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ORIGINAL ARTICLE

Flow-controlled ventilation during ear, nose and throat surgery

A prospective observational study

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BACKGROUND Flow-controlled ventilation (FCV) is a new mechanical ventilation mode that maintains constant flow during inspiration and expiration with standard tidal volumes via cuffed narrow-bore endotracheal tubes. Originating in manually operated 'expiratory ventilation assistance', FCV extends this technique by automatic control of airway flow, monitoring of intratracheal pressure and control of peak inspiratory pressure and end-expiratory pressure. FCV has not yet been described in a clinical study.

OBJECTIVE The aim of this study was to provide an initial assessment of FCV in mechanically ventilated patients undergoing ear, nose and throat surgery and evaluate its potential for future use.

DESIGN An observational study.

SETTING Two German academic medical centres from 24 November 2017 to 09 January 2018.

PATIENTS Consecutive patients ($\geq$ 18 years) scheduled for elective ear, nose and throat surgery. Exclusion criteria were planned laser surgery, intended fibreoptic awake intubation, emergency procedures, increased risk of aspiration, American Society of Anesthesiologists (ASA) physical status more than III and chronic obstructive pulmonary disease classified as GOLD stage more than II.

INTERVENTION Peri-operative use of FCV provided by a new type of ventilator (Evone) via a narrow-bore endotracheal tube (Tritube).

MAIN OUTCOME MEASURES Minute volume, respiratory rate, intratidal tracheal pressure amplitude (Δp) and end-tidal CO_2 ($P_{et}CO_2$) were recorded every 5 min. All adverse events were noted. Data are presented as median [IQR].

RESULTS Sixteen patients provided 15 evaluable data sets. A minute volume of 5.0 [4.4 to 6.4] l min^{-1} and a respiratory rate of 9 [8 to 11] min^{-1} generated a $P_{et}CO_2$ of 4.9 [4.8 to 5.0] kPa. Δp was 10 [9 to 12] cmH_2O. Five adverse events were recorded: a tube obstruction due to airway secretions and four tube dislocations (two attributed to coughing, two not study-related).

CONCLUSION FCV achieves adequate $P_{et}CO_2$ levels with minute volume and Δp in the normal range. Tritube's high flow resistance may increase the likelihood of tube dislocations if the patient coughs. Although further evaluation is necessary, FCV provides a new option for short-term mechanical ventilation. The successful operation of FCV with narrow-bore tubes contributes to the armamentarium for airway management.

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Introduction

In 2010, the development of a new ventilation mode, expiratory ventilation assistance (EVA), was reported.[1] With EVA, both inspiration and expiration are controlled during the ventilation cycle using an ejector-based flow reversal device[2,3] that applies positive pressure to insufflate gas into the lungs during inspiration and negative pressure to actively suck gas out of the lungs during

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expiration. This technique allows effective ventilation through a narrow-bore lumen as fine as 2 mm in diameter with a sealed airway.[4]

EVA made its debut as the manually operated Ventrain system (Ventinova Medical B.V., Eindhoven, The Netherlands), aimed at providing ventilation in emergency airway situations via a cannula cricothyrotomy.[5,6] The Ventrain system was shown to be efficacious in hypoxic animals[7–9] and emergency ventilation in humans.[10–12] It may help to avoid surgical tracheostomy,[13,14] and provides new clinical options for one lung ventilation.[15]

Flow-controlled ventilation (FCV), as provided in the new Evone ventilator (Ventinova Medical B.V.), extends the EVA technique by automatic control of the flow reversal device and continuous intratracheal pressure monitoring. The machine achieves a continuous, linear variation of pressure with time by applying constant positive flow during inspiration and constant negative flow during expiration. There are therefore no flow pauses during the ventilation cycle, and the rate of change of pressure and volume in the lungs is uniform. Linearising the fall of airway pressure during expiration was shown to be beneficial for lung recruitment.[16,17]

Compared with volume-controlled ventilation, FCV improved arterial oxygenation and CO_2 removal in healthy pigs[18] and in pigs with oleic acid induced acute respiratory distress syndrome[19] at the same end-expiratory pressure (EEP) and same peak inspiratory pressure (PIP).

How this new ventilation technique performs in clinical practice has not yet been described. Our aim in this observational study was to provide an initial assessment of FCV in mechanically ventilated patients undergoing ear, nose and throat (ENT) surgery, and evaluate the potential of this technique for general use in the operating room.

Materials and methods

The study received ethical approval (file reference 393/17, Ethics committee of the University of Freiburg, Engelberger Str. 21, 79106 Freiburg, on 18 September 2017) and was registered in the German register for clinical trials (DRKS00013312) before inclusion of the first patient. Written informed consent was obtained from all patients before participating in the study. Patients were recruited from 24 November 2017 to 9 January 2018.

Patients

Consecutive patients of age at least 18 years scheduled for elective ENT surgery under general anaesthesia with a scheduled operating time less than 120 min were assessed for inclusion during the normal preoperative anaesthesiological evaluation. Exclusion criteria were planned laser surgery, intended fibreoptic awake intubation, emergency procedures, increased risk of aspiration, ASA physical status more than III and history of chronic obstructive pulmonary disease classified as GOLD stage more than II.

Anaesthesia and Tritube for airway management

Following adequate preoxygenation (expired fraction of oxygen > 0.8), total intravenous anaesthesia with propofol and remifentanil was used for induction and maintenance. After neuromuscular blockade (drug and dose decided by the attending anaesthetist), all patients were intubated with the Tritube[20,21] (Ventinova Medical B.V.), and its cuff was inflated to 25 to 30 cmH_2O. The Tritube is a narrow-bore triple lumen tube: one lumen for ventilation, one for measurement of the intratracheal pressure and one for inflating/deflating the high-volume, low-pressure cuff (Fig. 1). It is 40 cm long with an outer diameter of 4.4 mm. The ventilation lumen has a cross-sectional area equivalent to that of a cylindrical lumen of approximately 2.4 mm diameter and is designed to work with devices providing EVA/FCV, such as Ventrain or Evone. A malleable stylet allows preshaping of the Tritube in order to facilitate intubation. The Tritube has successfully been used in clinical practice and was reported in a case study series.[22]

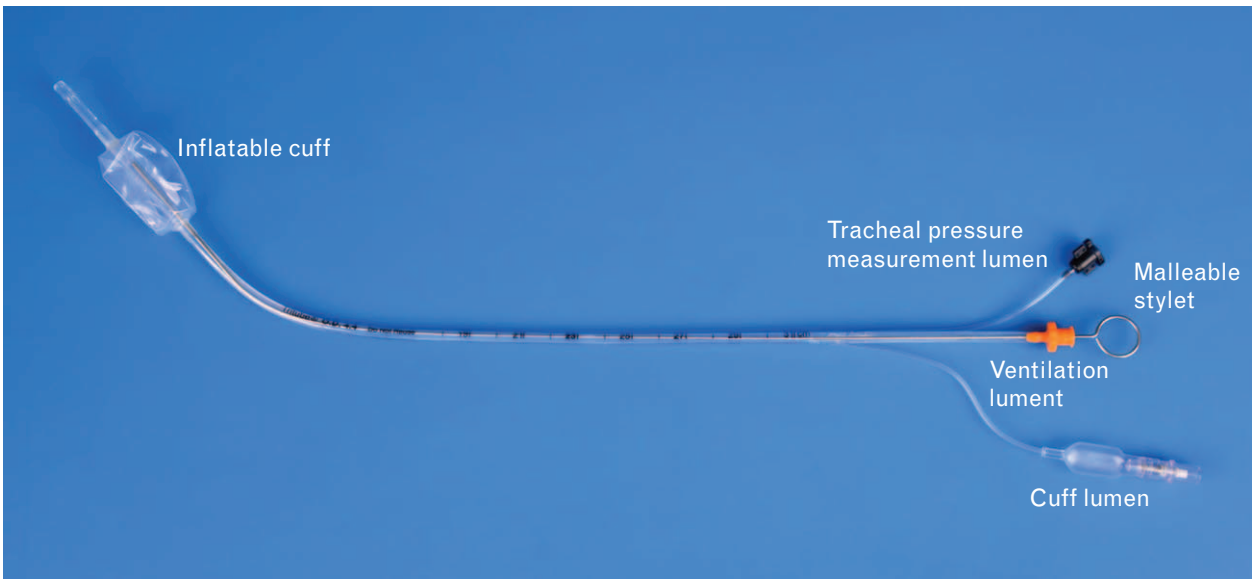
Flow-controlled ventilation and Evone ventilator

FCV is designed to ventilate the patient with constant flows during both inspiration and expiration. The pressure rises linearly from a set EEP to a set PIP during inspiration and then falls linearly from PIP to EEP during expiration (Fig. 2). The PIP and EEP are controlled according to thresholds in the intratracheal pressure, which is directly and continuously monitored via the dedicated pressure measurement lumen of the Tritube. This lumen is not used for ventilation and the flow inside is always zero, enabling an accurate pressure measurement without ventilation flow pauses. The operator sets the inspiratory flow rate and the ratio of inspiratory to expiratory time (I:E ratio). This gives full control of the ventilation cycle but results in two unusual features:

(1) The minute volume depends only on the set inspiratory flow rate ($\dot{V}_i$) and the I:E ratio, and is given by: $MV = \dot{V}_i / (1 + 1/\text{I:E ratio})$
(2) The respiratory rate cannot be set directly and depends on the PIP, EEP, set inspiratory flow rate, I:E ratio and lung compliance.

During inspiration, the ventilator generates a positive pressure to drive gas through the ETT into the patient's lungs. When the intratracheal pressure reaches the set PIP value, the ventilator switches from inspiration to expiration. The flow reversal device now exploits the Bernoulli effect to generate a negative pressure at the ventilator side of the ETT, and this sucks gas from the lungs. Although negative pressure is generated on the ventilator side of the ETT, the pressure in the patient's airway is positive at all times.

Fig. 1

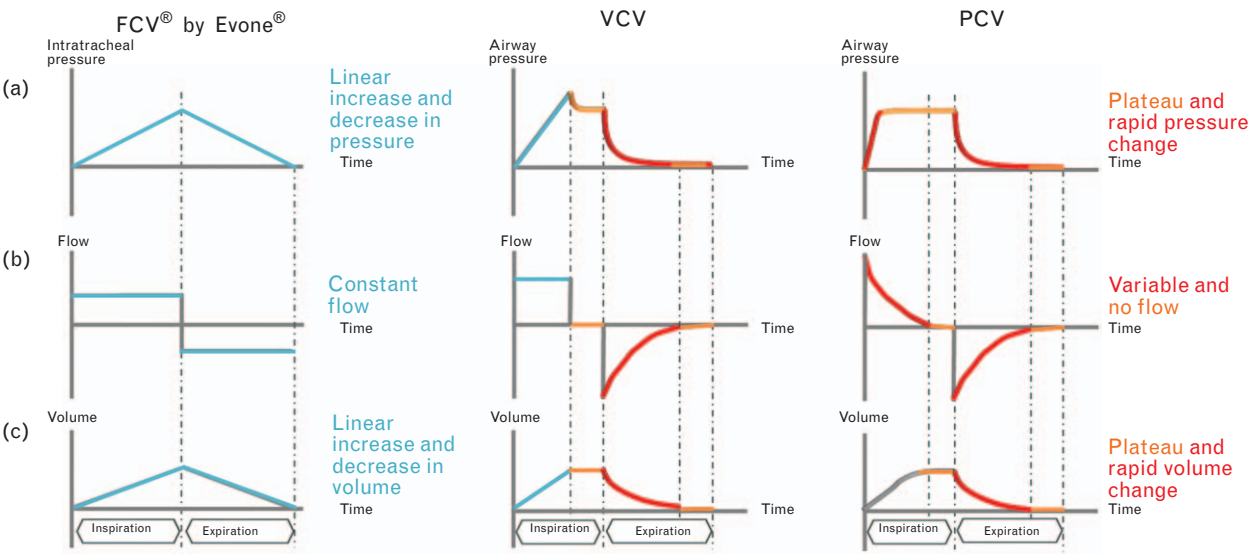


The Tritube, the narrow-bore endotracheal tube used in all patients in this observational study.

The Evone ventilator received its CE-mark in August 2017 and is currently the only commercially available ventilator providing FCV. Its intended use is mechanical ventilation of patients weighing more than 40 kg during surgical procedures, which do not require inhaled anaesthetic agents and take less than 24 h.

For this study, a heat and moisture exchange filter (Humid-Vent Filter Pedi straight; Teleflex Medical Europe Ltd, Athlone, Ireland) was used as recommended by the manufacturer (ref: Evone - Instructions for use, Version MSS076.03, https://www.ventinovamedical.com/wp-content/uploads/2018/07/MSS076.03-IFU_Evone_EN.pdf).

Fig. 2



Comparison of flow-controlled ventilation with conventional volume and pressure-controlled ventilation modes.

Emergence from anaesthesia and extubation

During emergence from anaesthesia, difficulties might arise if the patient tries to breathe against the high resistance of the Tritube. To facilitate the transition to spontaneous breathing, we devised four protocols:

(1) If controlled ventilation is well tolerated, FCV may be continued until extubation. If necessary, O_2 supplementation or ventilatory support may subsequently be provided with a face mask.
(2) On emergence, the clinician may switch from FCV to a jet ventilation mode also available in the Evone. The cuff of the ETT must then be deflated to provide a nonsealed airway.
(3) With an inspired oxygen fraction (FiO_2) of 1.0 and the cuff deflated, Tritube may also be used as a subglottic insufflation catheter that provides efficient apnoeic oxygenation probably with some CO_2 clearance. This might provide stability with the tube in place and the cuff deflated, until spontaneous breathing is sufficient.
(4) Spontaneous breathing may be established, or if necessary, ventilatory support may be given via a standard airway device such as a face mask or laryngeal mask, after removing the Tritube or with the cuff deflated and the Tritube left in place.

The decision for the individually applied emergence protocol was made by the attending anaesthetist.

Study protocol

Ventilation settings were at the discretion of the attending anaesthetist and consisted of FiO_2, inspiratory flow rate, I:E ratio, PIP and EEP. Mainstream capnography built into the ventilator was used for determination of end-tidal carbon dioxide partial pressure ($P_{et}CO_2$). Further measured values were minute volume, PIP, EEP, respiratory rate, I:E ratio, inspiratory tidal volume (V_T), peripheral blood oxygen saturation (SpO_2), noninvasively measured blood pressure (NIBP) and heart rate (HR). Resistance (R) and dynamic compliance (C_{dyn}) of the respiratory system as displayed by the ventilator were recorded. The intratidal tracheal pressure amplitude (Δp), defined as the difference between PIP and EEP, was calculated offline. Each measure was recorded in intervals of 5 min and the mean was determined for each patient to provide a representative and concise value for their intra-operative situation. Adverse events associated with ventilation were recorded.

Statistical analysis

Data are presented as median [IQR]. Descriptive statistics are used to illustrate the results. For the number of patients included in the study, the expected width of the 95% confidence interval is equivalent to mean $\pm$ 0.5 standard deviations.

Table 1 Patient characteristics and procedures

$n = 15$	
Female	6 (40)
Age (years)	56 [20 to 84]
Weight (kg)	83 [50 to 117]
Duration of surgery (min)	55 [30 to 440]
ASA physical status classification	
I	3 (20)
II	11 (73.3)
III	1 (6.7)
Surgical procedure	
Head and neck surgery	5 (33.3)
Panendoscopy	3 (20)
Endonasal surgery	3 (20)
Cochlea implant surgery	2 (13.3)
Tracheostomy[a]	1 (6.7)
Maxillofacial surgery	1 (6.7)
Extubation strategy	
FCV until extubation	5 (33.3)
Placement of LMA	5 (33.3)
Jet ventilation	2 (13.3)
Tracheal O_2 insufflation	2 (13.3)
Placement of tracheostomy tube[a]	1 (6.7)

Data are presented as percentage *n* (%) or median [range]. ASA, American Society of Anesthesiologists; FCV, flow-controlled ventilation; LMA, laryngeal mask. [a] Due to performed surgery (tracheostomy), none of the optional extubation strategies was required.

Results

Of the 20 patients assessed for participation, one refused and three could not be included because surgery was postponed, leaving 16 for enrolment. Subsequently, data from a further patient were excluded due to a Tritube dislocation caused by coughing 5 min after endotracheal intubation. In this case, the patient was re-intubated with a standard ETT and data recording was discontinued. A summary of patient and procedure data can be found in Table 1.

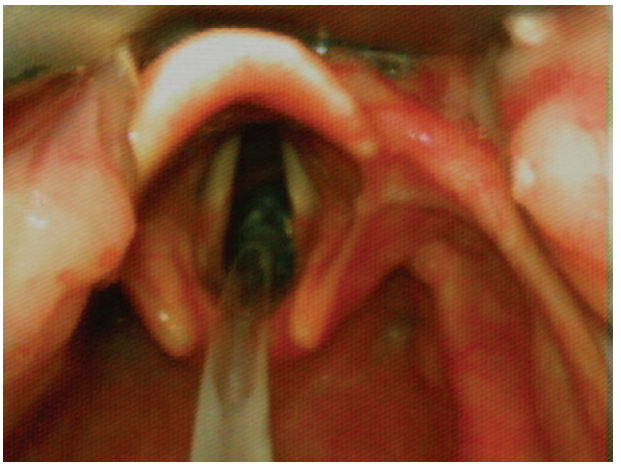
Airway management, ventilation and haemodynamic variables

No adverse events occurred during tracheal intubation with the Tritube. There was good visibility of the laryngeal structures during insertion and after placement of the Tritube (see Fig. 3 and Video, Supplemental Digital Content 1 for the insertion of a Tritube filmed by videolaryngoscopy, http://links.lww.com/EJA/A190).

With FCV, the variation of intratracheal pressure with time had a distinctive triangular profile (Fig. 4). A video of the ventilator screen during ventilation can be found in the digital content (see Video 2 Video, Supplemental Digital Content 2, which displays the Evone ventilator in FCV mode, http://links.lww.com/EJA/A191).

All respiratory variables, SpO_2, and $P_{et}CO_2$ were within the typical clinical range (Table 2). At a $\dot{V}i$ of 10 [9 to 13] l min^{-1} and a measured I:E ratio of 1 : 1 [1 : 1 to 1 : 1.1], the minute volume was 5.0 [4.4 to 6.4] l min^{-1} and achieved a $P_{et}CO_2$ of 4.9 [4.8 to 5.0] kPa. Δp was 10 [9 to 12] cmH_2O.

Fig. 3



Videolaryngoscopic view of Tritube in position. The cuff can be seen in the subglottic area. (C-MAC videolaryngoscope, Macintosh blade #4; Karl Storz SE & Co. KG, Tuttlingen, Germany).

All patients were haemodynamically stable and showed haemodynamic variables within the usual intra-operative range (Table 2).

Specific observations and adverse events

With the cuff deflated and the Tritube still in tracheal position, three patients could comfortably breathe spontaneously after emergence from anaesthesia and one of them even tolerated the Tritube until arrival in the postanaesthesia care unit. In another, a small dose of lidocaine gel (2%, 0.25 ml) on the cuff may have contributed to improved tube tolerance. Dislocation of the tube was observed in four patients as a result of the following: drape removal ($n = 1$), external manipulation as a result of the surgery ($n = 1$) and coughing ($n = 2$). Following tube dislocation due to coughing, ventilation was continued with standard equipment, resulting in exclusion of the patient from the study. Two patients were re-intubated after tube dislocation and FCV ventilation was resumed. In one patient, tube dislocation occurred close to emergence and a laryngeal mask was inserted to permit

Fig. 4

Photograph of the Evone ventilator (front), showing time course for mainstream capnography, tracheal pressure and inspiratory tidal volume. Adjustable settings are shown in the bottom of the screen. Measured variables appear on the right of the screen. On the far right of the housing, the orange-coloured cartridge (with the ejector inside), the attached sensor for mainstream capnography, the heat and moisture exchange filter and the line for tracheal pressure measurement are captured.

Table 2 Respiratory and haemodynamic variables during intraoperative flow-controlled ventilation

Variable	Value
FiO_2, set at ventilator	0.5 [0.5 to 0.8]
$\dot{V}_i$ (l min^{-1}), set at ventilator	10 [9 to 13]
SpO_2 (%)	99 [98 to 99]
$P_{et}CO_2$ (kPa)	4.9 [4.8 to 5.0]
MV (l min^{-1})	5.0 [4.4 to 6.4]
PIP (cmH_2O)	15 [14 to 17]
EEP (cmH_2O)	5 [4 to 5]
Δp (cmH_2O)	10 [9 to 12]
RR (min^{-1})	9 [8 to 11]
I:E ratio	1 : 1 [1 : 1 to 1 : 1.1]
V_T (ml)	546 [493 to 660]
V_T (ml kg^{-1}) IBW	8.6 [7.8 to 9.2]
C_{RS} (ml cmH_2O^{-1})	52 [45 to 61]
R (cmH_2O l^{-1} s^{-1})	6.0 [5.4 to 7.4]
Heart rate (min^{-1})	65 [57 to 72]
NIBP systolic (mmHg)	99 [91 to 108]
NIBP diastolic (mmHg)	49 [46 to 55]
NIBP mean (mmHg)	71 [68 to 76]

Data presented as median [IQR]. C_{RS}, respiratory system compliance; EEP, end-expiratory pressure; FiO_2, inspired oxygen fraction; IBW, ideal body weight; I:E ratio, inspiration to expiration time ratio; MV, minute volume; NIBP, noninvasive blood pressure; Δp, intratidal tracheal pressure amplitude; $P_{et}CO_2$, end-tidal carbon dioxide partial pressure; PIP, peak inspiratory pressure; RR, respiratory rate; R, respiratory system resistance; SpO_2, peripheral blood oxygen saturation; V_i, inspiratory flow rate; V_T, inspiratory tidal volume.

supported spontaneous breathing during emergence. In one patient, obstruction of the tube occurred during ventilation, which was overcome by flushing the tube with 3 ml of 0.9% saline.

Discussion

This observational study is the first to report the clinical use of FCV, with nearly constant and equal flows throughout the duration of both the inspiratory and expiratory phases of ventilation. Respiratory variables were within the typical clinical range, all patients were haemodynamically stable, three patients could comfortably breathe spontaneously after emergence with the Tritube still in place and its cuff deflated, and four patients experienced tube dislocation, twice due to coughing and twice for reasons unrelated to the study. The Tritube brings advantages in terms of ease of intubation and good laryngeal view when intubation is complete. Notwithstanding the high pressure drop across the ETT intrinsically associated with such a narrow bore, our study indicates that the FCV technique was able to provide sufficient ventilation.

In shared airway situations, we were able to ventilate patients continuously with a secured airway. Usually, such scenarios carry a higher risk of barotrauma or desaturation, as it is normal to employ jet ventilation or to ventilate intermittently. At the same time, the small outer diameter of the ETT provides minimal visual interference, allowing for a good view of the surgical field in upper airway surgery. Measuring intratracheal pressure via this tube eliminates concerns (in either FCV or jet ventilation mode) about both barotrauma and the build-up of intrinsic positive EEP,[23,24] as the ventilator continuously brings tracheal pressure actively back to EEP at the end of each ventilation cycle, even within a short expiratory time that enables an I:E ratio of 1 : 1. The narrow-bore ETT in combination with direct tracheal pressure measurement may be a means for implementing generally accepted ventilation strategies.[25,26]

Ventilation without flow pauses risks intrinsic positive EEP, which was not explicitly measured in this study, for example with an end-expiratory occlusion manoeuvre. However, in FCV mode, the Evone automatically purges the pressure measurement lumen at EEP level every 5 min with a flow pulse of 10 ml of respiratory gas within a 1-s ventilation pause, which allows detection of intrinsic positive EEP. Future studies should elucidate the relevance of intrinsic positive EEP during FCV in more detail.

The need for smooth emergence from anaesthesia and successful extubation make these critical points in the anaesthesia cycle.[27] We found that the combination of FCV, optional jet ventilation, efficient apnoeic oxygenation and minimal airway obstruction provided by the narrow-bore ETT (with the cuff deflated) allowed for well tolerated emergence, although some patients required short-term ventilatory support with a face or laryngeal mask. However, tolerance of the narrow-bore ETT even enabled one of our patients to talk with the Tritube in place, an experience that mirrors previous reports.[22] The ability to rapidly switch between FCV with the cuff inflated, jet ventilation and/or apnoeic oxygenation with the cuff deflated, and then to re-inflate the cuff and switch back to FCV with a secured airway if necessary may give substantial additional operating margin for unexpected events and a range of valuable options for evaluation of the patient's status[26] during the emergence and extubation phases.

The Evone provided permanent monitoring of key ventilation variables[28] such as mainstream $P_{et}CO_2$, V_T and minute volume throughout the procedure. Continuous intratracheal pressure measurement coupled with the ventilator control system and the small intrinsic volume of the patient circuit and narrow-bore ETT also ensured that the PIP and EEP pressures were accurately applied to the patient. The conception and innovative technical design of the Evone make it also a measurement tool rather than just another type of ventilator. In FCV mode, it gives a precise picture of dynamic lung mechanics throughout the ventilation cycle.[29,30] Some key differences between the Evone and standard ventilators are noted as follows:

(1) By its operating principle, FCV provides no period during the ventilation cycle wherein the flow is zero or even substantially lower than the requested flow.

(2) Although during FCV the V_T is set by adjusting the PIP and EEP comparable to pressure-controlled ventilation, changing PIP and EEP during FCV has no effect on minute volume, as this is determined solely by the flow rate and the I:E ratio.
(3) Increasing the PIP will increase V_T but at the same time cause a proportional decrease in respiratory rate and, consequently, the minute volume remains the same. In contrast to conventional ventilation modes, there is no option to set the respiratory rate directly. Instead, it is determined by the EEP and PIP, the flow rate, the I:E ratio and lung compliance. It must be stressed that the ventilator settings for FCV are very different compared with standard ventilation modes. Identical settings produce different respiratory rate and V_T for different patients due to different lung compliances. In consequence, specific training for using FCV is essential and was provided to the anaesthetists involved in the study. Further, it is worth noting that if jet ventilation or apnoeic oxygenation is used during emergence and transition to spontaneous breathing, the cuff must be deflated and so the trachea will be unsealed with a potential risk of aspiration.

Limitations

We observed a rather high incidence of tube dislocation. It needs to be emphasised that the study was conducted shortly after market release of the ventilator, so the anaesthetists involved were at the beginning of the learning curve. The high flow resistance of the Tritube in combination with an inflated cuff impedes a quick pressure release from the trachea. If the patient coughs, this physical characteristic promotes tube dislocations. In addition, coughing can be caused by surgical stimuli especially during ENT surgery.

Conventional endotracheal suctioning is restricted with the Tritube, because a suction catheter cannot be advanced through the narrow ventilation lumen. However, with the cuff deflated, the ventilation lumen of the Tritube, equivalent to the lumen of a white 12 CH suction catheter, may be used for removing secretions from the airway by suction.

We devised several protocols for the transition to spontaneous breathing for two reasons: First, the ventilation system is new and backup plans for every step in the anaesthesia cycle seemed necessary to provide the highest possible degree of safety. Second, for the concise reporting of this essential step, a clear management protocol was appropriate.

Possible advantages and disadvantages

Possible advantages of this new ventilation system may include the ability to switch between FCV, jet ventilation and apnoeic oxygenation and therefore ventilation with a sealed or unsealed airway without changing the airway device, continuous, direct measurement of P_{trach}, active expiration to control air trapping, more homogeneous lung aeration[18,19] and more efficient oxygenation and carbon dioxide removal.[18,19] Possible advantages of the Tritube are ease of intubation, minimal visual interference during shared airway scenarios and the ability to leave the tube in the trachea beyond emergence for difficult airway situations without the need to place an airway exchange catheter. Possible disadvantages of the Evone are different, unfamiliar settings of ventilation variables and need for specific training, the current inability to deliver volatile anaesthetics. In addition, conventional ventilation in volume or pressure-controlled mode is not possible and conventional pressure support mode is not available during emergence. There are also possible disadvantages related to the use of the Tritube, which are increased risk of tube dislocation, impossibility of conventional removal of secretions from the airway through the ventilation lumen and flushing after suction and the Tritube is not laser safe.

For jet ventilation, the visual interference of a Tritube seems to be comparable to a jet catheter for subglottic jet ventilation. FCV in combination with a Tritube also offers continuous $P_{et}CO_2$ monitoring, whereas conventional jet ventilators only provide intermittent capnometry. The assumed reduced risk of barotrauma is based on continuous, direct tracheal pressure measurement. However, modern jet ventilators and subglottic jet catheters with a dedicated pressure measurement lumen also offer this option. Nevertheless, in an obstructed upper airway scenario, FCV would still establish sufficient ventilation with adequate, active removal of expiratory gas, while jet ventilation always bears some risk of barotrauma caused by an inefficient egress of gas. Active expiration enables ventilation with a trachea sealed by the inflated cuff of the Tritube, preventing aspiration of fluid and debris during surgery in contrast to jet ventilation. The cuff also hampers uncontrolled backflow, which may cause undesired tissue movements and carry a contamination risk for the surgeon. The development of a laser safe Tritube would further extend its possible applications.

Conclusion

This is the first study describing the clinical use of FCV in combination with the new Evone ventilator and the narrow-bore Tritube, which provides a sealed airway and allows for controlled ventilation with normal minute volume and CO_2 clearance. It should be stressed that this is an observational study with a limited number of patients only. Prospective randomised controlled studies are needed to determine potential clinical benefits and potential risks of this ventilation system. Nonetheless, given the potential of FCV through a narrow-bore ETT, we feel it is valuable to bring our observations to the attention of the anaesthesia community.

Acknowledgements relating to this article

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Conflicts of interests: TB is a paid consultant to Ventinova Medical. He has applied for a patent on calculating and displaying dissipated energy. DE is the inventor of EVA/FCV technology (Ventrain, Tritube, Evone) and receives royalty payments from Ventinova Medical. He also is a paid consultant for Ventinova Medical. He has applied for patents on minimising dissipated energy and on calculating and displaying dissipated energy.

Presentation: none.

Supplemental Digital Content 1 (Video, SDC1.mp4, http://links.lww.com/EJA/A190): Videolaryngoscopic sequence of an endotracheal intubation with the Tritube. After exposure of the glottic level, the tip of the Tritube is inserted into the glottic opening, then the stabilizing stylet (inside the Tritube) is removed and the Tritube is placed with a counter clockwise rotation.

Supplemental Digital content 2 (Video, SDC2.mp4, http://links.lww.com/EJA/A191): Video of the Evone ventilator in FCV mode. The virtually constant inspiratory and expiratory flow generates a linearised ascent and descent of tracheal pressure. The high pressure turned into extreme gas velocity at the ejector nozzle inside the orange-coloured cartridge to the right causes the audible noise.

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