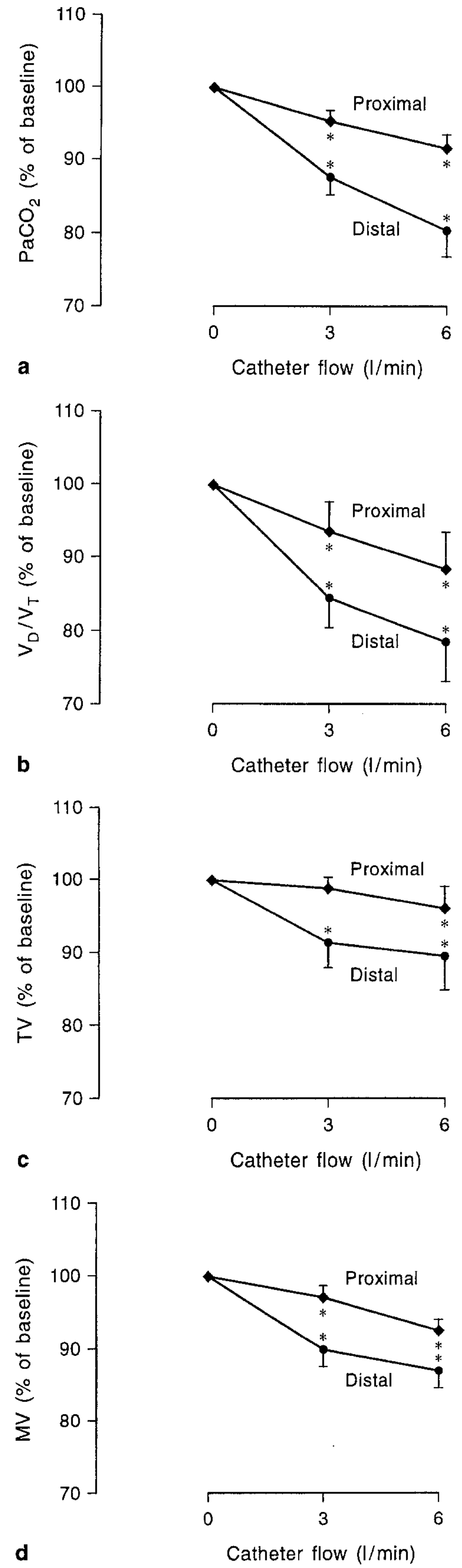

Fig. 2 The effects of TGI in group-1 patients. *Rhombuses* represent the proximal and *dots*, the distal position. *Asterisks* (*) denote statistically significant difference from baseline. Data are expressed as mean ± SD. **a** Percent reduction in P_aCO_2 from the baseline value as a function of catheter flow. **b** Percent reduction in V_D/V_T from the baseline value as a function of catheter flow. **c** Percent reduction in V_T from the baseline value as a function of catheter flow. **d** Percent reduction in MV from the baseline value as a function of catheter flow

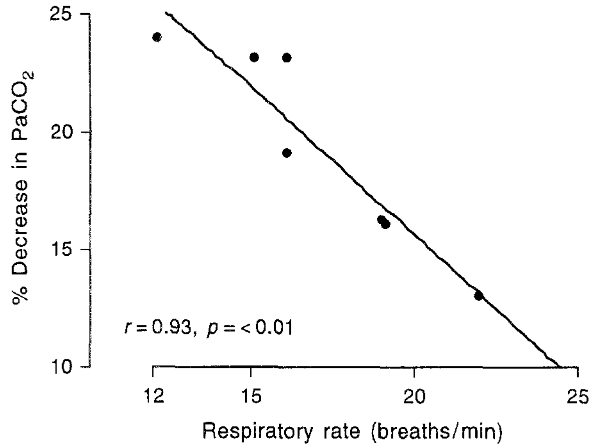

Fig. 3 Percent reduction in P_aCO_2 from the baseline value with catheter flow 6 l/min in group-1 patients, plotted as a function of respiratory rate. There was a significant inverse correlation between reduction in P_aCO_2 and respiratory rate

Physiologic dead space fraction (V_D/V_T) declined as a function of both catheter flow and catheter position (Table 2, Fig. 2b). (proximal position: catheter flow = 3 l/min, $p < 0.01$; proximal position: catheter flow = 6 l/min, $p < 0.001$; distal position: catheter flow = 3 and 6 l/min, $p < 0.0001$).

The respiratory rate (RR) was inversely correlated with the reduction in $PaCO_2$ and V_D/V_T. The best correlation that was statistically significant was observed between RR and $PaCO_2$ in the distal position with catheter flow of 6 l/min ($r = 0.93$; $p < 0.01$, Fig. 3). There was no significant change in mean P_aO_2 in either the distal or the proximal position at either low or high catheter flow.

Group 2: In the proximal position, P_aCO_2 remained unchanged at both catheter flows. In the distal position, there was a significant reduction in P_aCO_2 at both catheter flow rates (3 l/min, $p < 0.05$; 6 l/min, $p < 0.01$) (Table 2, Fig. 4a). There were no significant changes in physiological dead space fraction or P_aO_2 at both positions and catheter flows.

Effect of TGI on ventilation

Group 1: Tidal volume and minute ventilation declined as a function of both the flow and position of the catheter (Table 1, Fig. 2b, d). There was a statistically significant decrease in $\dot{V}_T$ at both positions and catheter flows (proximal position: catheter flow 3 and 6 l/min, $p < 0.05$; distal position: catheter flow 3 and 6 l/min, $p < 0.01$). TGI reduced MV from the baseline values ($p < 0.001$); in contrast, the respiratory rate remained unchanged throughout the experiment.

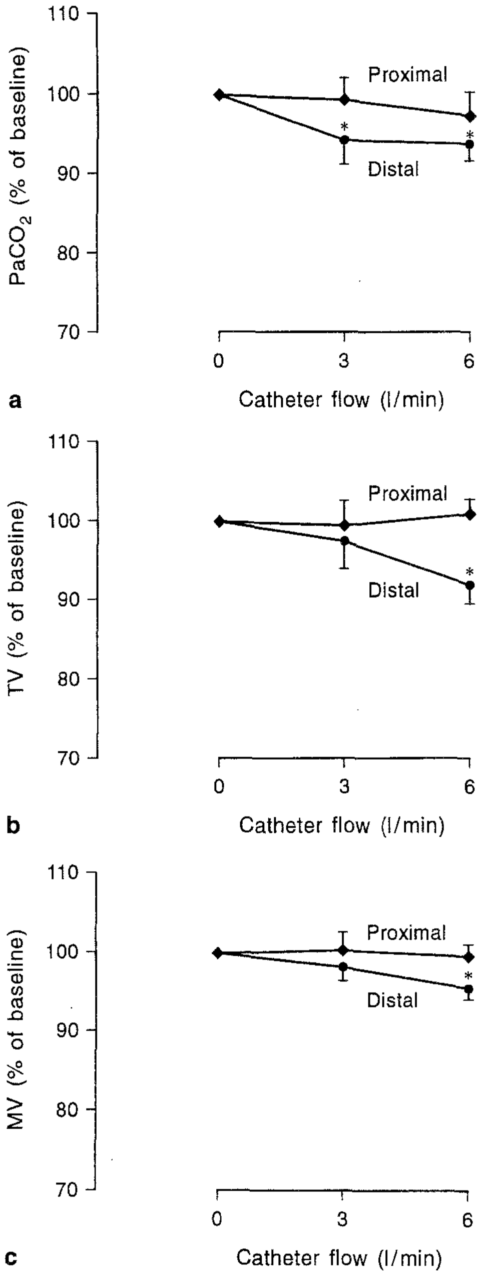

Fig. 4a–c The effects of TGI in group-2 patients. *Rhombuses* represent the proximal and *dots*, the distal position. *Asterisks* (*) denote statistically significant differences from baseline. Data are expressed as mean ± SD. **a** Percent reduction in P_aCO_2 from the baseline value as a function of catheter flow. **b** Percent reduction in V_T from the baseline value as a function of catheter flow. **c** Percent reduction in MV from the baseline value as a function of catheter flow

Group 2: There were statistically significant decreases in V_T and MV only at high catheter flow (6 l/min) and in the distal catheter position ($p < 0.01$) (Table 2, Fig. 4b, c). The respiratory rate remained unchanged throughout the experiment at both catheter positions and flows.

Discussion

This study shows that V_T, MV, P_aCO_2, and V_D/V_T were reduced in a flow-dependent manner when gas was delivered through a oral-tracheal tube (group 1). The distal catheter position was more effective than the proximal one. In contrast, when gas was delivered through the tracheostomy tube (group 2), TGI was ineffective in the proximal position and less effective than in group 1 in the distal position. Carbon dioxide production remained practically unchanged throughout the experiment in both groups of patients. Carbon dioxide output was measured in steady state conditions and with constant alveolar ventilation. Under these conditions, carbon dioxide output can represent carbon dioxide production. Unaccountably, carbon dioxide output was 18.5% lower in group 2. Patients in the two groups had a similar diet and were clinically stable and without fever. Anthropometric data are not available. The lower dead space fraction in group 2, which decreases work of breathing, is the only obvious factor that could reduce $\dot{V}\ CO_2$. At each stage of this study, alveolar ventilation was fairly constant when the measurements were made, as suggested by the constant values of P_aCO_2, and the patients were in steady state conditions.

Effects of TGI on gas exchange

The primary mechanism for improving the efficiency of CO_2 elimination is likely to be a functional decrease in anatomical dead space proximal to the catheter tip caused by the replacement of the CO_2-containing expirate with fresh gas. The end-expiratory, CO_2-laden gas in the anatomical dead space in patients breathing through a T-piece without TGI is driven back into the lungs at the beginning of the next inspiration. During TGI, this gas was replaced or diluted with fresh, non-CO_2-containing gas. TGI delivered in proximal position through the tracheostomy tube was ineffective, perhaps because the tracheostomy had already reduced the anatomical dead space. Distal advancement of the catheter increases the swept dead space volume by the catheter flow; therefore, catheter flow during expiration clears CO_2-laden gas from most of the dead space. Note that further advancing the catheter tip beyond the carina did not significantly improve alveolar ventilation and increased the risk of dynamic hyperinflation at high catheter flows [12]. The improvement in ventilatory efficiency resulting from the functional reduction of dead space allowed for a decrease in $PaCO_2$ at the same frequency and at lower tidal volume. Furthermore, turbulent eddies produced at the catheter tip may also augment alveolar ventilation [12, 15].

Effects of TGI on ventilation

The mechanism for the reduction of V_T with TGI is not clear. The reduction of V_T and MV with TGI may be related to central or peripheral receptors that control ventilation. The improved oxygenation could decrease minute ventilation in COPD patients via chemoreceptors that are responsive to PO_2, pH and PCO_2 [16]. In our group of patients, reduction in V_T through improved oxygnation was impossible because P_aO_2 did not change with TGI, the patients received the same FiO_2 with and without TGI. PCO_2 was the only parameter that changed during TGI. There is a linear relationship between PCO_2 and ventilation [17]; therefore, the decrease in PCO_2 may be totally or partially responsible for the reduction in V_T. The stimulation of irritant stretch receptors in the tracheobronchial tree and the lungs and of C-fiber endings could also reduce V_T, causing mainly rapid and shallow breathing [8, 18]. In our groups of patients, the reduction in V_T was probably not due to stimulation of these receptors, since none of the patients developed rapid and shallow breathing.

In the present study, it was shown that TGI reduced V_T and minute ventilation while the respiratory rate remained unchanged. Although this study does not provide any direct information concerning changes in work of breathing and dyspnea, the reduced V_T is likely to diminish inspiratory work of breathing and to help weaning from the ventilator.

In spite of the decrease in V_T, the ratio of dead space to tidal volume was significantly reduced. A possible explanation for this is that the decrease in dead space was greater than that in tidal volume.

Comparison with previous work

The benefit of bypassing the dead space of the upper airway was first noted in the early 1960s, when tracheostomy was performed as a treatment for patients with ventilatory failure [19]. More recently, air was insufflated directly into the trachea of spontaneously breathing, hypercapnic patients, being delivered to the tracheostomy tube by a closed circuit. Airway gas insufflation reduced V_T, dead space and minute ventilation without affecting PCO_2 in the acute stage [20]. In another study by the same group of investigators, airway oxygen insufflation effected a progressive reduction in V_T, dead space and minute ventilation and in contrast to the previous study, the decrease in dead space was accompanied by slight rises in alveolar ventilation and decrements in arterial PCO_2 in some of the patients [21]. The results of the latter study are quite consistent with ours.

Tracheal gas insufflation is now being applied experimentally as an adjunct to mechanical ventilation. The effect of TGI was studied in sedated, paralyzed and mechanically ventilated patients. During volume-cycled ventilation, constant flows were delivered through an endotracheal catheter. P_aCO_2 end V_D/V_T decreased significantly as a function of both catheter flow and catheter position [10, 22]. Our results are similar to those of both studies. In their study of mechanically ventilated humans receiving TGI, Ravenscraft et al. suggested that the effectiveness of a specific catheter flow was influenced by the percentage of total expiratory cycle time devoted to lung deflation, as well as by the relative proportion of lung and catheter flows during the terminal portion of exhalation. In our study, an inverse relationship between RR and P_aCO_2 was observed. This observation supports the premise of Ravenscraft et al. because the lower the RR, the greater the expiratory time.

Clinical applications

Tracheal gas insufflation has a potential clinical application in patients who are difficult to wean from mechanical ventilation and in whom it is desirable to decrease dead space and work of breathing and to increase alveolar ventilation. It should be noted that this study was not designed to address the problem of difficult weaning, as all patients met the criteria for weaning and all were successfully weaned within a few days after the end of the study. Another protocol will be necessary in order to address a number of questions, such as whether dead space washout by TGI could replace tracheostomy when the latter is indicated to facilitate weaning from mechanical ventilation and how TGI could be delivered at the carina level in extubated patients.

TGI is a simple and apparently safe method; however, with long-term use and at high catheter flow, humidification will be very important as it is necessary to minimize the inspissation of mucus. The presence of an intraluminal catheter may increase both inspiratory and expiratory resistance and, particularly with a small endotracheal or tracheostomy tube, could increase the risk of auto-PEEP. In addition, the presence of an intraluminal catheter complicates suction and sputum removal.

From the preliminary data reported here, we believe that TGI may prove a useful method for reducing P_aCO_2 and work of breathing and may help patients displaying difficulty during weaning.

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