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Main Article

Immediate post-operative vocal changes in patients using laryngeal mask airway versus endotracheal tube

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Abstract

Objective and hypothesis: (1) To examine the vocal symptoms and acoustic changes perceived in the short period immediately after laryngeal mask airway, and (2) to compare these findings in patients using laryngeal mask airway and endotracheal tube.

Materials and methods: A total of 27 patients were enrolled. They were evaluated pre-operatively and then at 2 and 24 hours post-operatively. Patients were divided into two subgroups, laryngeal mask airway and endotracheal tube. Patients were asked about the presence or absence of the following: hoarseness, vocal fatigue, loss of voice, throat-clearing sensation, globus pharyngeus and throat pain. Patients then underwent acoustic analysis of their voice, measuring the average fundamental frequency, relative average perturbation, shimmer, noise to harmony ratio, voice turbulence index, habitual pitch and maximum phonation time.

Results: In the laryngeal mask airway group, there was an increase in the incidence of all vocal symptoms two hours post-operatively, except for globus pharyngeus. The increase was statistically significant for vocal fatigue, loss of voice and throat pain. All the symptoms had reverted back to a normal baseline level by 24 hours. There was a decrease in the maximum phonation time and habitual pitch, with an increase in all the perturbation parameters, two hours post-operatively. At 24 hours, an increase was still present for shimmer, noise to harmony ratio and voice turbulence index. The maximum phonation time and habitual pitch reverted back to normal values.

In the endotracheal tube group, there was a significant increase two hours post-operatively in the incidence of hoarseness, loss of voice and throat pain. At 24 hours, all the symptoms reverted to baseline, except for vocal fatigue and throat pain. Two hours post-operatively, there was a significant decrease in maximum phonation time and an increase in all other parameters (however, the latter was significant only for relative average perturbation and noise to harmony ratio). At 24 hours, there was a significant increase in the maximum phonation time and a persistent (but statistically insignificant) increase in the average fundamental frequency, habitual pitch, noise to harmony ratio and voice turbulence index.

At two hours, there was more loss of voice and vocal fatigue in the laryngeal mask airway group, compared with the endotracheal tube group. At 24 hours, these symptoms were comparable in both groups. Comparing changes in acoustic parameters to baseline values in both groups, there were no statistically significant changes.

Conclusion: Shortly after reversal of anaesthesia, laryngeal symptoms following laryngeal mask airway are no less significant than those experienced following endotracheal tube anaesthesia. Both methods can be regarded as nontraumatic, in view of the lack of significant vocal symptoms and acoustic changes 24 hours after anaesthesia.

Key words: Endotracheal Intubation; Laryngeal Masks; Voice; Complications

Introduction

The incidence of laryngopharyngeal symptoms following endotracheal intubation varies between 5.7 and 90 per cent, with most resolving in 12 to 72 hours, unless substantial damage to the vocal folds or arytenoids has occurred.[1–4]

Since the introduction of the laryngeal mask airway by Brain in 1983, many have used it as an alternative to endotracheal intubation, especially in professional voice users, who require extreme caution and minimal manipulation of their airway.[5]

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Even though the laryngeal mask is not in direct contact with the vocal folds, the incidence of laryngeal discomfort has been reported to be as high as 30 per cent. Many have reported an array of laryngopharyngeal symptoms, with a wide discrepancy in incidence, depending on the method of data collection.[6,7] Rieger *et al.* have reported a higher incidence of dysphonia following intubation than following laryngeal mask airway insertion, on the day of surgery and on the first post-operative day. However, with a longer duration of anaesthesia, the frequency of dysphonia increased only in the laryngeal mask airway group.[8]

Despite the numerous reports of a lower incidence of laryngopharyngeal discomfort in patients using laryngeal mask airway versus those using endotracheal tube, this consensus must be viewed with scepticism, in light of the following. Firstly, laryngeal discomfort is an individual perception which varies with the way information is retrieved and the patient's ability to express themself. Secondly, most studies did not substantiate these symptoms by objective measures (such as laryngeal endoscopic evaluation or acoustic analysis).

Little has been published regarding vocal changes and acoustic findings following endotracheal intubation, and very little is known about the same parameters in patients using the laryngeal mask airway.[9–11] A PubMed search retrieved only two studies assessing acoustic variations in patients using laryngeal mask airway post-operatively.

The first study was published by Lee *et al.* in 1993 and assessed vocal fold changes in patients using laryngeal mask airway.[12] Acoustic waveform analysis was performed for 20 patients, who had used either laryngeal mask airway or endotracheal tube, at 1, 4 and 24 hours post-operatively. All four acoustic measures studied were worse than baseline at 1 and 4 hours in both groups, but the values had largely returned to baseline by 24 hours. In the laryngeal mask airway group, there were no significant changes in the amplitude variability, pitch variability and additive noise level, except for the noise to harmonics ratio. However, in the endotracheal tube group, all the vocal changes were significant. More so, there were significant differences between the two groups for amplitude variation at 4 hours, and for pitch variability and additive noise level at 1 and 4 hours.

On the other hand, in the study reported by Zimmert *et al.* in 1999,[13] there was no statistically significant difference in the acoustic vocal parameters between the same two groups, except that both had a post-operatively increased fundamental frequency, which was significant only in the laryngeal mask airway group. No other voice parameter investigated showed a significant difference between the two groups. Patients with sore throat, hoarseness or vocal fold haematoma did not have significantly worse vocal parameters, compared with the baseline values of the control group. It should be noted that this study performed acoustic analysis 18–24 hours post-operatively. The results also showed that laryngeal discomfort and the incidence of minor vocal folds lesions were less in the laryngeal mask airway group.

In a nutshell, the results of current studies are partially conflicting and non-conclusive, and do not give clear answers regarding the immediate vocal changes and acoustic findings in patients using the laryngeal mask airway, compared with those using the endotracheal tube.

The purpose of our study was (1) to examine the vocal symptoms and acoustic changes perceived in the immediate period following laryngeal mask airway, and (2) to compare these findings to those obtained following endotracheal intubation anaesthesia.

Materials and methods

This prospective study was conducted on patients admitted for non-ENT surgery at the American University of Beirut, Lebanon. A total of 27 patients was enrolled, after signing the informed consent form approved by the institution review board. Patients diagnosed with vocal fold lesions before or at the time of surgery were excluded. Patients who vomited post-operatively were also excluded.

All patients were evaluated pre-operatively on the morning of surgery, and at 2 and 24 hours after surgery. Patients were divided into two subgroups, those who had used a laryngeal mask airway and those who had undergone endotracheal intubation. The laryngeal mask airway group consisted of 10 patients, with tube sizes three and four being used respectively for women and men, and the mean intracuff pressure being maintained between 40 and 50 mmHg. The endotracheal tube group consisted of 17 patients, with polyvinyl chloride tube sizes seven and eight being used respectively for women and men. The two groups were matched according to demographic data and duration of anaesthesia.

Laryngopharyngeal discomfort was differentiated into six symptoms. Patients were asked about the presence or absence of: hoarseness, vocal fatigue, loss of voice, throat-clearing sensation, globus pharyngeus and throat pain. Only throat pain was graded, from one to 10 where 1 means no pain and 10 extreme pain.

Patients then underwent acoustic analysis of their voice, using the VISI Pitch Kay Elemetric program, model 3300 (Kay Elemetrics Corp., Lincoln Park, NJ). The vocal signal was directly recorded into the system, using a condenser microphone placed 15 cm from the patient's mouth. The average fundamental frequency, relative average perturbation, shimmer, noise to harmony ratio and voice turbulence index were measured by asking the patient to sustain the vowel 'ah' for 2 seconds. The habitual pitch was measured by asking the patient to count to 10 in a comfortable, normal voice. The maximum phonation time was calculated by asking the patient to take a deep breath and then to sustain phonation for as long as possible.

Data analysis

Two sets of outcome variables were considered: incidence of vocal complaints and changes in acoustic parameters. These were recorded at 2 and 24 hours post-operatively, and significant changes were tested using non-parametric tests for dependent samples, i.e. McNemar and Wilcoxon signed ranks test for categorical and continuous variables, respectively. Chi-square testing was performed to compare the change from baseline between the laryngeal mask airway and the endotracheal tube groups.

Differences were considered significant for $p < 0.05$. All analysis was conducted using the Statistical Package for the Social Sciences software (SPSS Inc, Chicago, Illinois, USA).

Results

The laryngeal mask airway group consisted of three men and seven women. Their ages ranged between 16 and 60 years, with a mean ± standard deviation (SD) of 31.3 ± 12 years. There was an increase in the incidence of all vocal symptoms at two hours post-operatively, except for globus pharyngeus. This increase was statistically significant for vocal fatigue, loss of voice and throat pain. All symptoms reverted back to normal baseline levels at 24 hours post-operatively (see Table I).

In the laryngeal airway group, regarding acoustic parameters, there was an increase in all the perturbation parameters two hours post-operatively, together with a decrease in the maximum phonation time and habitual pitch. None of these changes were statistically significant, except for those regarding relative average perturbation and noise to harmony ratio. At 24 hours, the maximum phonation time and habitual pitch reverted back to normal values (see Table II).

The endotracheal tube group had an age range of 16–60 years, with a mean ± SD of 33.0 ± 11.95 years. At two hours post-operatively, there was an increase in the incidence of all pharyngeal and vocal symptoms. At 24 hours, all the symptoms had returned to baseline or below-baseline levels, except for vocal fatigue and throat pain, both of which remained elevated, but not significantly (see Table III).

In the endotracheal tube group, regarding acoustic analysis parameters, at two hours post-operatively there was a significant decrease in maximum phonation time and an increase in all other parameters. At 24 hours, there was a significant increase in the maximum phonation time and a sustained (but statistically insignificant) increase in the average fundamental frequency, habitual pitch, noise to harmony ratio and voice turbulence index (see Table IV).

Comparing the vocal symptoms in the two groups, at two hours post-operatively, there was more loss of voice and vocal fatigue in the laryngeal mask airway group, compared with the endotracheal tube (see Table V).

Comparing the changes in acoustic parameters, compared with baseline values, in the two groups, there were no statistically significant changes (see Table VI).

Discussion

General anaesthesia can affect the voice by interfering with the various components integral to voice production. Both laryngeal and extralaryngeal structures may be affected. At the laryngeal level, damage to the vocal folds may be direct (secondary to a traumatic intubation, with resultant oedema, haematoma, laceration or dislocation) or indirect (with desiccation of the mucosal surface of the vocal folds secondary to inhalation of gaseous anaesthetic substances or intake of drying medications) as

TABLE I

PREVALENCE OF VOCAL COMPLAINTS IN PATIENTS INTUBATED USING LMA

Time point	Hoarseness (%)	Vocal fatigue (%)	Loss of voice (%)	Throat-clearing sensation (%)	Globus pharyngeus (%)	Throat pain (%)
Pre-op	10	0	0	10	0	0
2 h post-op	44.40	55.60	55.60	33.30	0	66.70
24 h post-op	10	0	11.10	11.10	0	11.10
p^*	0.125	0.031*	0.031*	0.125	–	0.016*
$p^†$	0.5	–	0.5	0.75	–	0.5

*Comparing vocal complaints pre-operatively (pre-op) and 2 hours post-operatively (post-op); †comparing vocal complaints pre-op and 24 h post-op. LMA = laryngeal mask airway; h = hours

TABLE II

ACOUSTIC PARAMETERS IN PATIENTS INTUBATED USING LMA

Time point	AvFF (Hz)	RAP (%)	Shimmer (%)	NHR	VTI	MPT (sec)	Habitual pitch (Hz)
Pre-op	171.9	1.37	6.89	0.149	0.041	10.89	176.96
2 h post-op	200.98	2.17	10.14	0.352	0.052	7.72	169.87
24 h post-op	209.81	1.11	8.95	0.345	0.058	11.57	172.63
p^*	0.213	0.049*	0.102	0.014*	0.248	0.285	0.285
$p^†$	0.064	0.223	0.248	0.125	0.41	0.367	0.125

Data displayed are mean values. *Comparing acoustic parameter pre-operatively (pre-op) and 2 h post-operatively (post-op); †comparing acoustic parameter pre-op and 24 h post-op. LMA = laryngeal mask airway; AvFF = average fundamental frequency; RAP = relative average perturbation; NHR = noise to harmonic ratio; VTI = voice turbulence index; MPT = maximum phonation time; h = hours

TABLE III

PREVALENCE OF VOCAL COMPLAINTS IN PATIENTS INTUBATED USING ETT

Time point	Hoarseness (%)	Vocal fatigue (%)	Loss of voice (%)	Throat-clearing sensation (%)	Globus pharyngeus (%)	Throat pain (%)
Pre-op	5.9	5.9	11.8	17.6	0	11.8
2 hours post-op	47.1	23.5	47.1	35.3	5.9	58.8
24 h post-op	5.9	11.8	5.9	5.9	0	36.4
p^*	0.008*	0.125	0.016*	0.125	–	0.001*
$p^\dagger$	1.00	0.50	0.75	0.5	–	0.266

*Comparing vocal complaints pre-operatively (pre-op) and 2 h post-operatively (post-op); †comparing vocal complaints pre-op and 24 h post-op. ETT = endotracheal tube; h = hours

reported also by Bless D and Shaikh A (unpublished data).[14] At the extralaryngeal level, restricted or depressed ventilation may last hours after reversal of general anaesthesia. This is usually secondary to the long term post-operative effects of barbiturates, narcotics and/or pain. The administration of anaesthetic agents may also interfere with fine neuromuscular control and sensation within the vocal tract, thus affecting the vocal signal.[15,16]

The acoustic variables accompanying the vocal changes witnessed after general anaesthesia may be very conflicting. While some authors have shown a decrease in the fundamental frequency and an increase in the perturbation parameters, others have shown a consistent increase in fundamental frequency after intubation, or simply no significant changes.[9,11] Changes in acoustic parameters have been attributed to rheological factors, alterations in the intrinsic vibratory characteristics of the vocal folds, and irregularities of the mucosal surface of the vocal folds. We observed a significant decrease in the maximum phonation time; this could be secondary either to the post-anaesthetic decrease in breathing support (discussed above), or to a decrease in breathing control due to changes in the vocal folds (also discussed above).

Beckford *et al.* evaluated both the audio-acoustic and laryngostroboscopic characteristics of the post-intubation voice. They found a statistically significant increase in jitter but not in fundamental frequency, although patient to patient variation was marked. They did not find consistent glottic mucosal changes, suggesting that the glottic contribution to postintubation vocal changes is rather minimal and that other, extralaryngeal factors may be responsible.[3]

In laryngeal mask airway patients, the reported incidence of pharyngeal symptoms such as globus pharyngeus and throat pain varies between 0 and 50 per cent. This difference has been attributed to several factors, such as the depth and duration of anaesthesia, number of intubation attempts, and (mostly) cuff pressure. The relationship between intracuff pressure and sore throat incidence has always been a controversial issue. In a recent study by Figueredo *et al.*, designed to compare the effects of laryngeal mask airway cuff pressure and mode of ventilation on post-operative laryngopharyngeal discomfort, the authors concluded that post-operative discomfort was related to the type of ventilation rather than to variations in laryngeal mask airway cuff pressure. The incidence of discomfort 24 hours after the surgery was reported as 11 per cent for dysphagia, 11 per cent for dysphonia and 28.8 per cent for sore throat.[17]

In our study, all patients received general anaesthesia, and the average mean cuff pressure did not exceed 40–45 mmHg. Sore throat was the most common pharyngeal symptom, followed by the vocal or laryngeal symptoms (mainly hoarseness, loss of voice and vocal fatigue). When considered together, these symptoms seem to be more pronounced, two hours post-operatively, in the laryngeal mask airway group, compared with the endotracheal tube group.

This is an interesting finding, in view of the common consensus that endotracheally intubated patients have more laryngeal symptoms than laryngeal mask airway patients following anaesthesia. These vocal symptoms, together with the changes in acoustic parameters in the laryngeal mask airway

TABLE IV

ACOUSTIC PARAMETERS IN PATIENTS INTUBATED USING ETT

Time point	AvFF (Hz)	RAP (%)	Shimmer (%)	NHR	VTI	MPT (sec)	Habitual pitch (Hz)
Pre-op	166.97	1.22	6.56	0.13	0.04	9.71	158.28
2 h post-op	181.87	2.54	11.59	0.29	0.09	6.87	163.07
24 h post-op	206.04	1.20	3.88	0.30	0.09	12.17	172.57
p^*	0.353	0.019*	0.065	0.004*	0.106	0.013*	0.229
$p^\dagger$	0.051	0.289	0.160	0.449	0.213	0.005*	0.062

Data displayed are mean values. *Comparing acoustic parameter pre-operatively (pre-op) and 2 h post-operatively (post-op); †comparing acoustic parameter pre-op and 24 h post-op. ETT = endotracheal tube; AvFF = average fundamental frequency; RAP = relative average perturbation; NHR = noise to harmonic ratio; VTI = voice turbulence index; MPT = maximum phonation time; h = hours

TABLE V

CHANGE IN VOCAL COMPLAINTS: LMA *VS* ETT

Change	Hoarseness (%)		Fatigue (%)		Loss of voice (%)		Throat-clearing sensation (%)		Globus pharyngeus (%)		Throat pain (%)	
	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT
2 h post-op *vs* pre-op	33.3	41.2	55.6	17.6	55.6	35.3	33.3	17.6	0	5.9	66.7	58.8
24 h post-op *vs* pre-op	0	0	0	18	11.1	9.1	11.1	0	0	0	11.1	36.4
p^*		0.517		0.063		0.281		0.332		0.654		0.571
$p^\dagger$		–		0.479		1		0.450		–		0.389

*Comparing LMA and ETT, for change in vocal complaints at 2 h (i.e. post-operative (post-op) values minus pre-operative (pre-op) values); †comparing LMA and ETT, for change in vocal complaints at 24 h (i.e. post-op values minus pre-op values). LMA = laryngeal mask airway; ETT = endotracheal tube; h = hours

TABLE VI

CHANGE IN ACOUSTIC PARAMETERS: LMA *VS* ETT

Change	AvFF (Hz)		RAP (%)		Shimmer (%)		NHR		VTI		MPT (sec)		Habitual pitch (Hz)	
	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT	LMA	ETT
2 h *vs* pre-op	21.4	14.5	0.78	1.47	4.29	5.65	0.21	0.15	0.016	0.054	−2.79	−2.84	−16	4.79
24 h *vs* pre-op	43.3	32.1	−0.21	−0.031	1.89	−3.18	0.192	0.167	0.014	0.056	0.94	3.45	−0.53	7.52
p^*		0.428		0.734		0.91		0.497		0.821		0.467		0.293
$p^\dagger$		0.569		0.84		0.849		0.425		0.382		0.382		0.849

*Comparing LMA and ETT, for change in acoustic parameters at 2 h (i.e. post-operative (post-op) values minus pre-operative (pre-op) values); †comparing LMA and ETT, for change in acoustic parameters at 24 hours (i.e. post-op values minus pre-op values). Mean duration of anaesthesia ± standard deviation: LMA, 82.0 ± 44.9 minutes; ETT, 89.7 ± 61.52 minutes ($p = 0.733$). LMA = laryngeal mask airway; ETT = endotracheal tube; AvFF = average fundamental frequency; RAP = relative average perturbation; NHR = noise to harmonic ratio; VTI = voice turbulence index; MPT = maximum phonation time; h = hours group, may be secondary to a number of factors, acting either singly or in combination.

The first factor is trauma from direct contact of the cuff or laryngeal mask airway tip with the supraglottic structures or the vocal folds, resulting in pressure-induced inflammatory changes and consequent vocal changes. Severe dysphonia following the use of laryngeal mask airway, with resultant vocal fold fixation, has also been attributed to arytenoid dislocation or recurrent laryngeal nerve palsy.[18] Removal of the laryngeal mask airway with an inflated cuff, forced traction, or twisting of the laryngeal mask airway may cause rotation of the larynx and possible dislocation of the arytenoids. Recurrent laryngeal nerve palsy, on the other hand, can be caused in several ways, but is usually due to pressure neuropraxia, with the point of injury generally being the cricoid region.

- **Since the introduction of the laryngeal mask airway by Brain in 1983, many have used it as an alternative to endotracheal intubation, especially in professional voice users who require extreme caution and minimal manipulation of their airway**
- **Even though the laryngeal mask airway is not in direct contact with the vocal folds, the incidence of laryngeal discomfort has been reported to be as high as 30 per cent**
- **This study aimed to examine the vocal symptoms and acoustic changes perceived in the immediate post-operative period following laryngeal mask airway anaesthesia**
- **Following the use of a laryngeal mask airway, the incidence of laryngeal symptoms was greater than that witnessed after use of an endotracheal tube, in the immediate post-operative period**

The second group of causative factors relate to alterations in the mucus layer overlying the vocal folds, secondary to changes in the relative average humidity of the inhaled air and in the flow rate. Individual vocal characteristics are related not only to the interplay between muscular and cartilaginous structures within the larynx, but also to the visco-elastic properties and pliability of the vocal folds. The rheological properties of the vocal folds are intimately related to the hydration of the tissues of these folds, and are negatively affected by dehydration.[19,20] Pre-anaesthetic fluid restriction and peri-operative fluid control, which unfortunately were not accurately documented in our study, are relevant to the analysis of vocal changes in patients using the laryngeal mask airway. In patients using a laryngeal mask airway, inhalation of cold and dry anaesthetic gases, with consequent alteration of relative humidity, together with changes in flow rate, may affect the vocal fold mucosa, thinning and dehydrating it. This may lead to an increase in the adhesiveness of the vocal folds during phonation.[20] The average flow rate during spontaneous breathing is 3–3.5 l/minute. During general anaesthesia using the laryngeal mask airway, the flow rate may reach up to 5 l/minute, which may in turn affect the vocal fold mucosa.

Subjectively perceived or objectively measured dysphonia is invariably accompanied by an increase in perturbation parameters. These are known to increase with dehydration, desiccation or decrease in humidification. The increase in perturbation parameters found in our study is similar to that found by Lee *et al.*, although only our noise to harmony ratio changes were significant. In our study, three acoustic variables remained elevated 24 hours post-operatively, but this was not significant compared with baseline values. In the study by Zimmert *et al.*, of the 12 variables evaluated, there were no significant differences in any parameter between the two groups, and both groups had a higher fundamental frequency post-operatively.[13] In our study, there was a decrease in the habitual pitch 24 hours post-operatively, but this was not statistically significant.

Conclusion

In our study, the incidence and severity of laryngeal symptoms following the use of a laryngeal mask airway were no less significant than those witnessed following endotracheal intubation, when assessed soon after extubation. The pathophysiology seems to differ, in this former the vocal changes seem to be secondary to changes in the mucosa rather than to direct contact or trauma to the vocal folds. These effects may be counteracted by increasing water intake both pre- and post-operatively. Both laryngeal mask airway and endotracheal intubation can be regarded as nontraumatic, in view of the lack of significant or permanent vocal symptoms and acoustic changes detected 24 hours after anaesthesia.

References

1 Peppard S, Dickens J. Laryngeal injury following short term intubation. *Ann Otol Rhinol Laryngol* 1983;**92**:327–30
2 Keane W, Rowe L, Denneny J, Atkins J. Complications of intubation. *Ann Otol Rhinol Laryngol* 1982;**91**:584–7
3 Beckford NS, Mayo R, Wilkinson A 3rd, Tierney M. Effects of short endotracheal intubation on vocal function. *Laryngoscope* 1990;**100**:331–6
4 Balestrieri F, Watson C. Intubation granuloma. *Otolaryngol Clin North Am* 1982;**15**:567–79
5 Brain AIJ. The laryngeal mask – a new concept in airway management. *Br J Anaesth* 1983;**55**:801–5
6 Alexander CA, Leach AB. Incidence of sore throats with the laryngeal mask. *Anaesthesia* 1989;**44**:791
7 Dingley J, Whitehead MJ, Wareham K. A comparative study of the incidence of sore throat with the laryngeal mask airway. *Anaesthesia* 1994;**49**:251–4
8 Reiger A, Brunne B, Hass I, Brummer G, Spies C, Stribel HW *et al.* Laryngo-pharyngeal complaints following laryngeal mask airway and endotracheal intubation. *J Clin Anaesth* 1997;**9**:42–7
9 Horii Y, Fuller B. Selected acoustic characteristics of voices before intubation and after extubation. *J Speech Hear Res* 1990;**33**:505–10

10 Lesser THJ, Williams RG, Hoddinott C. Laryngographic changes following endotracheal intubation in adults. *Br J Dis Comm* 1986;**21**:239–44
11 Yonick T, Reich A, Minifie F, Fink B. Acoustical effects of endotracheal intubation. *J Speech Hear Disord* 1990;**55**: 427–33
12 Lee SK, Hong KH, Choe H, Song HS. Comparison of the effects of the laryngeal mask airway and endotracheal intubation on vocal function. *Br J Anaesth* 1993;**71**:648–50
13 Zimmert M, Zwirnert P, Kruset E, Braun U. Effects on vocal function and incidence of laryngeal disorder when using a laryngeal mask airway in comparision with an endotracheal tube. *Eur J Anaesthesiol* 1999;**16**:511–15
14 Finkelhor BK, Titze IR, Durham PL. The effect of viscosity changes in the vocal folds on the range of oscillation. *J Voice* 1988;**1**:320–5
15 Tokics L, Hedenstierna G, Strandberg A, Brismar B, Lundquist H. Lung collapse and gas exchange during general anesthesia: effects of spontaneous breathing, muscle paralysis and positive end-expiratory pressure. *Anesthesiology* 1987;**66**:157–67
16 Cartwright P, Prys-Roberts C, Gill K, Dye A, Stafford M, Gray A. Ventilatory depression related to plasma fentanyl concentrations during and after anesthesia in humans. *Anesth Analg* 1983;**62**:966–74
17 Figueredo E, Vivar-Diago M, Munoz-Blanco F. Laryngopharyngeal complaints after use of the laryngeal mask airway. *Can J Anesth* 1999;**46**:220–5
18 Cros AM, Pitti R, Conil C, Giraud D, Verhulst J. Severe dysphonia after use of laryngeal mask airway. *Anesthesiology* 1997;**86**:498–500
19 Verdolini KM, Titze IR, Druker DG. Changes in phonation threshold pressure with induced conditions of hydration. *J Voice* 1990;**4**:142–51
20 Jiang J, Verdolini K, Aquino B, Ng J, Hanson D. Effects of dehydration on phonation in excised canine larynges. *Ann Otol Rhinol Laryngol* 2000;**109**:568–75

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