



Effect of perioperative corticosteroids on early postoperative voice changes after endotracheal intubation: a prospective controlled study

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Voice changes after endotracheal intubation

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Abstract

Aim: Endotracheal intubation (ETI) may cause early postoperative voice deterioration due to laryngeal trauma and edema. This study aimed to investigate the effect of perioperative corticosteroid administration on early postoperative voice changes following ETI.

Methods: This prospective controlled study included 40 patients undergoing tympanoplasty under general anesthesia with ETI. Patients were randomly assigned to a steroid group (n = 20) or a control group (n = 20). The steroid group received 40 mg intravenous methylprednisolone preoperatively, while no additional medication was administered to the control group. Objective acoustic voice parameters—fundamental frequency (F0), jitter (%), shimmer (%), shimmer (dB), and harmonics-to-noise ratio (HNR)—and subjective voice assessment using the Voice Handicap Index-10 (VHI-10) were evaluated preoperatively and at the 24th postoperative hour.

Results: No significant differences were observed between the groups in preoperative acoustic or subjective voice measures. Postoperatively, deterioration in acoustic voice parameters was observed in both groups. However, increases in jitter and shimmer values and decreases in HNR were significantly less pronounced in the steroid group compared with the control group. Postoperative VHI-10 scores increased in both groups; this increase was statistically significant in the control group but not in the steroid group.

Conclusion: Perioperative corticosteroid administration may attenuate early postoperative deterioration in both objective acoustic voice parameters and subjective voice perception following ETI. Although postoperative voice changes cannot be completely prevented, corticosteroids may contribute to improved early postoperative voice outcomes.

Keywords

endotracheal intubation, voice, acoustic analysis, corticosteroids, harmonics-to-noise ratio, voice handicap index

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Introduction

Endotracheal intubation (ETI) is a routinely performed procedure during general anesthesia to secure the airway and maintain adequate ventilation.¹ Despite its widespread use, ETI may lead to postoperative laryngopharyngeal complications, including sore throat, dysphagia, cough, and hoarseness, even after short-term intubation.^{2,3} These symptoms are primarily attributed to mechanical trauma and inflammatory edema of the laryngeal structures caused by endotracheal tube placement.⁴ Voice production is highly sensitive to even minor alterations in the anatomical and biomechanical properties of the vocal folds. Consequently, laryngeal edema and mucosal injury following ETI may result in measurable changes in voice quality. Previous studies have demonstrated that ETI can cause early postoperative deterioration in acoustic voice parameters such as fundamental frequency (F0), jitter, and shimmer reflecting impaired vocal fold vibration.⁵⁻⁷

Various perioperative strategies have been investigated to reduce intubation-related laryngeal morbidity, including optimization of endotracheal tube size, control of cuff pressure, and pharmacological interventions.^{4-6,8} Among these strategies, corticosteroids are known for their potent anti-inflammatory properties, including reduction of microvascular permeability and airway edema.^{9,10} Prophylactic corticosteroid administration has been shown to decrease the incidence of post-extubation stridor and laryngeal edema in adult patients.¹¹⁻¹⁴ However, data regarding the effect of corticosteroids on postoperative voice quality after ETI remain limited. Although several studies have evaluated voice changes following ETI, most have focused either on subjective symptoms or on isolated acoustic parameters.⁵⁻⁷ Studies assessing both objective acoustic voice analysis and subjective patient-reported outcomes are relatively scarce. Furthermore, the potential protective role of perioperative corticosteroid administration on early postoperative voice changes has not been clearly established.

Therefore, the aim of this prospective controlled study was to investigate the effect of perioperative corticosteroid administration on early postoperative voice changes following ETI, using both objective acoustic voice analysis and subjective assessment with the Voice Handicap Index-10 (VHI-10).

Materials and Methods

Study Design

This study was designed as a prospective controlled clinical study and was conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. Patients scheduled for elective ear surgery under general anesthesia with ETI were prospectively recruited from the otorhinolaryngology outpatient clinic. To minimize confounding factors affecting voice quality, only patients undergoing tympanoplasty were included. Participants were randomly assigned in a 1:1 ratio to the steroid or control group using a computer-generated randomization sequence created with Microsoft Excel. The allocation sequence was generated before patient enrollment. Group assignments were concealed until the time of enrollment to minimize selection bias. Due to the nature of the intervention, blinding of participants and investigators was not feasible.

Patient Selection

Patients aged 18 years and older who were scheduled for tympanoplasty under general anesthesia were eligible for inclusion. All patients underwent a comprehensive otorhinolaryngological and systemic examination preoperatively. Exclusion criteria were defined to eliminate factors that could affect voice quality or airway anatomy and included:

age under 18 years; history of laryngeal or vocal cord pathology; previous head and neck surgery; neurological disorders affecting voice; laryngopharyngeal reflux; allergic rhinitis, nasal polyposis, or significant septal deviation; asthma; upper respiratory tract infection within the previous month; smoking; pregnancy; systemic steroid use within the previous week; general anesthesia within the preceding three months; documented difficult intubation; postoperative vomiting within the first 24 hours after extubation. To ensure that ETI was the sole variable influencing voice changes, surgeries involving the nasal cavity, nasopharynx, oral cavity, oropharynx, hypopharynx, larynx, or neck were excluded. Only patients undergoing ear surgery were included.

Anesthetic and Intubation Protocol

All anesthetic procedures were standardized in collaboration with the anesthesia department. General anesthesia was administered by the same anesthesiologist for all patients, and all surgical procedures were performed by the same surgeon. ETI was performed using cuffed endotracheal tubes, with tube sizes of 7.0–7.5 mm for female patients and 8.0–8.5 mm for male patients. Only short-term intubations were included, and surgical procedures lasting longer than two hours were excluded. In the steroid group, 40 mg of intravenous methylprednisolone was administered 30 minutes prior to induction of anesthesia. No additional medication was administered to patients in the control group.

Voice Assessment Timing

Objective acoustic voice analysis and subjective voice evaluation using the Voice Handicap Index-10 (VHI-10) were performed preoperatively and repeated at the 24th postoperative hour in all patients.¹⁵

Voice Assessment and Acoustic Analysis

Objective acoustic voice analysis was performed using the Praat software program (Paul Boersma and David Weenink, University of Amsterdam), which is a widely used and validated tool for voice analysis.¹⁶ All recordings were obtained in a quiet room under standardized conditions. Participants were seated comfortably, and voice samples were recorded using a high-quality dynamic microphone (Audio-Technica AT2020) positioned at a fixed distance of 20 cm from the mouth and connected to a computer. Each participant was instructed to produce a sustained vowel /a/ at a comfortable pitch and loudness level. Three sustained phonations, each lasting longer than three seconds, were recorded for each participant. To ensure consistency and minimize variability, the second phonation was selected for analysis. To eliminate onset and offset effects, a 1-second segment from the middle portion of the phonation was extracted for acoustic analysis. The selected voice segments were digitized at a sampling rate of 50 kHz. The following acoustic parameters were analyzed: fundamental frequency (F0), jitter (%), shimmer (%), shimmer (dB), and harmonics-to-noise ratio (HNR, dB). These parameters were chosen because they reflect periodicity, amplitude stability, and noise components of vocal fold vibration and are commonly used in clinical voice assessment.

Subjective Voice Assessment

Subjective evaluation of voice-related symptoms was performed using the Turkish version of the Voice Handicap Index-10 (VHI-10), a validated self-assessment questionnaire.¹⁷ The VHI-10 consists of 10 items scored on a 5-point Likert scale ranging from 0 (never) to 4 (always), with higher scores indicating a greater perceived voice handicap. The VHI-10 questionnaire was administered preoperatively and repeated at the 24th postoperative hour for all participants.

Ethical Approval

Ethical approval information was not provided in the manuscript.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Between-group comparisons were performed using Student's t-test or Mann-Whitney U test according to data distribution. The differences in proportions between groups were compared by using Chi-Square or Fisher's Exact test, where appropriate. Descriptive statistics were used to summarize the data and expressed as mean $\pm$ standard deviation for normally distributed continuous variables, median (minimum-maximum) for skewed continuous variables, and count with a percentage of the total for categorical variables. To define significant differences for pre-post measurements, we used Wilcoxon signed-rank test or Paired t-test, where appropriate. A P value < 0.05 was considered statistically significant.

Sample Size Calculation

An a priori sample size calculation was performed using G-Power software (version 3.1.9.7; Heinrich Heine University, Düsseldorf, Germany). Based on the primary outcome (postoperative HNR), an effect size (Cohen's d) of 0.53, a two-sided significance level (α) of 0.05, and a statistical power of 80% were assumed. The required minimum sample size was 18 participants per group. Therefore, 40 participants (20 per group) were included in the present study.

Reporting Guidelines

The study was reported in accordance with the CONSORT guidelines.

Results

Forty patients who underwent tympanoplasty were included in the study. Twenty of them were in the study group and 20 of them were in the control group. The gender distribution of the groups was homogeneous, and there was no significant difference between the mean ages (Table 1). The operation time lasted an average of 67 minutes (30-110 minutes).

There was no significant difference between the preoperative results of both groups. When the postoperative results of the groups were compared, there was no significant difference between F0, Jitter%, and shimmer dB values, but there was a statistically significant difference between shimmer% and HNR values ($P = .048$ for shimmer %; $P = .033$ for HNR).

Objective Acoustic Voice Analysis

Objective acoustic analyzes of each group in the preoperative and postoperative periods were evaluated; F0, Jitter%, shimmer%, shimmer dB, and HNR values were compared (Table 2). While the mean preoperative F0 value of the patients in the study group was 165307.55 and the postoperative mean F0 value was 159163.15, this value

Table 1. The demographic characteristics of the patients

	Study group (N=20)	Control group (N=20)	p
Gender (female/male)	10/10	9/11	.752
Age (Mean $\pm$ SD; years)	37.30 $\pm$ 15.60	34.35 $\pm$ 11.85	.505

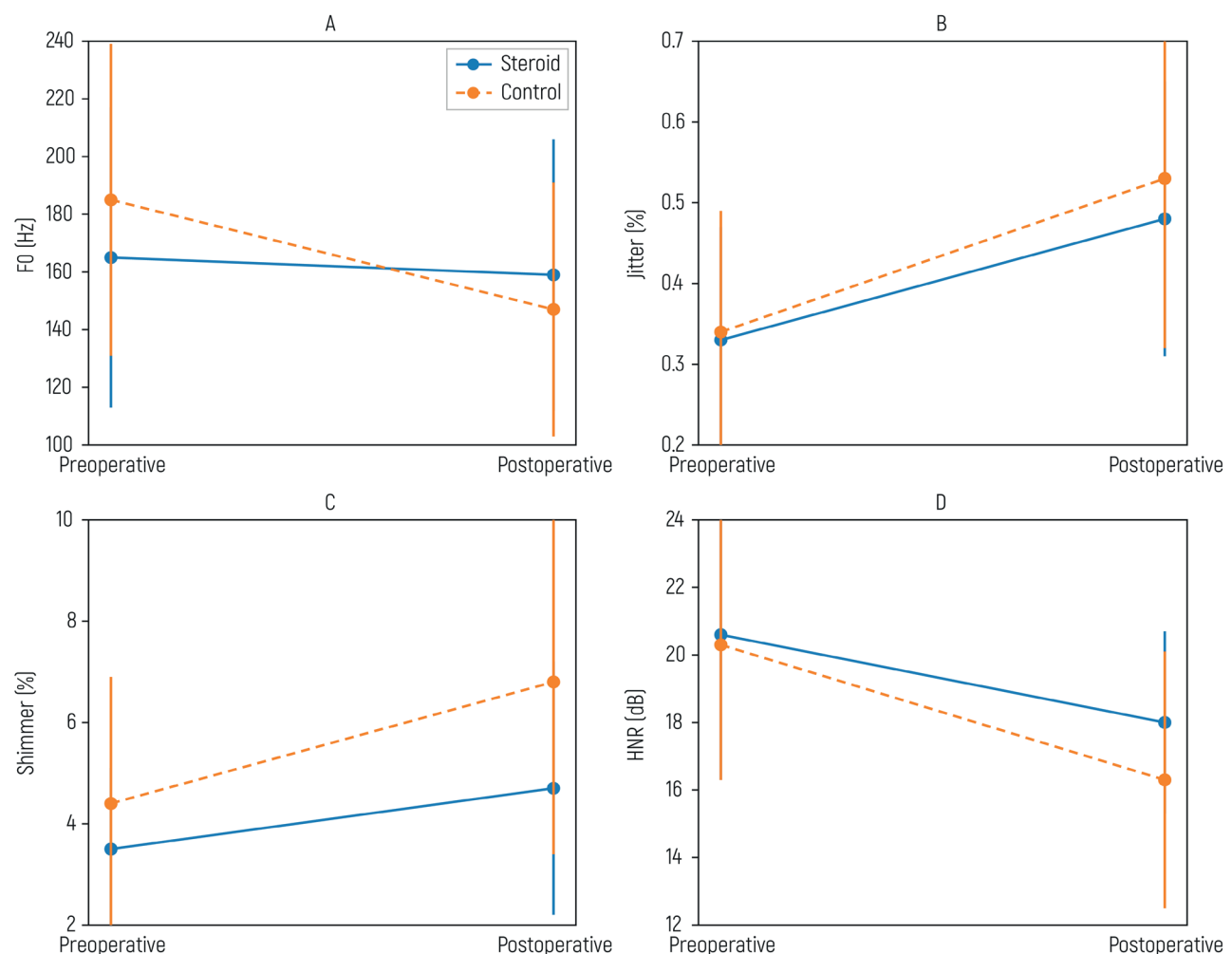


Figure 1. Changes in acoustic voice parameters before and after endotracheal intubation.

(A) Fundamental frequency (F0), (B) jitter (%), (C) shimmer (%), and (D) harmonics-to-noise ratio (HNR) values measured preoperatively and at the 24th postoperative hour in the steroid and control groups. Error bars represent standard deviation. The difference between Jitter%, shimmer%, and HNR values between the groups was statistically significant ($P < .001$, $P = .001$, $P < .001$).

Table 2. Statistical Analysis of Pre- and Postoperative F0, Jitter %, Shimmer %, Shimmer dB, and HNR values.

			F0	JITTER %	SHIMMER%	SHIMMER dB	HNR
Study group (N=20)	Preoperative	Mean ± S.D.	165307,55 ± 51731,96	0.33 ± 0.13	3526,25 ± 1599,91	0.33 ± 0.16	20583,1 ± 3056,53
		Median-Range	154538,5-155952,00	0.33-0.51	3188,5-7061,00	0.29-0.56	19532,00-11809,00
	Postoperative	Mean ± S.D.	159163,15 ± 47161,64	0.48 ± 0.18	4744 ± 2516,70	0.44 ± 0.24	18010.85 ± 2699,94
		Median-Range	151496,00-152621,00	0.46-0.58	4564,5-8809,00	0.43-0.76	17337,50-10730,00
Control group (N=20)	Preoperative	Mean ± S.D.	185664,1 ± 54278,34	0.34 ± 0.15	4445,3 ± 2532,43	0.38 ± 0.22	20270.15 ± 4022,17
		Median-Range	188413-174300,00	0.32-0.49	3923-9113,00	0.34-0.83	19495-13821,00
	Postoperative	Mean ± S.D.	147024,15 ± 44304,27	0.53 ± 0.21	6779,05 ± 3425,93	0.58 ± 0.26	16285,15 ± 3757,56
		Median-Range	138582,5-147689,00	0.53-0.71	6526-12437,00	0.57-0.87	15568,00-13035,00
	P^1		< .001	< .001	.001	.001	< .001
	P^2		.208	.989	.402	.589	.735
	P^3		.402	.323	.048	.051	.033

Table 3. Statistical Analysis of Scores of Voice Handicap Index-10

Study group N=20				Control grup N=20		P^2	P^3
VHI-10		Preoperative	Postoperative	Preoperative	Postoperative	.342	.161
	0	18(90.0%)	13(65.0%)	16 (80.0%)	7(35.0%)		
	1	1(5.0%)	5(25.0%)	4(20.0%)	10(50.0%)		
	2	1(5.0%)	2(10.0%)	0(0.0%)	3(15.0%)		
	P^1	.050		.011			

P^1 : The difference between the preoperative and postoperative analysis results of the groups; P^2 : the difference between the preoperative analysis results of the groups; P^3 : the difference between the postoperative analysis results of the groups.

was 185664.1 preoperatively and 147024.15 postoperatively in the control group (Figure 1). There was a statistically significant difference between the results ($P < .001$). While the mean jitter% values of the patients were 0.33 and 0.48 pre-and postoperatively in the study group, this value was 0.34 and 0.53 in the control group (Figure 1). While the mean shimmer% values of the patients were 3526.25 and 4744 pre and postoperatively in the study group, these values were 4445.3 and 6779.05 in the control group (Figure 1). While HNR values were 20583.1 and 18010.85 pre and postoperatively in the study group, it was 20270.15 and 16285.15 in the control group (Figure 1).

Subjective Voice Assessment

Preoperative Voice Handicap Index-10 (VHI-10) scores did not differ significantly between the steroid and control groups. Postoperatively, VHI-10 scores increased in both groups, indicating a deterioration in subjective voice perception (Table 3).

In the steroid group, the postoperative increase in VHI-10 scores did not reach statistical significance ($P = .050$). In contrast, the control group demonstrated a statistically significant increase in postoperative VHI-10 scores compared with preoperative values ($P = .011$). There was no significant difference between the two groups in postoperative VHI-10 score distribution.

Discussion

ETI is known to cause transient laryngopharyngeal morbidity even after short-term procedures. In the present study, we demonstrated that ETI resulted in early postoperative deterioration in both objective acoustic voice parameters and subjective voice perception. More importantly, perioperative administration of corticosteroids significantly attenuated these negative effects, as evidenced by smaller changes in jitter, shimmer, and HNR values and by stabilization of VHI-10 scores. Previous studies have reported postoperative voice changes following ETI, which have been attributed to mechanical trauma and inflammatory

edema of the laryngeal mucosa.²⁻⁴ Hamdan et al. and Ponnusamy et al. demonstrated early postoperative alterations in fundamental frequency, jitter, and shimmer values after intubation, supporting the findings of the present study.^{5,6} In addition, Böttcher et al. demonstrated that laryngeal injuries following ETI in otorhinolaryngologic surgery are closely associated with anatomical and mechanical factors, highlighting the role of non-neural mechanisms in postoperative laryngeal morbidity.¹⁸ Similarly, Šimić Prgomet et al. reported significant postoperative voice changes following thyroidectomy in patients without recurrent laryngeal nerve injury, supporting the concept that postoperative voice deterioration may occur due to non-neural mechanisms such as tissue edema and mechanical factors.¹⁹ Consistent with these reports, our results demonstrated postoperative deterioration in acoustic parameters in both groups, with significantly attenuated changes in patients receiving perioperative corticosteroids.

Jitter and shimmer reflect cycle-to-cycle variations in frequency and amplitude during phonation, and increases in these parameters are indicative of impaired vocal fold vibration and reduced voice stability.^{20,21} Previous studies have shown that even short-term ETI may lead to early postoperative deterioration in these acoustic parameters, likely due to mechanical trauma and inflammatory changes of the laryngeal mucosa.^{6,7} In the present study, both jitter and shimmer values increased significantly after surgery, with more pronounced changes observed in the control group, suggesting that ETI alone is sufficient to induce early postoperative voice instability. In contrast, the smaller magnitude of change observed in the steroid group supports a potential protective effect of perioperative corticosteroids on vocal fold vibration, most likely mediated through attenuation of inflammatory edema and improved mucosal recovery.^{9,10,22} Harmonics-to-noise ratio (HNR) reflects the proportion of periodic (harmonic) components relative to noise components in the voice signal and is inversely related to voice quality and dysphonia severity.^{23,24} A reduction in HNR indicates increased aperiodicity of vocal fold vibration, which

may result from mucosal edema, surface irregularities, or impaired glottal closure. In the present study, HNR values decreased significantly after surgery in both groups, with a more pronounced reduction observed in the control group. These findings suggest that intubation-related laryngeal changes contribute to increased noise components in the voice signal, even in the absence of overt nerve injury, as previously reported in studies evaluating postoperative voice changes after airway manipulation.¹⁸ In contrast, the relatively preserved HNR values in the steroid group support the notion that perioperative corticosteroid administration may help maintain harmonic structure by limiting inflammatory edema and promoting more stable vocal fold vibration during the early postoperative period.^{9,10,22}

Corticosteroids exert their beneficial effects by suppressing inflammatory responses, reducing capillary permeability, and limiting tissue edema.^{9,10} Their role in preventing post-extubation airway complications such as stridor has been well established in previous studies and meta-analyses.^{11,12,14} In critically ill patients, Cheng et al. demonstrated that methylprednisolone significantly reduced postextubation stridor and reintubation rates, which was associated with attenuation of inflammatory cytokine responses, supporting the anti-inflammatory role of corticosteroids in airway protection.²² However, data regarding their impact on postoperative voice quality remain limited. Our findings extend the existing literature by demonstrating that perioperative corticosteroid administration not only reduces airway complications but also mitigates early postoperative voice deterioration.

Subjective voice assessment using the VHI-10 revealed an increase in perceived voice handicap after surgery in both groups. While this increase reached statistical significance in the control group, it did not in the steroid group, suggesting that corticosteroids may also reduce the subjective impact of intubation-related voice changes. Similar increases in postoperative VHI scores have been reported previously, particularly in the early postoperative period.^{5,25} Ongoing randomized controlled trials continue to investigate the prophylactic use of corticosteroids to reduce post-extubation airway complications, which may provide further insight into their broader clinical effects.

Limitations

The present study has several limitations. First, the sample size was relatively small, which may limit the generalizability of the findings. Second, voice assessments were limited to the early postoperative period, and long-term voice outcomes were not evaluated. Finally, laryngoscopic evaluation was not performed postoperatively; therefore, structural changes of the vocal folds could not be directly correlated with acoustic findings. Despite these limitations, the present study provides both objective and subjective evidence supporting the beneficial effect of perioperative corticosteroid administration on early postoperative voice changes following ETI. These findings may be particularly relevant for patients for whom voice quality is important, such as professional voice users.

Conclusion

ETI causes early postoperative deterioration in both objective acoustic voice parameters and subjective voice perception. The findings of this prospective controlled study demonstrate that perioperative corticosteroid administration attenuates these negative effects by limiting deterioration in acoustic measures and stabilizing patient-reported voice outcomes. Although postoperative voice changes cannot be completely prevented, perioperative corticosteroids may contribute to a more favorable early postoperative voice profile following ETI. Further studies with larger sample sizes and longer follow-up periods are warranted to confirm these findings.

Declarations

Animal and Human Rights Statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed Consent

Written informed consent was obtained from all participants prior to enrollment.

Data Availability

The datasets used and/or analyzed during the current study are not publicly available due to patient privacy reasons but are available from the corresponding author on reasonable request.

Conflict of Interest

The authors declare that they have no conflicts of interest regarding the publication of this manuscript.

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Author Contributions (CRediT Taxonomy)

Conceptualization: D.A, E.A.K

Methodology: D.A, E.A.K

Software: D.A

Validation: D.A, E.A.K

Data curation: D.A, E.A.K

Formal analysis: D.A

Investigation: D.A, E.A.K

Writing – original draft: D.A, E.A.K

Writing – review & editing: D.A, E.A.K

Visualization: D.A, E.A.K

Supervision: D.A, E.A.K

Project Administration: D.A

AI Usage Disclosure

Artificial intelligence tools were used only for language editing and improving readability. No AI tool was used for data analysis, interpretation of results, or generation of scientific content. The authors take full responsibility for the content of the manuscript.

Abbreviations

ETI: Endotracheal intubation

F0: Fundamental frequency

HNR: Harmonics-to-noise ratio

VHI-10: Voice handicap index-10

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