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SUBGLOTTIC HIGH FREQUENCY JET VENTILATION IN SURGICAL MANAGEMENT OF BILATERAL VOCAL FOLD PARALYSIS AFTER THYROIDECTOMY

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SUMMARY – Lesion of the recurrent laryngeal nerves as a consequence of thyroid surgery results in bilateral vocal fold paralysis and respiratory obstruction. The initial treatment involves ensuring an adequate airway and it ranges from tracheostomy to endo-extralaryngeal laterofixating operations in general anesthesia. Subglottic high frequency jet ventilation (HFJV) is an alternative ventilatory approach in airway surgery. HFJV offers optimal endolaryngeal working conditions, immobility of vocal cords, adequate oxygenation and ventilation. The HFJV was prospectively studied in 20 consecutive female patients with bilateral vocal fold paralysis. Ventilation was performed as subglottic HFJV *via* jet catheter inserted through the vocal cord. Anesthesia was administered as total intravenous anesthesia. At the end of the procedure, the jet catheter was exchanged with LMA laryngeal mask until spontaneous breathing was established. Subglottic HFJV was used in 20 patients undergoing endo-extralaryngeal laterofixating operations with suspension microlaryngoscopy. The mean duration of surgery was 32.25 minutes, mean age 47.35 (SD 9.75) years, and mean body mass index 26.39 kg m^{-2} (SD 5.03). The mean arterial $PaCO_2$ 5 min before surgical procedure was 5.39 (SD 0.86) kPa, at 5 min of starting jet ventilation 6.19 (SD 0.91) kPa, and at the end of surgical procedure 5.93 (SD 0.99) kPa. There was significant correlation between $PaCO_2$ obtained 5 min before starting jet ventilation and $PaCO_2$ at 5 min of starting jet ventilation ($p<0.05$). No complications secondary to the ventilation technique were observed. No perioperative tracheotomy was necessary. It is concluded that subglottic HFJV is an easy and safe way to ventilate patients with bilateral vocal fold paralysis when endoscopic intervention is performed.

Key words: *Thyroidectomy; Recurrent laryngeal nerve; Vocal cord paralysis; Dyspnea; Tracheotomy; Cordotomy; High frequency jet ventilation*

Introduction

Bilateral vocal fold palsy (BVFP) due to recurrent laryngeal nerve (RLN) lesion is a well-known complication of thyroid surgery and remains one of the most feared problems in this kind of procedures, with a reported incidence between 1.5% and 12%[1–3].

After BVFP, vocal cords remain in a median or paramedian position with ensuing dyspnea, inspiratory stridor, and possible respiratory insufficiency. Treatment of such a condition can range from tracheotomy to minimally invasive transoral procedures such as endo-extralaryngeal lateral fixating surgeries

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or endoscopic posterior cordotomy with or without partial arytenoidectomy. Tracheotomy is certainly a straightforward procedure: it can be performed in all clinical cases; it does not affect vocal fold integrity, nor significantly impairs swallowing. However, it is associated with a morbidity that is not negligible, and is both physically and psychologically stressful for the patient. On the other hand, posterior cordotomy is a non-reversible procedure that should be performed only when BVFP has been demonstrated to be permanent (i.e. after adequate documentation of bilateral RLN neurotmesis or after 6-12 months of unchanged BVFP)[4]. In-between these two opposites, endo-extralaryngeal laterofixating operations present the advantages of obtaining an adequate airway, avoiding the morbidity of a tracheotomy, and being a reversible procedure[5-7].

Such endoscopic intervention is performed under general anesthesia with ventilation ensured by both endotracheal intubation with a small tube or High Frequency Jet Ventilation (HFJV). In BVFP, airway management by an endotracheal tube may be troublesome and obscure the surgical field, making more difficult the surgical endolaryngeal maneuvers needed to cure the patient[8-10]. Subglottic HFJV with a small self-centering tube has been the preferred technique for many anesthesiologists and laryngologists because it is safe and allows a non-obstructive view of the larynx, even though it is not widely spread due to the need of specific skills and equipment[11]. It is based on the Venturi's principle to augment ventilation produced by a narrow stream of gas applied with high speed originating from a high-pressure source[12,13].

The aim of this study was to prospectively evaluate the utility of subglottic HFJV during surgical treatment of BVFP after thyroidectomy by endo-extralaryngeal laterofixating operations without tracheostomy.

Materials and Methods

Subglottic HFJV was applied in all patients undergoing suspension microlaryngeal surgery at the Ear, Nose and Throat (ENT) Department, Vojvodina Clinical Center, Novi Sad, Serbia, during a one-year prospective, clinical study (December 2009 – December 2010). The study had been approved by the institutional Ethics Committee and written consent was preoperatively obtained from all study patients. A total of 20 consecutive female patients with ASA physical status II-III who had BVFP as a result of previous thyroidectomy underwent endo-extralaryngeal lateral fixating operations.

Total intravenous anesthesia was used in all cases due to the fact that subglottic HFJV is an open system. All patients were premedicated with 7.5 mg midazolam orally approximately 60 minutes before the start of total intravenous anesthesia. In case of severe airway obstruction, 0.03 mg kg^{-1} of midazolam was administered intravenously in the operating theater. Electroencephalography (ECG), heart rate, blood pressure and oxygen saturation were monitored in all patients. The induction of anesthesia was performed with a continuous intravenous infusion of propofol 10 mg kg^{-1} h^{-1} and remifentanil 0.8-1 μg kg^{-1} min^{-1}. When positive pressure ventilation *via* face mask was ensured, the non-depolarizing agent rocuronium 0.5 mg kg^{-1} was administered. Anesthesia was maintained by rates of propofol and remifentanil infusion doses were reduced to 3-5 mg kg^{-1} h^{-1} and 0.2-0.4 μg kg^{-1} min^{-1}, respectively. Rocuronium 0.01 mg kg^{-1} was supplemented as required. A radial arterial catheter was inserted and blood gas analysis performed at three time points: 5 min before starting jet ventilation, 5 min after starting jet ventilation, and at the end of surgical procedure.

The jet catheter (Double Lumen Jet Catheter acc. Biro, Acutronic Medical System, Switzerland) was inserted into the trachea with the anesthesiologist's preferred laryngoscope blade. Endotracheal placement of the jet catheter was facilitated by using a metal stylet providing appropriate rigidity and flexibility to perform such a maneuver.

Subglottic HFJV was provided *via* an automatic commercial Mistral jet ventilator (Acutronic Medical System, Switzerland) connected to the jet catheter. Respiratory parameters of the jet ventilator were the following: fixed inspired oxygen fraction of 60%, and fixed inspiration duration of 30% during the entire procedure. Only the driving pressure and respiratory rate were adjusted to achieve normocarbia (4.7-6 kPa). In addition, ventilation was observed clinically by auscultation of the lungs, and watching thorax excursions.

Table 1. Mean values, standard deviation and range of $PaCO_2$ (kPa) at defined measuring points

Measuring point	Number of patients	$PaCO_2$ (kPa)
5 min before starting jet ventilation	20	5.39 (SD 0.86); range 3.6-8
5 min after starting jet ventilation	20	6.19 (SD 0.91); range 4.67-8.27
End of surgical procedure	20	5.93 (SD 0.99); range 3.87-8

At the end of surgical procedure, the jet ventilation and intravenous infusions were stopped, jet catheter was removed and a laryngeal mask (LMA-Classic™, The Laryngeal Mask Company Limited, Nicosia, Cyprus) was used to secure the supraglottic airway until the patients regained protective reflexes and spontaneous breathing. The pressure measured in the LMA cuff was 50 cm H_2O (VBM Cuff Pressure Gauge, Germany). Neuromuscular block was antagonized with neostigmine 0.035 mg kg^{-1} and atropine 0.015 mg kg^{-1} at the end of the procedure. Train of four neuromuscular monitoring was used to ensure adequate reversal of neuromuscular block and the lungs were ventilated until spontaneous breathing was established. Postoperatively, the patients were closely observed to rule out the signs of necrotizing tracheobronchitis, e.g., violet coughing, dyspnea, wheezing and rise in temperature.

Patient data including age, body mass index (BMI), arterial blood gas values ($PaCO_2$), peripheral oxygen saturation (SaO_2), and duration of HFJV were evaluated. Statistical data analysis was performed including determination of mean and range values. Correlations between different variables were assessed with Pearson's method. A p-value <0.05 was considered to indicate statistical significance. Statistical analysis was performed by a commercially available computer program (SPSS version 14; SPSS Inc., Chicago, Illinois, USA).

Results

All patients were females of ASA grade II and III, mean age 47.35 (SD 9.75) years, range 26-62 years, and BMI 26.39 kg m^{-2} (SD 5.03), range 15.96-34.84 kg m^{-2}. Duration of surgery ranged from 14 to 49 minutes, with a mean of 32.25 minutes (SD 10.08). Duration of subglottic HFJV and time needed for patient awakening under conventional ventilation by LMA ranged from 27 to 60 minutes, with a mean of 42 minutes (SD 10.01).

The mean values, standard deviations, and range of preoperative $PaCO_2$ as measured through arterial catheter at defined measuring points are shown in Table 1. To obtain normocapnia (4.7- 6 kPa), driving pressure was enhanced or lowered during the intervention, depending on whether the patient had elevated or reduced levels of $PaCO_2$. During subglot-

Table 2. Mean values, standard deviation and range of SaO_2 (percentage) at defined measuring points

Measuring point	Number of patients	SaO_2 (%)
5 min before starting jet ventilation	20	94.88 (SD 2.44); range 89-99
5 min after starting jet ventilation	20	98.26 (SD 1.88); range 94.44-100
End of surgical procedure	20	97.77 (SD 2.43); range 93-100

tic HFJV, $PaCO_2$ was higher than 6.7 kPa in 5 (25%) patients in whom endo-extralaryngeal laterofixating operations including arytenoidectomy were performed. There was a significant correlation between $PaCO_2$ obtained 5 min before starting jet ventilation and $PaCO_2$ obtained 5 min after the start of jet ventilation ($p<0.05$).

Percentage SaO_2 at defined measuring points is shown in Table 2. There were only 2 (10%) patients with peripheral oxygenation less than 90%, who developed severe inspiratory stridor and dyspnea before surgery. The level of peripheral oxygenation was acceptable in all other patients. There were no significant differences between SaO_2 measured at three different time points during subglottic HFJV.

Placement of subglottic catheter was successful in all patients. All patients had stable hemodynamics at all times during the operation and in the recovery room. Complications resulting from ventilation with subglottic HFJV such as barotrauma, subcutaneous emphysema, gastric distension, or seeding of blood and debris into the tracheobronchial tree were not observed in any patient. No perioperative tracheotomy was necessary.

Discussion

Suspension microlaryngeal surgery requires good exposure of the larynx, continuous control of the airway patency, and immobility of the vocal cord. The balance between adequate surgical access and adequate ventilation and oxygenation must be achieved with close co-operation between the anesthesiologist and the laryngologist[10,14]. As a matter of fact, only optimal endolaryngeal working conditions allow for obtaining good functional outcomes in terms of adequate post-treatment airway and low complication rates. As surgery is conducted in the smallest area of the upper airway tract, the need for a safe airway competes, however, with the need for an undisturbed surgical field. The ideal system for anesthesia during this kind of surgery should enable good approach to the endolaryngeal structures, both in terms of adequate visibility and possibility to perform controlled and fine endoscopic maneuvers[15,16]. At the same time, the anesthesiologist needs to safely control the airway, including ventilation, oxygenation, and monitoring of the patient's physiological responses during surgery[10]. Moreover, the anesthesia technique should include the ability to measure the end-tidal carbon dioxide and tracheal pressure, as well as to perform continuous measures of tissue oxygenation.

In the present series, an adequate post-treatment airway was always obtained with the endo-extralaryngeal laterofixating operations performed under general anesthesia by subglottic HFJV without tracheotomy. Based on our results, we can confirm previous findings that subglottic HFJV is an easy and safe way to ven-

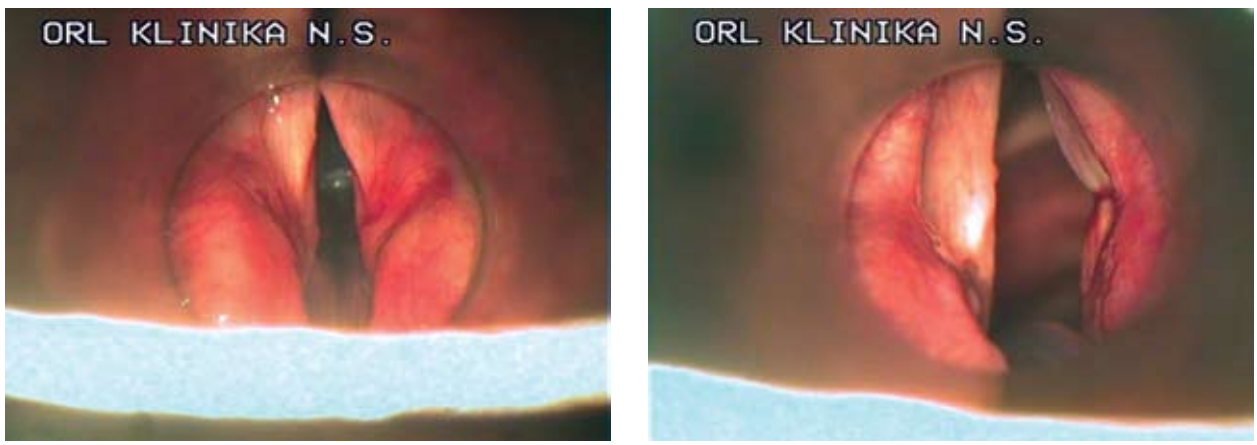

Fig. 1. Laryngeal views through operating laryngoscope before (a) and after (b) endo-extralaryngeal fixation procedure for bilateral vocal fold paralysis. Note that the subglottic jet catheter used for high frequency jet ventilation is in place, not obscuring the endolaryngeal view or limiting the surgical field available. Moreover, it does not interfere with the suspension laryngoscope used.

tilate patients during suspension microlaryngoscopy. Such an anesthesia technique is presently not widely and routinely used in daily practice despite a fair number of papers clearly demonstrating its advantages over conventional ventilation in certain conditions. For example, in the specific patient population described herein, even a small endotracheal tube may limit the access and visibility of the operative field, especially at the level of the posterior part of the glottis, where the tube rests and the most part of the endoscopic surgical work must be performed. On the other hand, the small diameter of the jet catheter employed during subglottic HFJV does not impede the surgeon during this kind of procedure[17] (Fig. 1a and b). Moreover, narrow jet catheters enable adequate space for observation and surgical manipulation, still permitting sufficient outflow of respiratory gases[18,19]. A further advantage of subglottic HFJV is that vocal folds remain motionless, thus not disturbing the microsurgical procedures performed, and positioning of the suspension laryngoscope does not interfere with the jet catheter. The subglottic jetting is not associated with blowing blood and debris into the distal tracheobronchial tree.

Rubin and Patel stress out that subglottic HFJV can be used safely and effectively in patients with difficult or partially occluded airways such as paralytic vocal fold conditions[19,20].

One of the major concerns regarding jet ventilation for airway surgery for BVFP, especially when associated with arytenoidectomy, is the possibility for blood to penetrate into the lower airway. We experienced 6 cases of intraoperative moderate bleeding, adequately controlled by the application of adrenaline-soaked cottonoids and monopolar or bipolar coagulation. No desaturation was simultaneously observed in these patients.

It was noted that 2 cases with BMI >30 were associated with an increase in $PaCO_2$ during surgery. However, ventilation was successful and $PaCO_2$ was maintained at acceptable levels throughout the procedure. Ventilation was effective in all other cases, as demonstrated by the normal levels of oxygen saturation.

From our experience, the use of remifentanil with total intravenous anesthesia protocol is safe and the patient is adequately protected from delayed respiratory depression[21]. No adverse events occurred in the present series as a result of the use of subglottic HFJV. At the end of the operation, jet catheter was replaced with LMA until spontaneous breathing was established in all cases. This enables good airway control, smooth and safe tracheal extubation[22-24]. Moreover, LMA provides an adequate view of the vocal cords, facilitates repeated endoscopic examination, and reduces immediate postoperative cough, which may have unfavorable effect on the recently performed surgery[20].

Conclusion

Subglottic HFJV was successfully employed in a series of patients undergoing endo-extralaryngeal lateral fixating procedures for BVFP after thyroidectomy under general anesthesia. Furthermore, our study showed this technique to provide optimal visibility of laryngeal anatomy, offering adequate space for surgical manipulation and avoiding the use of combustible material inside the larynx and trachea. Our study also showed that subglottic HFJV can be effectively used for BVFP in order to improve endoscopic view without tracheotomy.

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Sažetak

SUBGLOTIČNA VISOKOFREKVENTNA *JET* VENTILACIJA U KIRURŠKOM LIJEČENJU OBOSTRANE PAREZE GLASNICA NAKON OPERACIJE ŠTITNE ŽLIJEZDE

D. Janjević, V. Dolinaj, C. Piazza, R. Jović, J. Marinković i *N. Kalezić*

Obostrana pareza glasnica s posljedičnom opstrukcijom dišnoga puta nastaje kao rezultat lezije rekurentnog laringealnog živca tijekom operacije štitne žlijezde. Inicijalni postupci kojima se osigurava dišni put kod ovih bolesnika uključuju različite endo-ekstralaringealne zahvate te samu traheotomiju, koji se izvode u općoj anesteziji. Subglotična visokofrekventna *jet* ventilacija (VFJV) je alternativna tehnika ventilacije koja se koristi u kirurgiji dišnog puta. Ova tehnika ventilacije pruža optimalne endolaringealne uvjete za kirurški rad. U ovoj prospektivnoj studiji VFJV se rabio kod 20 bolesnica s obostranom parezom glasnica. Subglotična VFJV je provedena preko *jet* katetera postavljenog između glasnica u totalnoj intravenskoj anesteziji. Na kraju operacije je *jet* kateter zamijenjen laringealnom maskom sve do uspostavljanja spontanog disanja. Tehnika subglotične VFJV je upotrijebljena kod 20 bolesnica podvrgnutih endo-ekstralaringealnoj laterofiksaciji u suspenzijskoj mikrolaringoskopiji. Srednje vrijeme kirurške intervencije je bilo 32,25 minuta, srednja dob bolesnica 47,35 (SD 9,75) godina i srednji indeks tjelesne mase 26,39 (SD 5,03) kg m^{-2}. Srednja vrijednost $PaCO_2$ 5 minuta prije početka kirurške intervencije je bila 5,39 (SD 0,86) kPa, 5 minuta nakon primjene *jet* ventilacije 6,19 (SD 0,91) kPa, a na kraju kirurške intervencije 5,93 (SD 0,99) kPa. Uočena je značajna korelacija između vrijednosti $PaCO_2$ dobivenih 5 minuta prije početka kirurške intervencije i 5 minuta nakon početka primjene *jet* ventilacije ($p<0,05$). Komplikacije vezane za primjenu VFJV nisu primijećene. Tijekom perioperacijskog razdoblja nije bilo potrebe za traheotomijom. U zaključku, subglotična VFJV je sigurna tehnika ventilacije koja se primjenjuje tijekom endoskopskih intervencija kod bolesnika s obostranom parezom glasnica.

Ključne riječi: *Tiroidektomija; Rekurentni živac; Pareza glasnica; Dispneja; Traheotomija; Visokofrekventna* jet *ventilacija*