A new anesthetic system for microlaryngeal surgery

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Anesthesia for microlaryngeal surgery creates many obstacles for the anesthesiologist and otolaryngologist. Anesthetic techniques developed to improve surgical exposure have been met with significant limitations and are difficult for the anesthesiologist to monitor. A new subglottic jet ventilation anesthesia system is introduced that meets the needs of the otolaryngologist and the anesthesiologist. This new system is made up of two components: (1) The Hunsaker Mon-Jet tube is a laser-safe, subglottic jet ventilation tube constructed of a nonflammable fluoroplastic material. It allows monitoring of tracheal pressure and end tidal carbon dioxide, and it is designed with a basket-shaped distal extension to align the jet port away from the tracheal mucosa and to prevent trauma and submucosal injection of jetted gas. (2) An automatic jet ventilator, which has an adjustable respiratory rate, inspiratory/expiratory ratio, and flow rate, also monitors expiratory end peak airway pressures and has an automatic shutdown feature if either of these pressures are exceeded. This system was successfully used in 36 patients undergoing microlaryngeal surgery. (Otolaryngol Head Neck Surg 1998;118:55-60.)

Since the introduction of laryngoscopy by Desmoreaux[1] in 1853 and of suspension microlaryngeal surgery some 30 years ago, the safest and least obtrusive anesthetic technique for microlaryngeal surgery has yet to be found. This search is indicated by more than 200 references to anesthesia for microlaryngoscopy in the world literature.[1,2] The development of an ideal anesthetic system for microlaryngeal surgery has not been successful in satisfying both the surgeon and the anesthesiologist. Ideally, the surgeon would have an endotracheal tube that does not obstruct surgical visualization, impede surgical manipulation, move the vocal cords, or allow blood, tissue, or laser flumes to enter the bronchi. From the anesthesiologist's perspective the ideal anesthetic technique would allow for controlled ventilation with the ability to measure tracheal pressure and end tidal carbon dioxide ($ETCO_2$). Many techniques including topical and apneic anesthesia, diffusion respiration, spontaneous respiration, laser-shielded endotracheal tubes, and jet ventilation have been attempted with significant limitations.[2]

Jet ventilation has been the preferred technique for many otolaryngologists because it gives an unobstructed view of the larynx.[3-5] However, from the anesthesiologist's perspective supraglottic jet ventilation does not allow control of the airway. Reported complications of this technique include barotrauma, submucosal injection of gas, hypercarbia, and malposition of the injector.[6-8] Recent animal and human studies have established the superiority of subglottic jet ventilation for microlaryngeal surgery.[2,9] These studies have shown that a modified Ben-Jet tube (Tuta Labs, Sydney, Australia) answers most requirements of the otolaryngologist and the anesthesiologist including the ability for controlled ventilation with $ETCO_2$ and airway pressure monitoring. We introduce the Hunsaker Mon-Jet tube (Xomed, Jacksonville, Fla.), which is a laser-compatible version of the modified Ben-Jet tube (Fig. 1). The Hunsaker Mon-Jet tube is a self-centering subglottic tube that allows continuous monitoring of end expiratory and peak airway pressure and periodic sampling of $ETCO_2$. The tube is made of a nonflammable fluoroplastic material and is driven by an automatic jet ventilator. With the use of the tube's monitor port, automatic shutdown of the ventilator is triggered if the end expiratory or peak airway pressure rises above a preset level. This study is the first clinical series using the Hunsaker Mon-Jet tube anesthesia system.

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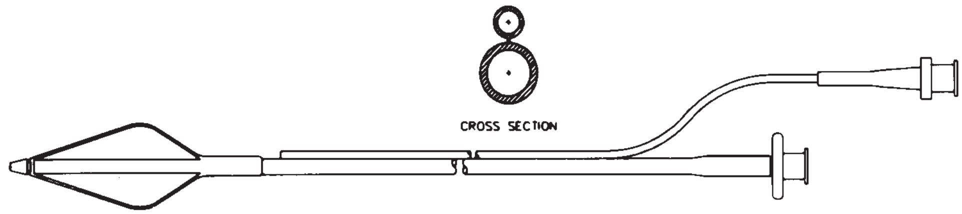

Fig. 1. Hunsaker Mon-Jet tube.

METHODS AND MATERIAL

After approval of the protocol was obtained from the Scientific Review Committee and consent forms by the Committee for Protection of Human Subjects were returned, a total of 36 consecutive patients were entered into the study. Subjects were selected based on their need for suspension microlaryngeal surgery with or without laser.

Exclusion criteria included weight less than 25 kg, American Society of Anesthesiologists class III or higher, or pregnancy. Preoperative evaluation and operative technique were dictated by the clinical judgment and preference of the individual surgeon. All cases were performed with either an adult Jako or Dedo laryngoscope suspended with a Lewy suspension device (Pilling Instrument Co., St. Louis, Mo.). The anesthetic system used was composed of two elements.

1. The Hunsaker Mon-Jet tube is a self-centering subglottic jet ventilation tube constructed entirely of a nonflammable fluoroplastic material (Fig. 1). It measures 35.5 cm in total length, 30 cm from the proximal connector to the jet port. The distance from the distal end of the monitor port to the distal end of the jet port is 3.2 cm. The maximum outer diameter of the jet and monitor port measures 4.3 mm, and the internal diameter of the jet port measures 2.7 mm. The tube has a natural curved shape design to facilitate ease of insertion. The tube is self-centering in the trachea because of a basket-shaped distal extension that prevents malalignment and jet port contact with the tracheal mucosa. The tube contains a 1 mm internal diameter monitor port attached proximally to a Leur-Loc adapter that opens 3.2 cm above the jet port. Attachment to an automatic ventilator allows continuous monitoring of tracheal pressure and intermittent monitoring of the $ETCO_2$ by switching a furnished three-way stopcock.

2. The Acutronic AMS 1000 is an automatic jet ventilator (UJV AMS 1000 High Frequency Jet Ventilator, Xomed, Jacksonville, Fla.). It has an adjustable respiratory rate, driving pressure, and inspiratory/expiratory ratio. The ventilator has two pressure lines. The patient connection line delivers the ventilation and measures the end expiratory pressure, and the monitoring pressure line measures the peak inspiratory pressure. Limits for these pressures can be set, and if exceeded, the ventilator automatically shuts down.

The following anesthetic sequence was used for all patients in the study. After routine monitors were placed, anesthesia was induced with propofol (2 mg/kg) and vecuronium (0.8 mg/kg). A nasopharyngeal airway was inserted to facilitate mask ventilation with the Mon-Jet tube in place before suspension. Intubation was performed with the anesthesiologist's preferred laryngoscopy blade. Depending on the preference of the anesthesiologist, the patient underwent intubation with the Hunsaker Mon-Jet tube after induction or as a replacement for a standard endotracheal tube after he or she was placed in suspension. The distal end of the tube was placed 7 to 8 cm below the glottis, ensuring that the monitor port was below the vocal cords. The tube was secured at the corner of the mouth. Maintenance anesthesia was achieved with an infusion of propofol and intermittent boluses of alfentanil and vecuronium as needed. The Acutronic Jet ventilator was initially set up with the following parameters.

1. FiO_2 100%
2. Inspiratory percentage time 20% to 30%
3. Driving pressure 15 psi
4. End expiratory pressure limit 10 cm H_2O
5. Peak pressure limit 35 to 40 cm H_2O

The gas delivery line was attached to the end of the Hunsaker Mon-Jet tube, and the pressure monitoring line was connected to the monitor port. A three-way stopcock was attached to the monitor port to allow for continuous monitoring of peak airway pressure with intermittent measurement of $ETCO_2$ with a capnometer. The driving pressure and respiratory rate were adjusted to maintain normal $ETCO_2$ values. Standard anesthesia parameters were monitored and recorded. All complications and difficulties with the techniques were documented. At the end of the procedure emergence was handled with a masked airway or a standard endotracheal tube at the anesthesiologist's discretion.

RESULTS

A total of 36 consecutive patients (28 men and 8 women) who required suspension microlaryngeal surgery during the period from June 1993 through August 1994 were entered in the study. They ranged in age from 19 to 57 years of age, with a mean age of 34 years. All 36 patients were treated by resident anesthesiologists and otolaryngologists with staff supervision. Twenty-seven of the 36 patients underwent suspension microlaryngoscopy with the CO_2 laser, 25 of 27 for ablation of laryngeal papillomatosis, 1 for treatment of a granuloma, and another for a nodule. No special precautions beyond standard laser safety procedures were undertaken. No cases of tube ignition, tube damage, or smoke production occurred. Nine of 36 patients underwent suspension microlaryngoscopy for excisional biopsy. All patients underwent initial intubation with the Mon-Jet tube. Thirty-three (91%) of 36 were intubated on the first attempt while 3 (8%) of 36 required several attempts because of an anteriorly positioned glottis. A stylet has since been added to the tube to facilitate insertion. Thirty of the 36 patients underwent emergence with masked ventilation. The other six patients underwent reintubation with a standard endotracheal tube, which was the preferred method of the staff anesthesiologist involved. The mean case length was 48 minutes. The lowest oxygen saturation was 95% in one patient; the others did not drop to less than 97% saturation. In case 8 there was automatic shutdown of the ventilator, which occurred in response to the peak airway pressure exceeding 35 cm H_2O when the epiglottis became dislodged from the laryngoscope, producing proximal obstruction. After the patient underwent resuspension, the remainder of the case was uneventful. A failure to record $ETCO_2$ beyond the initial measurement occurred in case 20. During this case the monitor port became obstructed and kinked, but ventilation was not affected. The tube was not replaced, and the case proceeded without further incident.

No reports were made of impairment of surgical manipulation or the need for tube repositioning to improve access. No instances of barotrauma, submucosal injection of jetted gas, gastric distension, mucosal damage, seeding of blood or debris into the tracheobronchial tree, or tube ignition occurred. Anesthetic parameters were maintained within normal limits in all cases (Table 1).

DISCUSSION

The ideal general anesthetic for suspension laryngoscopy would provide complete unimpeded access to the endolarynx for the surgeon while giving the anesthesiologist total control of the airway with the ability to monitor the physiologic response to the procedure. A number of anesthetic techniques have been developed in the search for this “ideal” form of anesthesia. All previously described techniques have limitations for either the anesthesiologist or the surgeon.

Many wrapped standard endotracheal tubes have been used to provide laser resistance.[10] Wrapping tubes with reflective metal foil is associated with complications such as kinking, aspiration of pieces of foil, and ignition at the seams of the protective wrap.[11,12] Commercially available resistant tubes have included a silicone tube wrapped with fluoroplastic tape (Laser-Shield II, Xomed, Jacksonville, Fla.) and a red rubber tube wrapped with copper foil and then coated with a woven polyester knit (Laser Trach, Sheridan Argyle, N.Y.). All wrapped tubes are of relatively large diameter and limit exposure of the larynx, especially the posterior commissure.

Supraglottic jet ventilation techniques that have a rigid metal tube fixed to the suspended laryngoscope have been used.[3-5] Ventilation is achieved by jetting oxygen through the vocal cords. A side channel in the laryngoscope can also be used as a delivery tube. Although desirable from a surgical exposure standpoint, the technique of supraglottic jet ventilation is associated with many potential complications. Those complications include gastric distension caused by high pressures and malalignment, inefficient or ineffective ventilation caused by malposition, blood and debris blown into the bronchi, vocal cord movement with respiration, and an inability to monitor airway pressure.[6-8,13]

Subglottic jet ventilation has also been attempted for microlaryngeal surgery.[14-15] This technique was first performed with either a 3.5 mm outer diameter plastic tube or by inserting a metal supraglottic tube through the glottis below the vocal cords. This method provides excellent ventilation and control for the anesthesiologist and is not associated with blowing blood and debris into the distal tracheobronchial tree. The small tube used for subglottic jet ventilation does not impede surgical access but has been associated with barotrauma caused by proximal obstruction of expiration of jetted gas. In 1979 Benjamin and Gronow[16] developed a small polyvinyl chloride (PVC) tube that had four petals on the distal end to ensure centering of the tube in the trachea, alleviating the risk of malalignment, displacement, and submucosal injection of jetted gas. The size of the tube allowed complete access to the endolarynx without impedance to the surgeon. Although it overcame most of the inherent problems with anesthesia for microlaryngeal surgery, the tube was not laser-resistant and did not address monitoring of tracheal pressure and $ETCO_2$.

Table 1. Summary of cases

Patient	Diagnosis	Laser	Case Length (mn)	Intubation(*)	Emergence	O_2Sat (%)
1	Nodule	None	60	Jet Tube1	Mask	100
2	Papilloma	CO_2	16	Jet Tube1	Reint†	95
3	Papilloma	CO_2	53	Jet Tube1	Reint	97
4	Nodule	CO_2	27	Jet Tube1	Reint	100
5	Granuloma	CO_2	30	Jet Tube1	Mask	100
6	Papilloma	CO_2	18	Jet Tube1	Mask	100
7	Papilloma	CO_2	27	Jet Tube1	Mask	100
8	Papilloma	CO_2	52	Jet Tube1	Mask	100
9	Papilloma	CO_2	70	Jet Tube1	Mask	99
10	Papilloma	CO_2	65	Jet Tube1	Mask	99
11	Papilloma	CO_2	80	Jet Tube1	Mask	99
12	Papilloma	CO_2	10	Jet Tube3	Mask	100
13	Papilloma	CO_2	50	Jet Tube1	Mask	100
14	Papilloma	CO_2	26	Jet Tube1	Mask	100
15	Papilloma	CO_2	50	Jet Tube3	Mask	99
16	Papilloma	CO_2	80	Jet Tube1	Mask	100
17	Papilloma	CO_2	55	Jet Tube2	Mask	100
18	Papilloma	None	45	Jet Tube1	Mask	100
19	Papilloma	CO_2	50	Jet Tube1	Mask	100
20	Papilloma	CO_2	105	Jet Tube1	Mask	100
21	Papilloma	CO_2	50	Jet Tube1	Mask	100
22	Nodule	None	30	Jet Tube1	Mask	100
23	Papilloma	CO_2	44	Jet Tube1	Mask	100
24	Papilloma	CO_2	68	Jet Tube1	Mask	100
25	Papilloma	CO_2	10	Jet Tube1	Mask	100
26	Cyst	None	50	Jet Tube1	Mask	100
27	Nodule	None	28	Jet Tube1	Reint	100
28	Cyst	None	88	Jet Tube1	Mask	100
29	Papilloma	CO_2	47	Jet Tube1	Mask	100
30	Papilloma	CO_2	89	Jet Tube1	Reint	100
31	Papilloma	CO_2	37	Jet Tube1	Mask	100
32	Cyst	None	50	Jet Tube1	Reint	100
33	Cyst	None	50	Jet Tube1	Mask	100
34	Nodule	CO_2	57	Jet Tube1	Mask	100
35	Papilloma	CO_2	45	Jet Tube1	Mask	100
36	Papilloma	CO_2	37	Jet Tube1	Mask	100

DP, Driving pressure; *PIP*, peak inspiratory pressure; *EEP*, end expiratory pressure; *BPM*, breaths per minute.

*Intubation attempts.

†Reintubation.

‡Ventilator shutdown caused by increased EEP.

§Unable to record $ETCO_2$ after initial read.

Note: O_2Sat, $ETCO_2$, and Rate represent averages of each case.

Hunsaker initially modified the Benjamin tube by adding a side port to facilitate the monitoring of tracheal pressure and $ETCO_2$. A previous study validated the $ETCO_2$ values when compared with blood gases.[2,9] The limitation of this tube was that it was not laser-compatible.

The Hunsaker Mon-Jet tube is a laser-compatible version of the modified Ben-Jet tube. Composed of a nonflammable fluoroplastic material, the safety of this new tube was established in a 100% O_2 environment with the use of the CO_2, KTP, and NdYag lasers at maximum output.[2]

$ETCO_2$	DP	Rate (bpm)	Complications
37	20	10	None
37	20	10	None
38	18	10	None
37	20	10	None
39	16	20	None
40	18	20	None
37	15	20	None
36	28	10	Note‡
35	18	20	None
36	18	20	None
37	18	10	None
31	16	20	None
33	18	20	None
40	18	20	None
33	18	20	None
42	18	20	None
30	16	20	None
37	18	20	None
36	20	10	None
32	18	20	Note§
40	28	20	None
40	20	20	None
34	18	10	None
30	20	10	None
32	22	10	None
34	22	10	None
26	20	10	None
31	18	20	None
37	20	20	None
40	18	15	None
34	26	15	None
36	20	15	None
32	20	15	None
38	20	15	None
33	20	15	None
34	20	15	None

In our study the Hunsaker Mon-Jet tube provided excellent visualization of the entire glottis without vocal cord movement in all 36 cases. The CO_2 laser was used in 27 cases without incident or the need for special precautions beyond standard laser safety precautions. From an anesthetic perspective minute ventilation was assessed by $ETCO_2$, which is the standard of care. In one case the monitor port was kinked, which caused the $ETCO_2$ tracing to be lost. In another case the preset end expiratory pressure was exceeded, which caused the ventilator to be automatically shut down. This occurrence was caused by proximal airway obstruction created when the epiglottis became dislodged from the laryngoscope. With this anesthetic system, which uses automatic shutdown of the ventilator, barotrauma can be prevented. Barotrauma has been a complication of previously described jet ventilation techniques.[7] In three of our cases mucus and blood entered the monitoring port and temporarily occluded the port; 1 to 2 ml of air or saline solution flushed through the port easily relieved the obstruction. The use of an antisialogogue minimizes this potential problem.

SUMMARY

This report presents the culmination of a series of steps to develop an anesthetic system that is safe and simple, satisfying the needs of both the surgeon and anesthesiologist for microlaryngeal surgery. This system uses two components: (1) the Hunsaker Mon-Jet tube, which is a self-centering, flexible, laser-compatible, subglottic tube with a side port to monitor tracheal pressure and $ETCO_2$ and (2) an automatic jet ventilator, which monitors peak and end expiratory airway pressure and automatically shuts off if preset pressures are exceeded. Our study clearly shows that this new anesthetic system provides a safe technique for microlaryngeal surgery.

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