Voice and Vocal Fold Condition Following Short-Term General Anesthesia: A Prospective Study

Voice and Vocal Fold Condition Following Short-Term General Anesthesia: A Prospective Study

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Summary: Background. Dysphonia, with or without laryngeal changes, has been reported as a complication following prolonged intubation. In contrast, it is unknown if laryngeal changes also occur following short-term airway instrumentation. The objectives of this study were to determine the prevalence of laryngeal changes in patients undergoing short-term routine general anesthesia using an endotracheal tube (ETT) or supraglottic airway (SGA), and to identify predictors to these changes.

Methods. Standardized voice assessments were performed preoperatively, postoperatively, and at follow-up on adults undergoing general anesthesia for an elective procedure of less than three hours requiring an ETT or a SGA. The standardized voice assessment protocol comprised a rigid videolaryngostroboscopy, the Voice Handicap Index (VHI), and acoustic voice analysis. The effects of demographic and anesthetic characteristics and type of airway instrumentation on the videolaryngostroboscopic variables were studied using multilevel logistic regression. Multilevel linear regression was used to reveal preoperative versus postoperative changes in VHI and acoustic voice scores.

Results. Overall, the prevalence of postoperative laryngeal changes was low. Significant postoperative laryngeal changes were found for the variables right-sided vocal fold redness in the ETT group ($P = 0.048$) and right-sided vocal fold blood vessels in both groups (ETT versus SGA). However, after adjustment for all demographic and anesthetic characteristics in the regression model, the effect of the type of airway instrumentation (ETT versus SGA) on the variable right-sided vocal fold redness was no longer significant.

Conclusions. ETT and SGA short-term airway instrumentation are vocal fold function sparing techniques with negligible laryngeal changes.

KEY WORDS: Anesthesia−Intubation−Intratracheal−Laryngeal mask−Vocal cords.

INTRODUCTION

Laryngeal complaints are common among patients following endotracheal intubation with an incidence of dysphonia varying between 14.4% and 50%.[1,2] Even more severe findings such as glottic hematoma, laceration, and subluxation of the cricoarytenoid joint have been reported (up to 6.2%).[3] Although dysphonia is reported less frequently following a supraglottic airway (SGA), injuries, such as cricoarytenoid subluxation and recurrent laryngeal nerve palsy have been reported.[1,4,5]

Postoperative dysphonia affects social and professional performance.[6−8] In the American Society of Anesthesiologists Closed Claims Project database 1990−2007, 7% of the 5230 claims were related to airway injury, of which 33% were of laryngeal nature.[9,10] Risk factors for laryngeal complaints after anesthesia include size of the endotracheal tube (ETT), use of an introducer or neuromuscular (NM) blocking agents, intubation and extubation conditions, type and duration of surgery, and demographic factors.[1,2,5,11,12]

Compared with the consequences of prolonged intubation, sufficient knowledge of laryngeal changes following short-term airway instrumentation is currently lacking.[6,13−16] A previous systematic review showed that dysphonia and laryngeal injuries are common findings following short-term general anesthesia. However, due to the heterogeneity in designs and poor methodological quality of the included studies, a meta-analysis to determine a reliable prevalence estimate of dysphonia or a causal relationship between laryngeal changes and short-term general anesthesia could not be carried out.[14]

To address this knowledge gap, this study was conducted to determine the prevalence of laryngeal changes in patients undergoing short-term routine general anesthesia using an ETT or SGA, and to identify predictors to these changes.

MATERIAL AND METHODS

Ethics approval

This single center study protocol was approved by the Medical Research Ethics Committee of the Maastricht University Medical Centre (MUMC+; NL33665.068.10/10-2-075 CCMO/METC Maastricht) in the Netherlands. The study was conducted in compliance with the provisions of the Declaration of Helsinki. Written informed

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consent was obtained from all patients. The study was registered in the '*Nederlands Trial Register*' (NTR2549).

Patient population

All adult patients planned for an elective procedure under general anesthesia between June 2011 and December 2012 were invited to participate. The following exclusion criteria were applied: less than 18 years in age, elective surgical procedures longer than three hours, American Society of Anesthesiologists classification above three, upper airway or neck surgery, critical illness, emergency surgery settings, cognitive impairment, and preoperative findings suggestive of head and neck cancer.

Voice and vocal fold assessment

All patients underwent a standardized assessment protocol comprised of a structured interview, Body Mass Index (BMI) measurement, the self-report Voice Handicap Index (VHI), a videolaryngostroboscopy by trained clinicians, and acoustic voice analysis. The first measurement (T0) was performed after admission on the morning of or the day before surgery. The second measurement moment (T1) took place in the time window of two hours to four days postoperatively depending on the wellbeing of the patient. The third measurement (T2) was performed one to six weeks postoperatively (Figure 1).

The Dutch version of the VHI was used to assess voice-related quality of life. The VHI is a validated questionnaire measuring voice problems in daily life. It consists of 30 items divided into three subscales: emotional (VHI-E), functional (VHI-F), and physical (VHI-P). Each item can be scored from 0 to 4, with 0 as "never" and 4 as "always". Summing the scores on the 30 items yields a total VHI score (VHI-T) ranging from 0 to 120. The higher the score, the higher the degree of patient-perceived vocal handicap.[17]

All videolaryngostroboscopy videos were obtained using a 70 degree rigid Hopkins endoscope (model 8706 CA, Karl Storz GmbH & Co KG, Tuttlingen, Germany) attached to a μ-Pulsar (Karl Storz GmbH & Co KG, Tuttlingen, Germany) and a Tele Pack X (model200450 Karl Storz GmbH & Co KG, Tuttlingen, Germany). The images were recorded on an external hard disc at 30 frames per second. If necessary, a topical anesthetic (Xylocaine 10%) was administered to the oropharyngeal mucosa. Video recordings of vocal fold vibration were made during repeated stable phonation of a sustained vowel /i:/ at comfortable pitch and loudness. Each video contained a phonation time long enough to allow the registration of at least one complete cycle of vibration. During the examination, patients were seated upright. The field of the videolaryngostroboscopic image included the laryngeal vestibule, vocal folds, anterior and posterior commissure, and the arytenoids.

Visuoperceptual ordinal and nominal videolaryngostroboscopic variables comprised of laryngeal changes and clinical diagnosis of vocal pathology and were derived from reports of the Phonosurgery Committee of the European Laryngological Society (ELS).[18,19–25] Prior to data collection, two students received training in visuoperceptual measurement for these videolaryngostroboscopic variables. The videos used for training were not included in the experimental set of videos. Training in the exact interpretation of each category of the different variables took place in sessions with both observers and was intended to generate substantial to almost perfect levels of intra- and interobserver agreement (kappa 0.61−0.99). The duration of the training program was predetermined and consisted of two sessions, of approximately one hour each, interspersed over the course of four weeks, with practice periods for the observers to do test runs separately. A written manual with well-defined descriptions of the categorical scales' levels was available for the observers during the training and the rating process. Variables were scored for each videolaryngostroboscopic video using the software program Windows Movie Maker version 5.1 (Microsoft Corporation, Redmond, WA). Scores were dichotomous (normal-abnormal) or trichotomous (none-mild-severe; Table 3). Furthermore, the training process comprised two separate rating tasks: independent rating and consensus panel rating of the same randomized videolaryngostroboscopic videos. While the two observers were blinded to each other's ratings during the independent task, the decision on the score was reached in consensus during the panel task, which took place one month later. Differences between the raters during the panel task were solved by discussion using the manual with the well-defined descriptions of the scales' levels. Few deviations

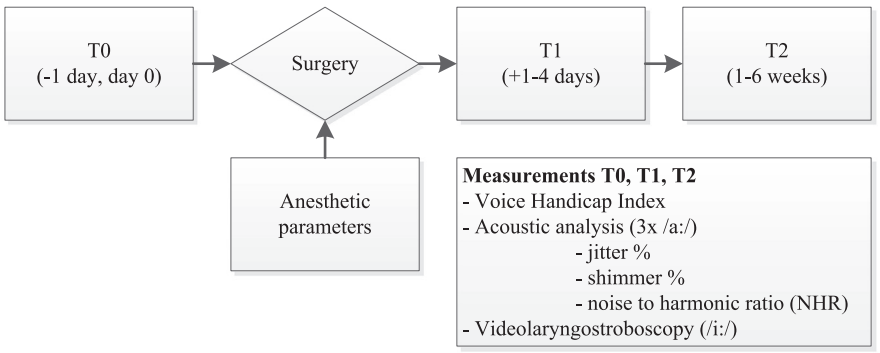

FIGURE 1. Study design.

in the scores of both students were observed during this training period, which consisted of an overestimation of vocal pathology (false positive score in case of variants of "the normal"). Based on the results of this student training program, it was decided to review the abnormally scored videos of the dataset by an expert panel. This method of panel-based consensus assessment including observer agreement levels and the training for this technique were described in previous publications.[25,26] Both pairs of observers were blinded for the patients' identity and medical history, for the technique of airway instrumentation (ETT or SGA), for vocal sound recording, and for the preoperative versus postoperative time point (T0, T1, T2). To determine intrapanel observer agreement of the expert panel, 29% of the videos were rated twice (repeated measurements). These videos were randomly selected and again blinded for the observers. Fatigue-related observer bias was avoided by limiting the judge's rating task to two hours per session. Patients with persistent laryngeal changes following T2 underwent follow-up examination until complete remission.

All participants underwent acoustic voice analysis. Acoustic signals were collected with a computerized Speech Lab Model (4300 (CSL, Kay Elemetrics Corporation, Pine brook, NJ). The speech acoustic signal was transduced with a condenser omnidirectional microphone at a 5 cm mouth-to-microphone distance and 45° mouth-to-microphone angle. The participants were asked to produce three repeated stable phonations of a sustained vowel /a:/ at comfortable pitch and loudness. The relatively stable mid-vowel sections were analyzed using the Multi-Dimensional Voice Program (MDVP, Kay Elemetrics Corporation, Pine Brook, NJ). Three acoustic parameters were measured for each sample: jitter, shimmer, and noise-to-harmonic ratio (NHR). This combination appears to be successful for monitoring voice quality changes over time.[27] The percentage of jitter provides an indication of the variability of the pitch period within the analyzed voice sample. It represents the relative period-to-period variability.[27] The percentage of shimmer gives an indication of the period-to-period variability of the peak-to-peak amplitude.[27] The evaluation of the noise present in the signal is expressed as NHR: the average ratio of energy of the harmonic components in the 1500−4500 Hz range to the harmonic components energy in the 70−4500 Hz range.[27]

Induction and maintenance of general anesthesia

The anesthesia regime was left to the discretion of the anesthesiologist who was blinded to the aim of this study. All patients received standard anesthesia care with insertion of either an ETT or a SGA. NM blocking agents were standard in case of endotracheal intubation. However, standardized NM-monitoring was not carried out. Cuff pressure was measured in all patients. All physicians of the anesthesiology department (n = 40) took part in the study. The type and duration of surgery, drugs administered, type of airway management, patient position, and extubation strategy were reported on a standardized information sheet.[1,2,11,12]

Statistics

Results were expressed as mean (standard deviation [SD]) for quantitative variables while frequencies and proportions (%) were used for categorical variables. Demographic and anesthetic characteristics were compared between the ETT and SGA group using a Student t-test for normally distributed variables and the Wilcoxon signed rank test otherwise. Proportions of outcome variables were compared using the chi-squared test for cross tables.

In the context of statistical dichotomization, the videolaryngostroboscopic ordinal categories "mild" and "severe" of the trichotomous variables vocal fold "redness," "swelling," and "blood vessels" were pooled into one category "abnormal" to improve statistical power. Furthermore, demographic and anesthetic characteristics of the present study population were listed in Table 1. The effect of these demographic and anesthetic characteristics, and type of airway instrumentation (ETT versus SGA) on the change of the videolaryngostroboscopic variables between T0 and T1 was studied using multilevel logistic regression analyses to account for the presence of repeated measurements. In the same way, multilevel linear regression was used to reveal changes in preoperative versus postoperative VHI and acoustic voice scores. Results were considered significant at the 5% critical level ($P < 0.05$). All calculations were performed using SAS (version 9.1 for Windows; SAS Institute, Cary, NC, USA) statistical package. Observer agreement for the repeated measurements of categorical variables was verified using Cohen's kappa coefficient (PASW Statistic 20, SPSS Inc., Hong Kong, China).

A power analysis could not be performed before the start of this study, since only heterogeneous studies on adverse laryngeal effects following short-term elective general anesthesia have been published without any precise information on the prevalence of these adverse effects.[14]

RESULTS

General results

Two hundred eighteen patients were included in the study. One hundred and one patients were lost to follow-up; gagging, or excessive choking despite local oropharyngeal anesthesia was the main reason followed by early hospital discharge and postoperative illness (Figure 2). Subsequently, videolaryngostroboscopic recordings of 117 patients were analyzed at T0 and T1. Only 45 patients underwent measurement T2, making this group too small for further statistical analysis. The acoustic voice analysis of the first 10 patients could not be used due to a technical software problem in the equipment described above.

Patient characteristics

Sixty-seven (57.3%) of the included patients were men. The average age (SD) was 54 (14.3) years. The average BMI (SD) was 26.8 (4.8) kg m^{-2}. The BMI was significantly

TABLE 1.
Demographic and Anesthetic Characteristics of the 117 Patients: Number (%) for Qualitative Variables and Mean (SD) for Quantitative Variables. Demographic and Anesthetic Characteristics were Compared between the ETT and SGA Group Using a Student t-test for Normally Distributed Variables and the Wilcoxon Signed Rank Test Otherwise

		Total $n = 117$	ETT[†] $n = 65$ (55.6)	SGA[‡] $n = 52$ (44.4)	*P* value
Gender	Male	67 (57.3)	37 (56.9)	30 (57.7)	0.930
	Female	50 (42.7)	28 (43.1)	22 (42.3)	
Age (yrs)		54.3 (14.3)	55.2 (15.2)	53.2 (13.2)	0.460
Length (cm)		173.4 (8.8)	172.0 (9.2)	175.2 (7.8)	**0.046**
Weight (kg)		80.5 (16.1)	81.5 (17.6)	79.2 (14.0)	0.450
BMI[§] (kg m^{-2})		26.8 (4.8)	27.5 (5.3)	25.8 (3.9)	**0.039**
Mouth opening (cm)		4.9 (1.0)	4.9 (1.0)	4.8 (0.9)	0.640
Thyromental distance (cm)		6.2 (1.2)	6.3 (1.2)	6.1 (1.1)	0.510
Mallampati score (1–4)	1	71 (61.2)	36 (57.1)	35 (67.3)	0.370
	2	36 (31.0)	21 (33.3)	15 (28.9)	
	3	8 (6.9)	6 (9.5)	2 (3.9)	
	4	0 (0.0)	0 (0.0)	0 (0.0)	
Smoker	No	65 (55.6)	37 (56.9)	28 (53.9)	0.740
	Yes	52 (44.4)	28 (43.1)	24 (46.2)	
	PY[¶]	20.7 (14.2)	9.45 (14.4)	8.87 (13.5)	0.820
Anamnesis of reflux	No	85 (72.7)	46 (70.8)	39 (75.0)	0.610
	Yes	32 (27.4)	19 (29.2)	13 (25.0)	
Antireflux medication	No	16 (50.0)	11 (57.9)	5 (38.5)	0.280
	Yes	16 (50.0)	8 (42.1)	8 (61.5)	
Inhalation medication	No	107 (91.5)	61 (93.9)	46 (88.5)	0.300
	Yes	10 (8.6)	4 (6.2)	6 (11.5)	
Surgical discipline	ENT[††]	16 (13.7)	12 (18.5)	4(7.7)	
	Gynecology	7 (6.0)	6 (9.2)	1 (1.9)	
	Orthopedics	38 (32.5)	23 (35.4)	15 (28.9)	
	Plastic surgery	18 (15.4)	6 (9.2)	12 (23.1)	
	Abdominal surgery	16 (13.7)	8 (12.3)	8 (15.4)	
	Ophthalmology	15 (12.8)	7 (10.8)	8 (15.4)	
	Urology	5 (4.3)	1 (1.5)	4 (7.7)	
	Vascular surgery	2 (1.7)	2 (3.1)	NA[‡‡]	
SGA size	LMA[§§] 4	22(18.8)	NA	22 (42.3)	
	LMA 5	30 (25.6)	NA	30 (57.7)	
ETT size	ETT 6	1 (0.9)	1 (1.5)	NA	
	ETT 7	5 (4.3)	5 (7.7)	NA	
	ETT 7.5	23 (19.7)	23 (35.4)	NA	
	ETT 8	32 (27.4)	32 (49.2)	NA	
	ETT 8.5	4 (3.4)	4 (6.2)	NA	
Patient position	Supine	91 (77.8)	43 (66.2)	48 (92.3)	NA
	Prone	5 (4.3)	5 (7.7)	NA	
	Recovery	20 (17.1)	16 (24.6)	4 (7.7)	
	Chair	1 (0.9)	1 (1.5)	NA	
Anesthesia duration (min)		92.6 (36.2)	99.7 (38.2)	83.6 (31.8)	**0.016**
NM[¶¶] blocking agents	No	43 (36.8)	0 (0.0)	43 (82.7)	<0.0001
	Yes	74 (63.3)	65 (100.0)	9 (17.3)	
Cormack-Lehane score ($n = 60$; 5 missing values)	1	48 (41.0)	48 (80.0)	NA	
	2	9 (7.7)	9 (15.0)	NA	
	3	3 (2.6)	3 (5.0)	NA	
Number of intubation attempts ($n = 62$; 3 missing values)	1	50 (42.7)	50 (80.7)	NA	
	2	11 (9.4)	11 (17.7)	NA	
	3	1 (0.9)	1 (1.6)	NA	

[†] ETT: Endotracheal tube.
[‡] SGA: Supraglottic airway.
[§] BMI: Body mass index.
[¶] PY: Pack year.
[††] ENT: Ear, nose, and throat.
[‡‡] NA: Not applicable.
[§§] LMA: Laryngeal mask airway.
[¶¶] NM: Neuromuscular.

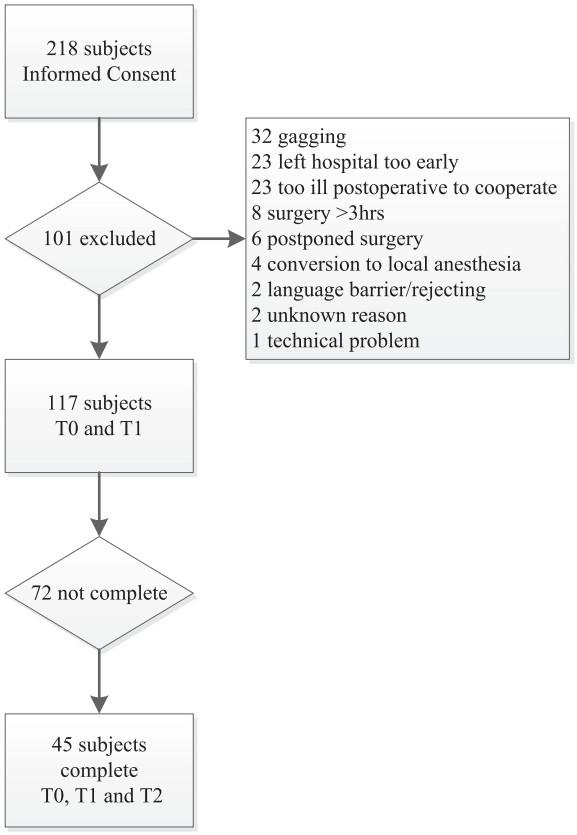

FIGURE 2. Loss to follow-up.

lower in the SGA group (25.8 [3.85] kg m^{-2}) compared with the ETT group (27.5 [5.33] kg m^{-2}) (P = 0.039). Fifty-two (44.4%) patients were active smokers or smoked in the past, with an average (SD) of 20.7 (14.2) pack years. Thirty-two (27.4%) patients reported gastro-esophageal reflux on a regular basis (at least once a month). Half of them (n = 16; 16.5%) used anti-reflux medication. The surgical interventions were carried out by eight different medical disciplines (Table 1).

Anesthetic characteristics

The mean duration (SD) of the general anesthesia was 92.6 (36.2) minutes. In 65 (55.6%) patients an ETT was inserted and in the remaining 52 patients (44.4%) a SGA was placed (Table 1). Twelve ETT patients (19.4%) underwent more than one intubation attempt. These patients had a significantly higher Cormack-Lehane (CL) and Mallampati score compared with patients in the ETT group undergoing just one intubation without repeated attempts (CL-score P = 0.0049; Mallampati score P = 0.017).

Intrapanel observer agreement

Table 2 shows the levels of intrapanel observer agreement of the expert panel with standard error and 95% confidence interval for all videolaryngostroboscopic variables. All levels of agreement were moderate to substantial (Kappa > 0.50−0.80).

Videolaryngostroboscopic results

Table 3 shows outcomes for each of the three components of the standardized voice assessment protocol at baseline (T0) and postsurgery (T1) as a function of airway instrumentation (ETT versus SGA). Few statistically significant changes in videolaryngostroboscopic variables between T0 and T1 were found. The proportion of abnormal right-sided vocal fold redness at T0 was similar for patients in the ETT and SGA group, the pattern changed at T1 with a greater proportion of patients in the ETT group showing abnormal right-sided vocal fold redness than in the SGA group (P = 0.048). However, after adjustment for all demographic and anesthetic characteristics in the multilevel logistic regression model, the effect of the type of airway instrumentation (ETT versus SGA) on right-sided vocal fold redness was no longer significant.

The next and last significant change between T0 versus T1 was found for the variable right-sided vocal fold blood vessels. The postoperative score of this variable decreased significantly (P = 0.043) compared to the baseline score in the ETT and SGA group, independent of the type of airway instrumentation or smoking status.

Other notable findings in the present study were the significantly higher proportions of preoperative and postoperative bilateral vocal fold swelling and blood vessels in smokers compared to nonsmokers independent of the type of airway instrumentation. Furthermore, a significantly higher proportion of normal vocal fold closure was seen in patients not using inhalation medication compared to users again independent of the type of airway instrumentation (P = 0.0043). Finally, left-sided vocal fold redness significantly decreased in smokers at T1 compared to T0 (P = 0.030).

Table 4 shows the clinical diagnosis of vocal pathology derived from reports of the ELS before (T0 vertical) and after (T1 horizontal) airway management for the ETT and SGA group in absolute numbers.

In the ETT group 36 clinical diagnoses were consistent preoperative versus postoperative. Of the initial 36 normal vocal fold observations (T0), eight (22.2%) patients had a clinical diagnosis at T1 of which five (13.9%) had a clinical diagnosis of vocal fold atrophy. This atrophy was not accompanied by significant changes in other variables such as vocal fold closure and defect or vocal fold swelling.

At T1, a normal vocal fold status was observed in four (26.7%) of the 15 patients who initially had a clinical diagnosis at T0. In the SGA group 35 clinical diagnoses were consistent preoperative versus postoperative. Of the initial 36 normal vocal fold observations (T0), three (8.3%) patients had a clinical diagnosis at T1. At T1, a normal vocal fold status was observed in five (55.6%) of the 9 patients who initially had a clinical diagnosis at T0.

Results of the VHI and acoustic voice analysis

The VHI questionnaire was reviewed for possible floor and ceiling effects, noting the number of respondents who

TABLE 2.
Intrapanel Observer Agreement Levels of the Expert Panel for Videolaryngostroboscopic Variables

	n	% Agreement	Kappa[†]	SE[‡]	95% CI[§]
Vocal fold redness R	28	85.7	0.70	0.14	0.40–0.93
Vocal fold redness L	28	82.1	0.61	0.16	0.28–0.89
Vocal fold blood vessels R	27	81.5	0.52	0.18	0.17–0.84
Vocal fold blood vessels L	27	82.1	0.59	0.17	0.20–0.89
Vocal fold swelling R	28	82.1	0.64	0.14	0.36–0.88
Vocal fold swelling L	28	85.7	0.50	0.15	0.22–0.79
Vocal fold closure	23	82.6	0.62	0.17	0.23–0.91

[†] Kappa coefficient.
[‡] SE: Standard error.
[§] CI: Confidence interval.
<0 less than chance agreement.
0.01–0.20 slight agreement.
0.21– 0.40 fair agreement.
0.41–0.60 moderate agreement.
0.61–0.80 substantial agreement.
0.81–0.99 almost perfect agreement.

obtained the lowest or highest possible scores. The floor effect was significant because 36.8% (n = 43 out of 117) of the respondents got the lowest possible score for the VHI-T at T0 and 37.1% (n = 43 out of 116) at T1. Only 22.2% (n = 26) of the patients at T0 versus 19% (n = 22) at T1 scored 10 or more points on the VHI-T, indicating a pathologic VHI score (cut-off score of 10).[28,29] The threshold values of the measured acoustic voice variables were ≤1.040% for jitter, ≤3.810% for shimmer, and ≤0.190 for the NHR (Table 3).

Multilevel linear regression did not reveal any significant preoperative versus postoperative differences for the VHI-T and subscale scores, nor for the measured acoustic voice outcome scores in either groups (ETT versus SGA). Therefore, only the VHI-T scores were presented (Table 3).

Despite the fact that for the SGA group the mean (SD) T0 value for shimmer was higher than the threshold value (4.3% [3.4]) and that the NHR score decreased at T1, multilevel linear regression did not reveal any significant differences between the preoperative versus postoperative measured acoustic voice outcome scores in both groups (ETT versus SGA).

DISCUSSION

This is the first and largest prospective study that systematically investigated the prevalence of laryngeal changes following short-term routine anesthesia using an ETT or SGA in adults and using high quality validated assessment tools. Laryngeal changes following prolonged intubation have been described in the literature, but the prevalence of laryngeal changes due to short-term airway instrumentation remained unclear because of poor methodological quality of previous studies and heterogeneity in the design of these studies.[26]

All patients in the current study underwent short-term airway instrumentation in the same hospital. The use of strict and clearly defined inclusion and exclusion criteria monitors the external validity of the current target sample. Moreover, the sample size consisted of 117 patients whose demographics are seen in the larger population. For example, the average BMI of the study population was 26.8 kg m^{-2} which is similar to the average BMI of 26.2 kg m^{-2} for Dutch men and 25.3 kg m^{-2} for women.[30] Finally, by using a large number of anesthesiologists, possible therapist effects on group performance or treatment outcome were minimized.

In the present study, a multidimensional validated voice assessment protocol was applied to capture different aspects of the vocal function as recommended by the Phonosurgery Committee of the ELS. In addition to vocal fold imaging and patient self-assessment of voice, the analysis of vocal sound production is an indispensable dimension of the voice assessment protocol.

The prevalence of laryngeal changes between T1 and T0 using videolaryngostroboscopic variables was very low. Previous studies described higher prevalence values for dysphonia and vocal fold problems following short-term airway instrumentation. For example, Böttcher and colleagues reported vocal fold lesions in 30.2 % (n = 16) of their participants following short-term intubation.[31] Similar findings were described by Mencke and colleagues with a frequency of 27% (n = 14) vocal fold problems in their study population.[32] Several other studies found a prevalence of vocal fold injuries ranging from 14.5% to 50%.[14] However, these studies were small and frequently showing diverse methodological shortcomings. The requirements to obtain reliable study results are among others blinding of the observers combined with consensus training for the visuoperceptual variables applied and independent scoring to determine observer agreement levels. The three studies of Mencke and colleagues did not apply blinding of observers and reliability analysis, as only one observer scored the videolaryngostroboscopic videos.[2,12,14,30] The same methodological observation was done for the study

TABLE 3.
Descriptive Statistics of the Baseline Data (T0) and the Postsurgical Data (T1) for Videolaryngostroboscopy, the VHI Questionnaire, Acoustic Voice Analysis, the Number of Patients per Airway Management Group, and the Level of Significance of the Difference between Postsurgical Data (T1) Compared to Baseline Data (T0) for the Patients in the ETT and SGA Group

			Before Intubation T0		After Intubation T1					
Variable	Type of Airway Management	*n*	None *n* (%)	Mild + severe *n* (%)	None *n* (%)	Mild + severe *n* (%)	Worse	Better	Predictors to Laryngeal Changes	*P* Value
Videolaryngostroboscopic variables										
Vocal fold redness R	ETT[†]	53	44 (83.0)	9 (17.0)	38 (71.7)	15 (28.3)	9	3	Increase redness R in ETT at T1	0.048
	SGA[‡]	45	36 (80.0)	9 (20.0)	38 (84.4)	7 (15.6)	2	4		
Vocal fold redness L	ETT	53	43 (81.1)	10 (18.9)	40 (75.5)	13 (24.5)	8	5	Decrease redness L in smokers at T1	0.030
	SGA	45	36 (80.0)	9 (20.0)	39 (86.7)	6 (13.3)	1	4		
Vocal fold swelling R	ETT	53	47 (88.7)	6 (11.3)	42 (79.3)	11 (20.8)	6	1	Overall higher proportion swelling R in smokers at T0 and T1	0.0003
	SGA	45	40 (88.9)	5 (11.1)	41 (91.1)	4 (8.9)	2	3		
Vocal fold swelling L	ETT	53	48 (90.6)	5 (9.4)	45 (84.9)	8 (15.1)	3	0	Overall higher proportion swelling L in smokers at T0 and T1	0.0018
	SGA	45	40 (88.9)	5 (11.1)	40 (88.9)	5 (11.1)	2	2		
Vocal fold blood vessels R	ETT	52	40 (76.9)	12 (23.1)	44 (84.6)	8 (15.4)	2	6	(1) Overall higher proportion vessels R in smokers at T0 and T1 (2) Decrease vessels R in smokers and nonsmokers at T1	(1) .0003 (2) 0.043
	SGA	45	35 (77.8)	10 (22.2)	38 (34.4)	7 (15.6)	1	4		
Vocal fold blood vessels L	ETT	52	41 (78.9)	11 (21.2)	43 (82.7)	9 (17.3)	4	6	Overall higher proportion vessels L in smokers at T0 and T1	0.0003
	SGA	45	36 (80.0)	9 (20.0)	39 (86.7)	6 (13.3)	0	3		
			Normal	*Defect*	*Normal*	*Defect*				
Vocal fold closure and Defect	ETT	50	25 (50.0)	25 (50.0)	14 (28.0)	36 (72.0)	13	2	Overall higher proportion normal closure in group without inhalation medication than in group with inhalation medication at T0 and T1	0.0043
	SGA	45	19 (42.2)	26 (57.8)	23 (51.1)	22 (48.9)	5	9		
Redness arytenoid	ETT	18	16 (88.9)	2 (11.1)	11 (61.1)	7 (38.9)	5	0	Increase redness arytenoid in ETT at T1	0.011
	SGA	8	8 (100)	0	8 (100)	0	0	0		
VHI[i] scores			*Before intubation T0 Mean (SD) Median*		*After intubation T1 Mean (SD) Median*		*Change Mean (SD) Median*			
VHI total	ETT	65	6.2 (9.8) 2.0		7.9 (13.9) 2.0		1.7 (8.6) 0.0		None	0.049
	SGA	52	6.9 (12.0) 2.0		6.1 (12.6) 2.0		−0.84 (3.7) 0.0			

(*Continued*)

TABLE 3. (*Continued*)

Variable	Type of Airway Management	*n*	Before Intubation T0		After Intubation T1		Predictors to Laryngeal Changes			*P* Value
			None *n* (%)	Mild + severe *n* (%)	None *n* (%)	Mild + severe *n* (%)	Worse	Better		
Acoustic voice variables			*Before intubation T0 Mean (SD) Median*		*After intubation T1 Mean (SD) Median*		*Change Mean (SD) Median*			
Jitter (norm ≤ 1.040%)	ETT	57	0.90 (0.66) 0.6		0.9 (0.74) 0.7		0.1 (0.86) 0.0		None	
	SGA	45	1.2 (1.82) 1.0		1.2 (1.87) 0.7		0.0 (0.57) −0.1			
Shimmer (norm ≤ 3.810%)	ETT	57	3.5 (2.1) 3.1		3.8 (2.3) 3.1		0.2 (1.94) −0.1		None	
	SGA	45	4.3 (3.4) 3.7		4.2 (2.2) 2.9		−0.1 (2.52) 0.0			
NHR[¶] (norm ≤0.190)	ETT	57	0.131 (0.017) 0.129		0.134 (0.026) 0.131		0.003 (0.024) 0.002		Decrease NHR in SGA at T1	0.042
	SGA	45	0.147 (0.092) 0.136		0.138 (0.066) 0.127		−0.010 (0.037) −0.010			

† ETT: Endotracheal tube.
‡ SGA: Supraglottic airway.
§ VHI: Voice Handicap Index.
¶ NHR: Noise-to-harmonic ratio.
R: Right-sided; L: Left-sided.

of Beckford and colleagues not providing any information on the videolaryngostroboscopic assessment protocol making it impossible to repeat the study.[33] Another methodological issue in previous studies on this topic were small sample sizes such as in the study of Lesser and Lesser just including six patients.[34]

In the present study, changes to some videolaryngostroboscopic outcomes were observed. Specifically, the score of the variable right-sided vocal fold redness was significantly increased following general anesthesia in the ETT group but the same pattern was not seen with the patients in the SGA group ($P = 0.048$). However, after adjustment for all demographic and anesthetic characteristics in the regression model, the type of airway instrumentation was no longer significant. Counter-intuitive was the finding of decreased right-sided vocal fold blood vessels following general anesthesia (T1 versus T0; $P = 0.043$) independent of the type of airway instrumentation. A decreased score on that variable following general anesthesia with an ETT carried out by a population of anesthesiologists who are usually right-handed, can be expected as a result of local contact between the ETT and the right vocal fold compressing the blood vessels. However, a decreased score on this same variable following SGA placement is more difficult to explain as there is no contact with the vocal folds during SGA airway instrumentation.

In addition to an instrumental assessment of the voice, attention was also paid to the patient's perception of his/her own voice. Because of "no vocal fold contact," we expected an advantage of SGA insertion compared to ETT on VHI and acoustic voice analysis outcomes. However, robust multilevel linear regression did not reveal any significant differences between the preoperative and postoperative (T0 versus T1) scores of the VHI-T and of the measured acoustic voice outcome variables in either group (ETT versus SGA). The latter results compare with two previous small studies ($n = 35$ and 10 patients) examining short-term airway instrumentation using ETT; there too none of the acoustic voice variables were associated with ETT-related parameters.[16,33]

Currently, the VHI is one of the most reliable self-report tools to assess voice-related QoL.[35,36] Originally the Dutch version of the VHI was validated for mixed etiologies of dysphonia.[28] This validated tool uses a cut-off point to determine the relevant impact of dysphonia on the health-related QoL. The current patient population had a very low prevalence of voice complaints at T0, reflecting a VHI-T floor effect. However, no significant increase in VHI-T score was observed at T1 for the total group (ETT and SGA) showing that patients did not experience any adverse effects from short-term airway instrumentation.

Limitations

A significant number of patients was lost to follow-up after completing the written informed consent.

However, a sample size of 117 patients was believed to be sufficient to reveal laryngeal changes between T0 versus T1

TABLE 4.
Clinical Diagnosis of Vocal Pathology Derived from Reports of the Phonosurgery Committee of the European Laryngological Society (ELS) Before (T0 Vertical) and After (T1 Horizontal) Airway Management for the ETT[†] and SGA[‡] Group in Absolute Numbers

			After Intubation T1							
	ETT Group	Total	Normal	Reinke[§] 1	Reinke 3	Atrophy	Granuloma	Nodules	Consistent Diagnosis	Change
Before intubation T0	Normal	36		1		5	2		28	8
	Reinke 2	3			1				2	1
	Cyst R	1						1		1
	Hematoma	2	1						1	1
	Atrophy	3	2						1	2
	Granuloma	1							1	0
	Laryngitis	1	1							1
	Nodules	1							1	0
	Cyst L	1					1			1
	Laryngitis Sicca	1							1	0
	Leukoplakia	1							1	0
	Total	51	4	1	1	5	3	1	36	15

			After Intubation T1						
	SGA Group	Total	Normal	Reinke 2	Polyp R	Atrophy	Laryngitis	Consistent Diagnosis	Change
Before intubation T0	Normal	36		1		1	1	33	3
	Reinke 1	2	2						2
	Reinke 2	1					1		1
	Cyst R	2	1		1				2
	Atrophy	2	2						2
	Laryngitis	1						1	0
	Cyst L	1						1	0
	Total	45	5	1	1	1	2	35	10

[†] ETT: Endotracheal tube.
[‡] SGA: Supraglottic airway.
[§] Reinke: Reinke space edema grade 1, 2, and 3.
R: Right-sided; L: Left-sided.

following short-term anesthesia. The majority of the patients cancelled the measurements at T2 because they did not experience any vocal or laryngeal complaints. It remains difficult to motivate participants to return to the hospital for follow-up measurements in the context of scientific research if they do not experience any complaints.

CONCLUSION

ETT and SGA short-term airway instrumentation are vocal fold function sparing techniques with negligible laryngeal changes.

AUTHORS' CONTRIBUTIONS

Study design/planning: J.W.B., A.H., B.K., L.B.

Study conduct/Data analysis: J.W.B., S.V., A.H., S.B., G. Z., L.B.

Writing paper: J.W.B., S.V., A.H., S.B., G.Z., L.B.

Revising paper: all authors.

DECLARATION OF INTEREST

A.E.W. Hamaekers was a member of the medical advisory board of Ambu and has received free samples of airway equipment for teaching and clinical evaluation from several companies. She has no financial interest in any company.

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J.W. Brunings is independent of any commercial funder, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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