Original Research

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A prospective randomized study comparing respiratory efficacy of percutaneous transtracheal and endotracheal, low-frequency jet ventilation during microlaryngeal surgery

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Abstract

Background: Transtracheal jet ventilation is an alternative ventilatory approach in airway surgery. The purpose of this study was to compare respiratory efficacy of percutaneous transtracheal with endotracheal, low frequency jet ventilation during microlaryngeal surgery.

Methods: Ninety ASA class I-II patients aged between 16 and 70 years undergoing elective microlaryngeal surgery were prospectively studied and randomly assigned to one of two groups: Percutaneous Transtracheal Jet Ventilation (PTJV) group or subglottic Endotracheal Jet Ventilation ETJV via the Ben-jet tube group.

Results: No significant differences in demographic data between the two study groups were observed. The understudy population included; ETJV=42 (total) 25 men, 17 women; PTJV= 48 (total) 34 men, 14 women. Age ranges were: ETJV: 43.83 ±11.52 yr, PTJV: 44.92±12.08 yr; weight ranges were ETJV: 69.62±11.66 kg, PTJV: 71.33±11.57 kg; BMI ranges were ETJV: 24.97±2.58, PTJV: 25.06±2.71. There were no significant differences between the measured pHa, PaO_2, $PaCO_2$ in two study groups at the initiation of operation. Significant differences were observed between measured PHa, PaO_2 and $PaCO_2$ during operation in ETJV group as compared with PTJV group.

Conclusion: We conclude that ETJV procedure provides regular pulmonary gas exchange during microlaryngeal surgery and carbon dioxide elimination can be better maintained in this group compared to the PTJV group.

Keywords: endotracheal, transtracheal, jet ventilation, microlaryngeal surgery

Introduction

Microlaryngeal surgery is associated with difficulty in providing adequate mechanical ventilation during laryngoscopy because the view of the operating field should not be hindered [1,2].

The laryngeal structures should be freely accessible with surgical instruments and the application of a laser should be possible without endangering patients or personnel in the operating room. Patients undergoing microlaryngeal surgery may additionally suffer from severe obstruction in the upper airway, caused by laryngeal pathologies which inhibit gas exchange and the insertion of ventilation tubes [1,2,3].

Choosing a suitable ventilation method is a major consideration when providing anesthesia in a patient undergoing laryngotracheal surgery. Airway management using a conventional tracheal tube may not be possible and may obscure the surgical field. Alternatively the technique of ventilation without a tracheal tube

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with total IV anesthesia may be preferable [1,2]. One of the promising developments that may solve these problems is jet ventilation [2,3,4].

Jet ventilation was first described by Sanders for use during rigid bronchoscopy[5] and was later modified by Outlon and Donald to provide ventilation during microlaryngeal surgery [5,6]. Jet ventilation has been an established and safe anesthetic technique for ventilation in microlaryngeal surgery [7]. Jet ventilation permits an unobstructed view of the larynx while providing adequate ventilation and can eliminate flammable material from the airway. It also plays a significant role in providing ventilation under emergency conditions [1,2,3,4,7,8].

Several different types of jet ventilation have been investigated regarding the ventilatory mode (i.e. respiratory frequency, driving pressure, timing of ventilatory bursts, or ventilatory technology) and to the access route [1,2,3,4, 7,8,9,10].

Several different types of endotracheal catheter have been used in jet ventilation (ETJV) safely and routinely.

Percutaneous transtracheal jet ventilation (PTJV) using a large bore catheter at the cricothyroid membrane is a life saving, relatively safe and simple procedure that requires little experience [11,12,13,14]. Although the transtracheal method is a suitable procedure, it is invasive and cannot be the choice.

There are several studies that measured end tidal CO_2 concentrations during jet ventilation in comparison with conventional ventilation, but we did not find any report in the literature comparing PTJV and ETJV concerning BMI and gas exchange, which is the main aim of this study.

Methods

All the patients have been informed of the research conditions and a letter of consent was obtained from each patient. Eighty-two ASA class I-II patients aged between 16 and 70 years undergoing elective microlaryngeal surgery were prospectively studied and randomly assigned to one of two groups, percutaneous transtracheal jet ventilation (PTJV) group via the plastic catheter (G 13) or subglottic endotracheal jet ventilation (ETJV) via the Ben-jet tube group. Patients with morbid obesity (Body Mass Index>35) and COPD were excluded from the study. Electrocardiogram, NIBP and

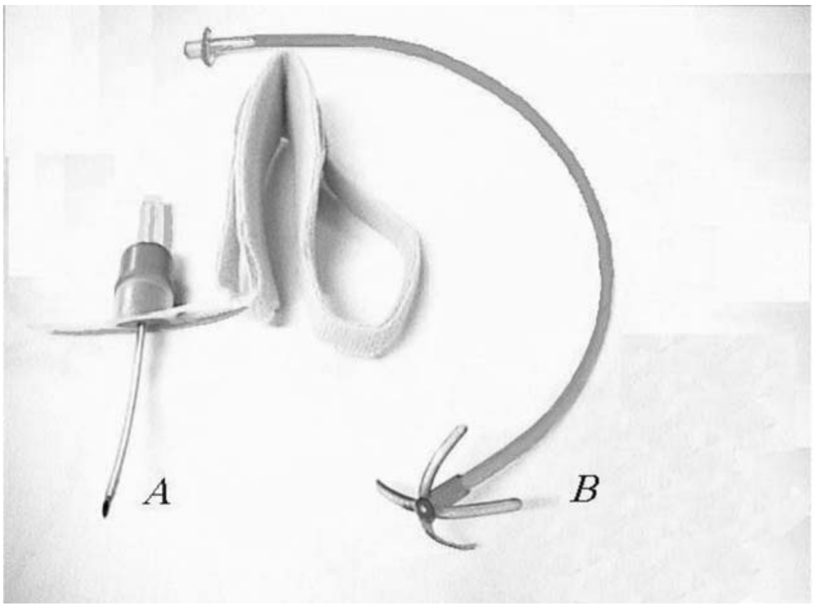

Fig.1. Percutaneous Transtracheal jet ventilation catheter (A) and Ben-jet tube (B).

arterial oxygen saturation were monitored, and the patients were given 100% oxygen. After skin preparation and under local anesthesia, a radial artery catheter was established and the first sample of ABG was obtained. Intravenous Ringer's lactate solution (10ml/Kg) was administered. Anesthesia was induced with midazolam (30 µg/Kg), fentanyl (2 µg/Kg) and propofol (2.5 mg/Kg) followed by atracurium (0.5 mg/Kg), and the patient's lungs were ventilated with oxygen, using a facemask attached to a circle system. After anesthetic induction, in the PTJV group, the plastic cannula (13G) (Fig. 1(A)) was inserted through the cricothyroid membrane. Entrance into the trachea was confirmed by aspiration of air with a syringe containing fluid and the catheter was secured with a ribbon. In contrast in the ETJV group endotracheal intubation was performed via Ben-Jet tube (Fig.1 (B)). The Ben-jet is a polytetrafluoroethylene, self-centering, fine bore tube that can be inserted via the mouth through the subglottic region that allows the application of either high or low frequency jet ventilation. The tube was equipped with a basket on its tip to avoid direct contact of the jet nozzle with the tracheal wall and aligns the catheter with the trachea. The tube or catheter was connected to the cannula and low frequency jet ventilation, 24-30 times/min with 45 PSI pressure was applied by activating the system manually. Manu Jet lll system introduced by VBM Medizintechnik GmbH Company was used. I/E ratio was 1/3. Once the jet flow stops, expiration will occur as a result of the elastic recoil of the thorax. Adequacy of ventilation was confirmed by the presence of chest wall movement and adequate pulse oxymeter readings. Anesthesia was maintained with an intravenous infusion of (propofol, fentanyl, atracurium) technique (TIVA). Following anesthesia, vital signs were recorded and repeated measurements of blood gas were obtained every 15 minutes. Statistical analysis of data was performed with SPSS/version 14. Chi-square test, ANOVA, t-tests, and correlations between variables were used as statistical analysis to compare ages, BMI; duration of surgery and $PaCO_2$, pH, PaO_2 in the two groups. A significant level was set as $P< 0.05$.

Results

No significant differences in demographic data between the two study groups (ETJV=42, 25 men, 17 women; PTJV=48, 34 men, 14 women) were observed. Age ranges were: ETJV: 43.83±11.52 yr, PTJV: 44.92±12.08 yr; weight ranges were ETJV: 69.62±11.66 kg, PTJV: 71.33± 11.57 kg; BMI ranges were ETJV: 24.97±2.58, PTJV: 25.06±2.71). There were no significant differences between the

Subject	Time	PTJV	ETJV	P value
pH	Time 0	7.406±.009	7.407±.009	0.905
(mean±SD).	After 15 min	7.361±.025	7.400±.016	0.000*
	After 30 min	7.339±.034	7.404±.020	0.000*
$PaCO_2$ (mmHg)	Time 0	36.6±.80	36.5±.89	0.549
(mean±SD).	After 15 min	40.9±3.2	34.5±2.4	0.000*
	After 30 min	43.4±4.0	34.1±3.4	0.000*
PaO_2 (mmHg)	Time 0	263.5±47.5	276.7±43.0	0.196
(mean±SD).	After15min	244.1±51.4	199.4±36.3	0.000*
	After 30 min	235.4±58.3	196.3±34.5	0.001*
SaO_2 (%)	Time 0	99.80±.12	99.81±.12	0.625
(mean±SD).	After 15 min	99.74±.17	99.76±.15	0.619
	After 30 min	99.65±.32	99.66±.34	0.769

Table 1. Arterial pH, $PaCO_2$, PaO_2, at initiation of operation and their changes, 15 and 30 minutes later in the two study groups ($P<0.05$).

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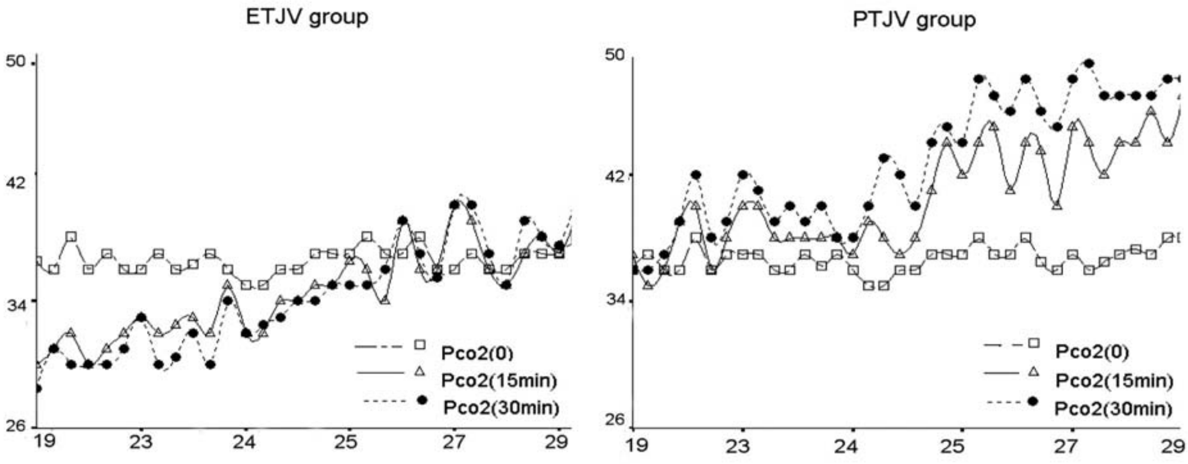

Fig. 2. $PaCO_2$ during the study in two groups.

measured pHa, PaO_2, $PaCO_2$ in the two study groups at the initiation of operation. Significant differences between measured PaO_2, at min 15 and min 30 in ETJV group were detected. In addition, there were significant differences between the measured pHa, $PaCO_2$ in these groups during the operation.

The light patient in ETJV group hyperventilated and heavy patient was in normal range, but the heavy patient in PTJV group hypoventilated and $PaCO_2$ raised.

Conclusion

The present study demonstrates that arterial oxygenation was lower and carbon dioxide elimination can be maintained better with subglottic endotracheal jet ventilation (ETJV) percutaneous transtracheal jet ventilation (PTJV) during microlaryngeal surgery. The physiologic backgrounds of these findings which were clarified by this study showed that the tidal volumes that could be administrated were greater with subglottic endotracheal jet ventilation (ETJV) than percutaneous transtracheal jet ventilation (PTJV). This hypothesis is based on the observation that the measured $PaCO_2$ and PaO_2 in the ETJV group was lower than PTJV group. It means that, the FiO_2 which was received by patients in the ETJV group was lower than the PTJV group. Thus, the ventilation gas which was delivered by the jet ventilator (FiO_2 ~ 80%) in the two groups must have been mixed with environmental air (FiO_2 =21%), a phenomenon that is generally known as environmental air entrainment which is generated as a result of the Venturi effect; in the ETJV group it was more than the PTJV group. It has been shown that a greater amount of environmental air entrainment results in greater tidal volumes, a fact that could, at least in part, have contributed to the more efficient CO_2 elimination and lower FiO_2 results, lower PaO_2 and $PaCO_2$. The respiratory rate, Jet ventilator pressure, I/E ratio, internal diameter of the catheter and distance of distal end of catheters in the trachea were same in the two groups, still the cause of better ventilation with Ben-jet catheter which was observed by fiberoptic, is due to the fact that the Ben-jet catheter is situated in the center of the trachea after insertion and the air flow is laminar, not turbulent (conclusively, no backward flow exists during operation). In contrast the PTJV catheter is not situated in the center. Adjacent to the posterior wall of the trachea the air flow becomes turbulent and has back ward flow due to lateral holes on the sides of the PTJV plastic catheter leading to prevention of the Venturi effect.

We concluded that ETJV provides regular pulmonary gas exchange during microlaryngeal surgery and carbon dioxide elimination can be maintained better in this group in comparison with the PTJV group. The view of the glottis and surgical access are not hindered by an endotracheal catheter in the PTJV group. No clinically relevant differences were observed with regard to surgical acceptance of either technique.

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