COMPARISON OF THE EFFECTS OF THE LARYNGEAL MASK AIRWAY AND ENDOTRACHEAL INTUBATION ON VOCAL FUNCTION

S. K. LEE, K. H. HONG, H. CHOE AND H. S. SONG

SUMMARY

We have compared changes in vocal function produced after insertion of a laryngeal mask airway (LMA) with those produced by tracheal intubation in 20 patients. Using acoustic waveform analysis, we computed amplitude variability (AV), pitch variability (PV), harmonics-to-noise ratio (HNR) and additive noise level (ANL) before anaesthesia and at 1, 4, and 24 h after tracheal extubation. There were no significant changes in vocal function after extubation except for HNR ratio (P = 0.046) at 4 h in the LMA group. There were differences in all four variables at 1 h, 4 h, or both, after tracheal extubation compared with baseline in the tracheal tube group. In both groups, all variables were the same as baseline values 24 h after extubation. These observations suggest that the LMA causes less vocal change than tracheal intubation (Br. J. Anaesth. 1993; 71: 648-650)

KEY WORDS


It is well known that tracheal intubation produces voice changes [1, 2]. The laryngeal mask airway (LMA) is used as an alternative to tracheal intubation [3-6], but its effect on vocal changes has not been studied. We have therefore measured voice changes in the first 24 h after a standard anaesthetic in patients allocated randomly to the use of either an LMA or a tracheal tube.

PATIENTS AND METHODS

After obtaining written informed consent and approval from the Hospital Ethics Committee, we studied 20 males (ASA grade I) undergoing minor elective orthopaedic procedures of the upper or lower extremity. Patients were excluded if they had respiratory tract disease, anatomical abnormalities of the upper airway or hearing problems, or if they were smokers. They were also excluded from the study if either a tracheal tube or an LMA could not be placed into the airway at the first attempt. The patients were allocated randomly to one of two groups according to the use of either LMA or tracheal tube: LMA group (n = 10): LMA without laryngoscopy; tube group (n = 10): tracheal intubation using tracheal tube with laryngoscopy (blade No. 3, curved type) through the orotracheal route. The mean (range) age and body weight of the patients were 26.5 (19-38) yr and 64.6 (57-77) kg in the LMA group and 22.7 (22-27) yr and 65.8 (58-76) kg in the tube group, respectively. The patients were blinded to the study group.

No premedication was given and all operations were carried out under general anaesthesia, induced with thiopentone 5 mg kg⁻¹ and either orotracheal intubation or LMA insertion facilitated using suxamethonium 1.5 mg kg⁻¹. A No. 3 LMA (Intravent, Pacific Medical Supplies Pty Ltd, Australia) was used in the LMA group and a low-pressure, high-volume cuffed tracheal tube of 7.0-mm P.V.C. (Sheridan, U.S.A.) in the tube group. Anaesthesia was maintained with 50 % nitrous oxide and 1-1.5 % halothane in oxygen. Neuromuscular block was produced with pancuronium 0.1 mg kg⁻¹ and subsequent incremental doses were given as necessary. Monitoring was performed in our routine manner. The patient was placed supine with the head in a neutral position using a ring support. At the end of surgery, residual neuromuscular block was antagonized with neostigmine 35 µg kg⁻¹ and atropine 20 µg kg⁻¹. The mean durations of intubation were 97.5 min (range 45-170 min) in the LMA group and 105.5 min (range 50-180 min) in the tube group.

Acoustic analysis

The voice was recorded on an ordinary magnetic tape with a digital tape-recorder in a noiseless room, on the morning of surgery (preanaesthesia) and after full recovery from general anaesthesia (clear mental state and adequate skeletal muscle power), at 1, 4 and 24 h after extubation. A mouth-to-microphone distance of about 10 cm was maintained during tape recording. Each patient was instructed to phonate the Korean vowel /e/ at least three times.

Voice samples for the vowels were low-pass filtered, digitized (16-bit quantization), and stored on a personal computer. Voice analysis was performed with the H & A Speech Lab Software Version 3.0 (2071). The temporal and spectral characteristics of the vowel /e/ were measured using the following parameters:

- **Amplitude variability (AV)**: varying from 0 (no change) to 100 (maximum change).
- **Pitch variability (PV)**: varying from 0 (no change) to 100 (maximum change).
- **Harmonics-to-noise ratio (HNR)**: a measure of the ratio of the fundamental frequency to the noise level.
- **Additive noise level (ANL)**: a measure of the noise level.

For each parameter, the value was calculated at 1, 4, and 24 h after extubation. A repeated measures analysis of variance (ANOVA) was used to compare the changes in vocal function between the LMA and tracheal tube groups. If the ANOVA indicated significant differences (P < 0.05), post-hoc pairwise comparisons were performed with Bonferroni's correction. The significance level was set at P < 0.05.

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filtered and digitized through a 12-bit A/D converter at a sampling rate of 30 kHz. Segments of the voice samples (0.5 s) were extracted by excluding the initial and final portions from each sample and were stored on floppy disc for subsequent analysis, conducted by IBM-compatible personal computer and a software program for voice analysis devised by one of the authors (K.H.H.). The voice analyst was blinded to the study group.

We calculated the extent of perturbation for roughness. Pitch variability (PV) is a measure of how the pitch of the voice (in a single vowel sound) varies over short time periods. Therefore, PV is the coefficient of variation (CV) \( CV = \frac{SD}{\text{Mean}} \times 100\% \) of the time intervals between adjacent peaks of waveforms. Amplitude variability (AV) is the amplitude change between adjacent peaks of waveforms and expressed as CV (%).

For noise level determination, harmonics-to-noise ratio (HNR) and additive noise level (ANL) were obtained. HNR was calculated from the acoustic waveform by a peak picking method [7]. Harmonics is the energy of the average waveform, while noise is the mean energy of the difference between the individual and the average waveform. Thus HNR is a particular form of signal-to-noise ratio. ANL is the energy of noise from the actual waveforms within the frequency range greater than 1 KHz; it was obtained directly from adaptive comb-filtered acoustic waveforms using Fast-Fourier transform with a Hamming window.

Statistical analysis

Results are expressed as mean (SD). The Wilcoxon signed-rank test was used for statistical analysis of the PV and AV values within each group at different times of measurement. HNR and ANL values for intragroup comparisons were compared using Student's paired t test for parametric data. Between group comparisons were made using Student's unpaired t test. \( P < 0.05 \) was considered significant.

<p>| Table 1. Differences of each variable from baseline value at 1, 4 and 24 h (mean (SD)). ( AV = ) Amplitude variability; ( PV = ) pitch variability; ( HNR = ) harmonics-to-noise ratio; ( ANL = ) additive noise level. ( ns = ) Not significant |</p>
<table>
<thead>
<tr>
<th>Change from the baseline values</th>
<th>P for difference between groups</th>
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<tbody>
<tr>
<td></td>
<td>LMA group</td>
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<tr>
<td>AV (%)</td>
<td></td>
</tr>
<tr>
<td>1 h</td>
<td>0.22 (0.57)</td>
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<tr>
<td>4 h</td>
<td>0.28 (0.67)</td>
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<tr>
<td>24 h</td>
<td>0.18 (0.55)</td>
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<tr>
<td>PV (%)</td>
<td></td>
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<tr>
<td>1 h</td>
<td>0.18 (0.47)</td>
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<tr>
<td>4 h</td>
<td>0.31 (0.66)</td>
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<tr>
<td>24 h</td>
<td>-0.09 (3.57)</td>
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<tr>
<td>HNR (dB)</td>
<td></td>
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<tr>
<td>1 h</td>
<td>-3.08 (5.63)</td>
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<tr>
<td>4 h</td>
<td>-3.78 (5.23)</td>
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<tr>
<td>24 h</td>
<td>-0.55 (3.47)</td>
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<td>ANL (dB)</td>
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<tr>
<td>1 h</td>
<td>1.10 (4.00)</td>
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<tr>
<td>4 h</td>
<td>1.25 (3.91)</td>
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<tr>
<td>24 h</td>
<td>0.73 (4.25)</td>
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RESULTS

All four measures of vocal change were worse than baseline at 1 and 4 h in both groups, but the values had largely returned to baseline by 24 h. Several of these changes were significant for the tube group, but only one for the LMA group. Five of the eight differences between groups (at 1 and 4 h) were statistically significant (table 1).

DISCUSSION

The LMA was first used in anaesthesia as an alternative to tracheal intubation by Brain in 1983 [8] and has been used safely in general anaesthesia for children and adults in spontaneously breathing patients and those undergoing controlled ventilation [9-12]. There should be little possibility of an LMA damaging the vocal cord or the other intralaryngeal structures which may change vocal function, but in contrast, laryngeal complications, including hoarseness, may develop after short-term or long-term tracheal intubation [13-16]. It has been reported that LMA placement was associated with a smaller incidence of sore throat than tracheal intubation [17].

A computer system is widely applicable for voice analysis in clinical practice [18] and many acoustic parameters have been developed [7, 19-23]. New terms have been devised: "jitter" is the cycle-to-cycle variation in pitch which we have measured as "pitch variability"; "shimmer" is the corresponding variation in amplitude—our "amplitude variability"; others [19, 20, 24] have used slightly different ways of expressing essentially the same features. These measures reflect the "roughness" of the voice and are now widely accepted in acoustic waveform analysis. HNR and ANL are measures of the "breathiness" of the voice.

In this study there were differences in age, duration of airway placement, or both; these factors may influence vocal changes after surgery. However, we believe that the differences were too small to have any appreciable effect on the difference in vocal change between the two groups.

We have performed a large number of significance tests and therefore some of the apparently significant differences from baseline and between groups may be attributable to chance; however, it does seem clear that, overall, there was less change in vocal cord function with the LMA than with the tracheal tube. Priebe, Henke and Hedley-White [1] found that the acoustic waveform obtained 2 days after tracheal extubation demonstrated a restoration towards normal speech and approximately 4 days elapsed before the waveform of normal phonation resumed. However, in our study, all variables had returned virtually to the preanaesthesia value at 24 h in both groups. We have no explanation for this difference between Priebe's results and our data.

Our data in the tube group are similar to those of Beckford and colleagues; they showed a statistically significant increase in cycle-to-cycle fundamental frequency variation in patients after intubation [2]. However, they did not demonstrate consistent
changes in mucosal function with electroglot-
tography or laryngeal endoscopy. Therefore, because
phonation depends on both laryngeal and extra-
laryngeal factors, they suggested that postoperative
vocal changes occurred as a result of multifactorial
changes and were not caused solely by vocal fold
trauma or vocal cord oedema. Our findings that the
LMA caused statistically significant changes (P = 
0.046) in HNR 4 h after extubation, with slight
increases in PV and AV, may support the conclusion
of Beckford’s group, because the LMA would not be
expected to damage the vocal cords directly.

Our results are consistent with those of Harris and
colleagues [25], who also found significant dif-
ferences in vocal effects produced by the LMA and
the tracheal tube. However, in Harris and colleagues’
study, the vocal changes produced by tracheal
intubation were observed electroglottographically
18–24 h after surgery, while the vocal changes in our
study, measured acoustically, resumed preanaes-
thesia values at 24 h in both groups. These dif-
fferences reflect the different methods used for
assessing vocal cord function.

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