Mechanical ventilation with the esophageal tracheal combitube (ETC) in the intensive care unit

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SUMMARY

Mechanical ventilation in critically ill patients is usually performed with the conventional endotracheal airway. The esophageal tracheal combitube (ETC) is a new device for cardiopulmonary resuscitation, conceived to bridge the gap between hospital and prehospital phases. The ETC may be used in esophageal and endotracheal positions. The authors report six patients who were ventilated with the ETC in the esophageal obturator position for 2–8 h after emergency ventilation. Blood gas data showed adequate ventilation with the ETC during the observation period. Data suggest that mechanical ventilation with the ETC is possible for several hours after cardiopulmonary resuscitation. This might be helpful during the initial post-arrest period, when replacement of the ETC by a conventional endotracheal airway might destabilize a vulnerable patient.

INTRODUCTION

Mechanical ventilation in critically ill patients is usually performed with the endotracheal airway. Under certain circumstances, endotracheal intubation may be difficult. Besides different aids for endotracheal intubation, alternative methods have been described. Most known are the esophageal obturator airway (Don Michael *et al.*, 1968; Don Michael & Gordon, 1980) and the pharyngeal-tracheal lumen airway (Niemann *et al.*, 1984). The esophageal obturator airway has been criticized because of insufficient face-mask seal and inadvertent tracheal insertion causing complete airway obstruction. The pharyngeal-tracheal lumen airway is surrounded by an oral cuff for upper-airways sealing. The semi-rigid stylet ensures correct shaping which has to be removed when the trachea is entered. The short lumen allows a test 'obturator' ventilation before assuming successful endotracheal intubation.

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A new airway, the esophageal tracheal combitube (ETC) allows esophageal or tracheal placement. The ETC has been evaluated during routine surgery (Frass *et al.*, 1987a) as well as during cardiopulmonary resuscitation (Frass *et al.*, 1987b). Emergency intubation is the primary aim of the ETC. To gain experience with the ETC during mechanical ventilation after cardiopulmonary resuscitation, the authors used it in critically ill patients for up to 8 h. Patient characteristics and blood gas data are presented.

METHODS

The ETC (Sheridan Catheter Corporation, Argyle, New York, USA) is a double-lumen tube (Frass *et al.*, 1987a,b). One lumen may be used for esophageal obturator ventilation; it is perforated proximally and closed distally (Fig. 1). The second lumen may be used for endotracheal ventilation; it has a distal open end. Proximal to the perforations, the ETC is surrounded by a pharyngeal balloon which is filled with 100 ml of air after insertion. The distal cuff is designed for sealing either the esophagus or the trachea.

In most cases of blind insertion, esophageal position is obtained. Therefore, it is advisable to attach the bag-valve to the (longer) connector of the so-called 'esophageal' lumen. Air is blown through the perforations into the pharynx and from there beyond the epiglottis into the trachea. The pharyngeal balloon and the distal cuff prevent the escape of air through mouth, nose and esophagus, respectively.

When using the esophageal lumen, failure to hear breath sounds in the lungs and auscultation of gastric insufflation mean *endotracheal* insertion of the ETC. The bag-valve must be changed immediately to the (shorter) connector of the 'tracheal' lumen. The position of the ETC remains unchanged. Ventilation occurs through the tracheal lumen directly into the trachea. The distal cuff seals the trachea.

Fig. 1. Esophageal tracheal combitube (ETC): (A) 'esophageal' lumen; (B) perforations of lumen A; (C) distal closed end of lumen A; (D) longer connector for lumen A; (E) partition wall; (F) 'tracheal' lumen; (G) distal open end of lumen F; (H) shorter connector for lumen F; (I) printed ringmarks indicating depth of insertion; (J) pharyngeal balloon; (K) distal cuff.

PATIENTS

During a 3-month period ending in November 1986, six patients were ventilated on the intensive care unit with the ETC in the esophageal position following emergency intubation. The indications for using the ETC were cardiopulmonary resuscitation on the general ward (3), failure of conventional endotracheal intubation (2) and impeded vocal cord visualization due to massive regurgitation (1). Within 20 min after intubation, the four patients who underwent cardiopulmonary resuscitation on the general ward were transported to the intensive care unit. The patients were ventilated with a respirator (Servo 900C, Siemens, Elema, Sweden) at an average tidal volume of 12 ml/kg body weight; frequency of ventilation and fractional inspired oxygen, as well as positive end-expiratory pressure, were individually adjusted. I:E-ratio was 1:2 in all patients. Patients characteristics are summarized in Table 1.

After ventilation for 2–8 h, the ETC was replaced by a conventional endotracheal airway (Mallinckrodt Lab. Ltd, Athlone, Ireland). Blood gas analyses (ABL 2 Radiometer, Copenhagen, Denmark) were recorded 15 min after beginning mechanical ventilation with the ETC and every hour subsequently until replacement of the ETC by a conventional endotracheal airway, as well as 15 min, 1 and 2 h thereafter. The ventilatory parameters were not changed between the last hour of ETC-ventilation and the first 15 min of endotracheal airway ventilation. Glycopyrroniumbromide was administered to two patients, to reduce bronchial secretions.

Intubation with the ETC was performed by the physician on duty (first year resident). Replacement with an endotracheal airway was done by the chief resident.

The study was approved by the Ethical Commission of the University of Vienna.

Table 1 Patients characteristics*

Patient	Age	Sex	Diagnosis	Indication for use of ETC	Final outcome
1	73	m	Coronary heart disease, ventricular fibrillation	CPR at the general ward	Survived
2	50	f	Gastric cancer, skeletal metastases, asystole	CPR at the general ward	Died
3	65	f	Acute respiratory distress syndrome due to septic shock	Failure of endotracheal intubation at the ICU	Died
4	74	m	Hip endoprosthesis, acute respiratory failure	CPR at the general ward	Survived
5	48	m	Kidney transplantation, cytomegalovirus infection, acute respiratory failure	Impeded visualization of the vocal cords due to massive regurgitation	Survived
6	68	m	Coronary heart disease, aortocoronary bypass surgery, ventricular fibrillation	Failure of endotracheal intubation at the general ward	Survived

*CPR: cardiopulmonary resuscitation; ICU: intensive care unit.

Table 2 Blood gas data during esophageal tracheal combitube (ETC) ventilation and subsequent endotracheal airway ventilation. Ventilatory parameters were adjusted at the beginning of the respective observation period. FiO_2 : fractional inspired oxygen; EMV: expiratory minute volume (L/min); PEEP: positive end-expiratory pressure (cm H_2O); PaO_2 : arterial oxygen tension (mm Hg); PaCO_2 : arterial carbon dioxide tension (mm Hg); BGA: blood gas analysis. + Died prior to 2 h blood gas analysis

Pat	BGA	Esophageal tracheal combitube						Endotracheal airway					
		15 min	1 h	2 h	3 h	4 h	5 h	6 h	7 h	8 h	15 min	1 h	2 h
1	FiO_2	1.0	1.0	1.0							1.0	1.0	1.0
	EMV	11	11	11							11	11	11
	PEEP	5	8	8							8	10	10
	PaO_2	77.2	110.3	102.5							83.0	92.8	103.5
	PaCO_2	38.8	39.4	38.2							39.4	44.8	42.2
2	pH	7.4	7.32	7.29							7.4	7.4	7.35
	FiO_2	1.0	1.0	1.0							1.0	1.0	+
	EMV	10	10	11							11	11	
	PEEP	5	10	10							10	10	
	PaO_2	55.2	86.7	92.7							56.0	59.0	
3	PaCO_2	22.3	28.5	31.3							28.8	25.3	
	pH	6.97	7.41	7.42							7.44	7.29	
	FiO_2	1.0	1.0	1.0							1.0	1.0	1.0
	EMV	9	9	9							9	9	9
	PEEP	5	10	10							10	10	10
4	PaO_2	91.2	102.3	110.5	112.9						101.2	105.8	110.7
	PaCO_2	30.7	30.8	32.2	33.5						32.5	34.2	35.1
	pH	7.44	7.41	7.43	7.45						7.41	7.43	7.46
	FiO_2	1.0	0.8	0.8	0.7	0.6	0.5				0.5	0.6	0.7
	EMV	11.5	11.5	10	10	10	10				10	10	10
	PEEP	8	8	8	8	8	8				8	8	8
	PaO_2	327.9	107.2	161.3	145.8	160.8	108.2				87.8	86.5	130.4
	PaCO_2	50.1	30.2	28.8	27.7	32.4	32.4				34.1	33.9	37.8
	pH	7.31	7.52	7.52	7.5	7.5	7.47				7.51	7.5	7.43

5	FiO ₂	1.0	0.7	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5
	EMV	12	12	12	12	12	12	12	12	12	12	12
	PEEP	10	5	5	5	5	5	5	5	5	5	5
	PaO ₂	330.1	176.8	103.4	109.8	103.9	81.3	116.9	115.3	111.0	98.0	106.8
	PaCO ₂	60.8	38.7	36.0	32.8	32.0	29.1	36.6	37.1	30.1	33.4	30.9
9	pH	7.02	7.21	7.24	7.26	7.3	7.29	7.27	7.31	7.29	7.27	7.25
	FiO ₂	1.0	0.8	0.8								
	EMV	9	9	9								
	PEEP	5	5	5								
	PaO ₂	160.8	105.1	106.8								
	PaCO ₂	61.4	55.2	38.2								
	pH	7.06	7.1	7.35								

RESULTS

Prompt insertion of the ETC was possible and resulted in the esophageal position in all six patients. The patients were ventilated with the ETC in the esophageal position for 2–8 h. Blood gas data during ETC ventilation and subsequent endotracheal airway ventilation are shown in Table 2. The blood gas data showed adequate ventilation with the ETC during the observation period. Blood gas analysis of the last hour of ETC ventilation and first 15 min of endotracheal airway-ventilation showed similar results while ventilatory parameters remained unchanged.

DISCUSSION

The early establishment of a patent airway and adequate ventilation are major determinants of successful resuscitation in acutely ill or injured patients. The best method is endotracheal intubation. However, endotracheal intubation requires training and the opportunity to continually maintain this skill.

The EOA is frequently used in the prehospital setting (Shea *et al.*, 1985; Hammargren *et al.*, 1985; Hoflehner *et al.*, 1984), but its use and effectiveness have been criticized recently (Auerbach & Geehr, 1983; Smith *et al.*, 1983). Many perceived EOA problems are due to poor mask fit (White, 1984), inadvertent tracheal intubation (Bryson *et al.*, 1978) and esophageal or gastric rupture (Hoffman *et al.*, 1983).

The ETC was designed to overcome these disadvantages. The pharyngeal balloon instead of the face-mask seals the upper airways and the two-tube system allows ventilation in either esophageal or tracheal position (even if the position is unrecognized, the other lumen allows spontaneous breathing). The risk of upper gastrointestinal rupture may be lower due to the shorter length of the ETC. A further advantage of the ETC is that head extension and neck movement are not required for insertion. This might be important in patients with cervical spine injuries.

Mechanical ventilation with the ETC is possible for up to 8 h after emergency intubation. Blood gas data show comparable results for ventilation with ETC and endotracheal airway. This might be helpful during the initial post-arrest period, when replacement of the ETC by a conventional endotracheal airway might be difficult. Replacement can be postponed until the patient's condition has stabilized.

This study confirms earlier reports (Frass *et al.*, 1987a,b) of effective ventilation during both routine surgery and cardiopulmonary resuscitation. The authors suggest the following indications for use of the ETC: cardiopulmonary resuscitation by medical staff not trained in endotracheal intubation; failure of conventional endotracheal intubation (Tunstall & Geddes, 1984); massive regurgitation or haemorrhage; inadequate access to the oropharynx; cervical spine injury; and surgery in rheumatoid arthritis with subluxation of the atlantoaxial joint.

In the authors' opinion, the ETC serves as a simple airway, especially suitable for the prehospital phase. However, during in-hospital cardiopulmonary resuscitation, the ETC can be used whenever ideal conditions, facilities and staff trained in endotracheal intubation are not immediately available.

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