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High Frequency Ventilation for Suspension Laryngomicrosurgery under General Anesthesia

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The purpose of this study is to evaluate the use of high frequency percutaneous transtracheal ventilation and high frequency jet insufflation for laryngomicrosurgery performed under general anesthesia.
Twenty patients were anesthetized with intermittent intravenous anesthetics and paralyzed with either d-tubercurarine or pancuronium. For the operations for 8 of them (group 1) ventilation was supplied through a 16 G Angiocatch introduced into the trachea through the cricothyroid membrane. For the operations for 12 remaining patients (group 2) ventilation was supplied through a 5 mm endotracheal catheter. A respiratory rate of 100 breaths/minute was used at an FiO_2 1.0 using a solenoid valve-actuated ventilator. The inspiratory-expiratory ratio was 1:2. The driving pressure of oxygen was 10-45 psi. In neither group was there any significant change in the value of the pH, of $PaCO_2$, or of PaO_2. Cardiovascular parameters such as blood pressure and heart rate were slightly increased. Data obtained from these observations indicate that these techniques and devices, when used properly, should provide adequate ventilation and improve the visibility of the operative field.

Key Words: High frequency ventilation, suspension laryngomicrosurgery, transtracheal, cricothyroid.

The technical advances in anesthesia for laryngomicrosurgery have meant an introduction of various techniques permitting ventilation of the surgical field (Carden and Crutchfield 1973; Poling *et al.* 1975; and Smith and Sjöstrand 1983).

Numerous reports on the use of different types of endotracheal insufflation catheters, combined with the manual or automatic administration of ventilation during laryngoscopy, have been presented (Carden and Crutchfield 1973 and Babinski *et al.* 1980). High frequency positive pressure ventilation via a percutaneous transtracheally introduced catheter has also been described (Smith *et al.* 1974).

This study was undertaken in order to evaluate the effectiveness of ventilation and the effectiveness of using either a high frequency ventilator with endotracheal insufflation or a percutaneous transtracheal catheter in providing good visibility of the operative field in the performance of suspension laryngomicrosurgery.

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MATERIALS AND METHODS

The subjects were twenty patients, ranging in age from 2 to 67 years (Table 1 and 3). They were all scheduled for diagnostic or therapeutic suspension laryngomicrosurgery.

The premedication administrated 1 hour prior to the procedure were 0.01 mg/kg of atropine sulfate and 1-2 mg/kg of hydroxyzine.

Group 1. A 16 G gauge (1.19 mm diameter) catheter was used for percutaneous transtracheal ventilation. Under local anesthesia a catheter was inserted into the trachea through the cricothyroid membrane while the neck of the patient was extended. The catheter, with the inner needle in place, was attached to a syringe positioned with the flunge upward. The needle directed downward, in the middle, at approximately 45°. The syringe was kept aspirating continually. When air was returned, the plastic catheter around the needle was advanced while the needle was kept stationary. When the catheter hub reached the skin, the metal inner needle was then withdrawn.

Patients were preoxygenated and 5 mg/kg of thiopental sodium was administered, followed by the connection of a high frequency ventilator cannula to the percutaneous transtracheal catheter. The patient's lungs were inflated via the transtracheal catheter.

Group 2. Anesthesia was induced with 5 mg/kg of thiopental sodium administered intravenously with the face mask fitted in place, followed by the administration of 1 mg/kg succinylcholine. After muscle relaxation was achieved, an insufflation catheter (for the adults, one 450 mm in length and 5 mm in internal diameter and for the children, one 450 mm in length and 3 mm in internal diameter) was inserted near the carnia. The distal end of the catheter had three holes in it to prevent shivering. After the introduction of the catheter into the trachea, each patients was ventilated with 100% oxygen. Anesthesia and relaxation were maintained with intermittent doses of Thalamonal, ketamine, pethidine, and d-tubocurarine or pancuronium.

High frequency ventilator and method of ventilation: the ventilator was essentially a timer that drove a solenoid valve. The repiratory rate (solenoid valve frequency) and inspiratory/expiratory time (solenoid valve duty cycle) could be adjusted independently. Oxygen was delivered under a pressure of 0 to 50 psi, from a centralized medical gas supply. A driving pressure was controlled by a reducing valve that was placed between the ventilator and the tube of pressurized gas. The inspiratory to expiratory time was 1:2 (0.2:0.4 sec.) and the respiratory rate was 100 breaths/minute. The driving gas pressure was adjusted to 10-50 psi (adults 30-45 psi, children 10 psi).

Arterial blood gas samples were drawn anaerobically from the radial artery into heparinized syringes: preoperatively, while the patient was being ventilated with 100% oxygen by mask for 2 to 3 minutes; and fifteen minutes after high frequency ventilation with 100% oxygen had been supplied.

Blood pressure was monitored with the sphygmomanometer while condition of the heart was monitored by checking for arrythmia and pulse rates with Kontron® electrocardiography.

The data was evaluated with an analysis of a t-test using an Abstat® package program. The differences were considered to be statistically significant at $p<.05$.

RESULTS

The average length of time of high frequency ventilation was supplied was 70 minutes in group 1 and 59.8 minutes in group 2 (Tables 1 and 3)

The average pH, PaO_2, and $PaCO_2$ of arterial blood gases varied in both groups:

Group 1.

pH	7.36 to 7.38
PaO_2	406.4 mmHg to 415.3 mmHg
$PaCO_2$	45.5 mmHg to 42.5 mmHg

Group 2.

pH	7.41 to 7.39
PaO_2	408.0 mmHg to 414.0 mmHg
$PaCO_2$	40.9 mmHg to 40.9 mmHg

In both groups, blood sampling data showed no significant difference from the pre applying these techniques (Tables 2 and 4).

Table 1. Age, sex, weight, diagnosis, and length of time of high frequency ventilation was applied in group 1

Patient No.	Age	Sex	Weight (kg)	Diagnosis	Time (minute)
1	35	f	50	Vocal cord polyp	40
2	51	m	71	Vocal cord polyp	85
3	53	m	60	Vocal cord polyp	65
4	67	m	60.5	Laryngocele	60
5	48	m	39	Intubation granuloma	45
6	27	m	60	Laryngeal papilloma	165
7	62	f	52	Reinke's edema	45
8	33	f	42	Vocal cord papilloma	55
Mean	47		54.8		70
S.D.	±14.2		±11.1		± 41.0

Table 2. Comparison of arterial blood gas, blood pressure, and heart rate before and after high frequency ventilation in group 1.

Patient No.	pH		PaO_2 (mmHg)		$PaCO_2$ (mmHg)		Sys. BP (mmHg)		Dia. BP (mmHg)		Heart rate (rate/min.)	
	A	B	A	B	A	B	A	B	A	B	A	B
1	7.47	7.42	455	502	33	37	150	160	90	100	70	94
2	7.41	7.41	384	305	37	40	110	130	80	90	95	112
3	7.38	7.39	480	480	36	33	130	160	90	100	95	110
4	7.18	7.21	384	331	75	65	120	170	80	110	74	130
5	7.32	7.34	392	462	43	45	120	140	80	80	112	111
6	7.36	7.38	342	373	46	43	150	120	100	80	104	110
7	7.44	7.46	376	451	47	47	110	180	80	100	72	120
8	7.32	7.45	438	418	47	30	140	110	100	60	70	90
Mean	7.36	7.38	406.4	415.3	45.5	42.5	128.8	146*	87.5	90	86.5	109.6*
S.D.	±0.09	±0.09	±46.4	±71.9	±13.1	±10.8	±16.4	±25.0	±8.9	±16.7	±17.0	±12.9

*<.05 Sys.: systolic Dia.: diastolic BP: blood pressure
A: before high frequency ventilation
B: after high frequency ventilation

Table 3. Age, sex, weight, diagnosis, and length of time of high frequency ventilation was applied in group 2

Patient No.	Age	Sex	Weight (kg)	Diagnosis	Time (minute)
1	51	f	55	Tracheal stenosis	160
2	35	f	70	Vocal cord nodule	55
3	50	m	62	Laryngeal carcinoma	50
4	4	m	15	Vocal cord papilloma	45
5	31	m	70	Vocal cord papilloma	90
6	2	m	12	Vocal cord papilloma	12
7	36	f	52	Vocal cord nodule	40
8	58	m	63	Leukoplakia	60
9	51	f	56	Vocal cord polyp	45
10	42	m	58	Vocal cord polyp	45
11	60	f	60	Reinke's edema	70
12	40	m	81	Laryngeal papilloma	45
Mean	38.3		54.5		59.8
S.D.	±18.8		±20.7		± 36.6

The heart rate in both groups and the systolic blood pressure of group 1 were significantly increased. There was no significant change in the diastolic blood pressure in either group and the systolic pressure of group 1 (Tables 2 and 4).

DISCUSSION

The two techniques of using ventilation for laryngomicrosurgery that have been the subjects of this study are among several anesthetic techniques that have been suggested.

Table 4. Comparison of arterial blood gas, blood pressure, and heart rate before and after high frequency ventilation in group 2.

Patient No.	pH		PaO_2 (mmHg)		$PaCO_2$ (mmHg)		Sys. BP (mmHg)		Dia. BP (mmHg)		Heart rate (rate/min.)	
	A	B	A	B	A	B	A	B	A	B	A	B
1	7.55	7.52	380	420	34	41	180	160	110	90	85	92
2	7.37	7.36	424	414	45	44	100	140	60	90	73	84
3	7.40	7.35	496	427	48	54	115	130	80	90	92	93
4	7.23	7.23	483	505	56	56	100	110	60	70	90	105
5	7.45	7.44	512	476	36	36	130	130	80	80	84	110
6	7.35	7.26	300	391	31	41	100	100	70	70	110	140
7	7.48	7.39	437	407	37	45	100	100	60	90	103	128
8	7.31	7.46	435	396	47	44	110	140	70	90	90	90
9	7.41	7.53	333	385	40	26	130	160	90	100	72	85
10	7.39	7.40	401	376	39	37	130	130	90	90	75	85
11	7.65	7.41	414	388	29	40	150	140	80	90	87	86
12	7.36	7.37	391	383	35.6	27	110	180	80	120	75	134
Mean	7.41	7.39	408	414	40.9	40.9	121.3	135.0	77.5	89.2	86.3	102.7*
S.D.	±0.11	±0.09	±67.8	±39.5	±9.6	±9.0	±24.5	±24.3	±14.8.	±13.1	±11.9	±20.7

*$p<.05$

This study supports the conclusion of Jonzon *et al.* (1971), Sporel *et al.* (1971), Smith (1974), Babinki *et al.* (1980), and Satyanryana *et al.* (1980) that both of these techniques of using ventilation during laryngomicrosurgery have distinct advantages over previously described methods. Of these, the most important is that in using these techniques control of the airway is possible for extended periods of time without interfering with the surgical field.

Sander *et al.* (1967) has reported that the venturi principle can applied to ventilate patients safely during bronchoscopy by releasing intermittent jet stream of oxygen through a small orifice. Other modified methods developed by Albert *et al.* (1972), Carden and Crutchfield (1973), and Smith *et al.* (1974) have been introduced.

A technique of percutaneous transtracheal ventilation has been described by Sporel and Greenway (1971), and its application to resuscitation suggested by Jacobs (1972) and Smith *et al.* (1974) have reported on the use of transtracheal ventilation in patients with airway obstruction.

Several Scandinavian papers (Jonzon *et al.* 1971; Heijman *et al.* 1972; Sjöstrand 1977) have described work using a small catheter insertion.

We first considered both techniques of administering anesthesia in relation to the safety of the patient. Arterial blood gas levels indicated that patients were ventilated with 100% oxygen. This meant that throughout the procedure the patient was extremely well oxygenated and, far more important, at the end of the operation, the lung were fully oxygenated.

As can be seen from the results tabulated in Tables 2 and 4, both techniques ensured adequate oxygenation and carbon dioxide removal in all but 7 cases. Three cases in group 1, and 4 cases in group 2 resulted in the disproportionate amount of carbon dioxide which was out of normal range (40±5 mmHg). However, there were no significant differences between these and the pre applying techniques.

In the carrying out of these techniques, for virtually all of the inspiratory cycle gas was blowing out through the cords and so was minimizing the hazard of inhalation of blood and surgical debris.

Operating conditions were generally found to be extremely good because of the lack of obstruction to the operator's line of vision. Surgeon wished to operate on the posterior part of the cords, it was easily accomplished without interfering with the standard insertion of the endotracheal tube.

Changes of cardiovascular parameters were thought to be due to the stimulation of the upper respiratory tract resulting from increased sympathetic tone and inappropriate use of intravenous anesthetics.

It would seem that both techniques ensure great safety for the patient and almost perfect operating

conditions where the surgical field is concerned. This combination of merits would seem to be unique in the field of anesthesia for suspension laryngo-microsurgery.

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