Adverse Laryngeal Effects Following Short-term General Anesthesia

A Systematic Review

Elodie J. Mendels, MD; Jan W. Brunings, MD; Ankie E. W. Hamakers, MD; Robert J. Stokroos, MD, PhD; Bernd Kremer, MD, PhD; Laura W. J. Baijens, MD

Objective: To conduct a systematic review to determine the occurrence and type of vocal cord injury, as well as the occurrence of hoarseness, in adults using an endotracheal tube or laryngeal mask during routine anesthetic care.

Data Sources: Two reviewers independently performed a literature search using PubMed, EMBASE, and Cochrane Central Register of Controlled Trials. The search was limited to articles published in English, German, French, or Dutch. In addition, reference lists of the included articles were searched manually.

Data Extraction: Studies describing vocal cord injury and/or hoarseness following short-term general anesthesia (<5 hours) using an endotracheal tube or any type of laryngeal mask were included. To obtain a reliable outcome regarding the occurrence of anesthesia-related laryngeal morbidity, only studies reporting both preoperative and postoperative measurements of vocal cord function were included.

Data Synthesis: A total of 4119 articles were identified; of these, 13 studies met the inclusion criteria. The studies were found to be heterogeneous and hardly comparable. Hoarseness and vocal cord injuries were common findings in most investigations.

Conclusions: Hoarseness and vocal cord injuries are clinically relevant complications related to short-term general anesthesia using an endotracheal tube or laryngeal mask. However, more well-designed prospective studies are necessary to generate reliable data as well as to investigate techniques to reduce adverse laryngeal effects. For future research, a proposal to categorize the vocal cord lesions due to general anesthesia is presented. Furthermore, use of a preoperative and postoperative standardized measurement protocol using acoustic analysis and the Voice Handicap Index is advised.


Each year, millions of patients undergo instrumentation/manipulation of the airway as part of routine anesthetic care. Although both endotracheal intubation and the use of a laryngeal mask (LM) are associated with postoperative laryngeal morbidity, the incidence of hoarseness and vocal cord injuries is not clear.1

Vocal cord injuries due to prolonged or difficult intubation are well known.2,4 However, thorough knowledge of the occurrence as well as the type of injury related to short-term general anesthesia using an endotracheal tube (ET) or LM is needed to develop techniques for reducing the risk of adverse laryngeal effects and provide improved patient care. According to anesthesia-related claims in a closed claims database,2 7% of all claims are related to airway injury. The most frequent site of injury is the larynx, with the most common lesions being vocal cord paralysis, hematomas and granulomas (severe vocal cord lesions usually seen after prolonged intubation) of the vocal cords, and arytenoid luxation.6 These injuries may result in severe, prolonged laryngeal dysfunction.7,13

Postoperative hoarseness, an important clinical sign of laryngeal injury or dysfunction, can be distressing to a patient.8,12 It may have a negative effect on the patients’ degree of satisfaction, as well as on their level of activity after hospital discharge.14 However, patients usually consult an otorhinolaryngologist only if postoperative hoarseness persists for a longer time (eg, 6 weeks), since it is considered to be a typical effect of general anesthesia and is expected to recover spontaneously.13

The primary aim of this article is to systematically review all published studies on the occurrence of vocal cord injuries and hoarseness in adults following short-term anesthetic care. The types of injury are also described.
Table 1. Medical Subject Heading (MeSH) Terms

<table>
<thead>
<tr>
<th>MeSH Terms Used</th>
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<tbody>
<tr>
<td>Intubation, intratracheal</td>
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<tr>
<td>Laryngeal masks</td>
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<tr>
<td>Laryngeal diseases</td>
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<td>Granuloma, laryngeal</td>
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<td>Laryngeal edema</td>
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<td>Laryngeal neoplasms</td>
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<tr>
<td>Laryngism</td>
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<tr>
<td>Laryngitis (croup)</td>
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<td>Laryngomalacia</td>
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<td>Laryngostenosis</td>
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<tr>
<td>Tuberculosis, laryngeal</td>
</tr>
<tr>
<td>Vocal cord paralysis</td>
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<tr>
<td>Voice disorders (aphonia, dysphonia, hoarseness)</td>
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<td>Voice</td>
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<td>Voice quality</td>
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<td>Speech</td>
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<tr>
<td>Speech acoustics</td>
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<td>Speech intelligibility</td>
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<td>Phonation</td>
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<td>Glottis</td>
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<td>Vocal cord</td>
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Table 2. Inclusion and Exclusion Criteria

<table>
<thead>
<tr>
<th>Type of Criteria</th>
<th>Items</th>
</tr>
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<tbody>
<tr>
<td>Inclusion</td>
<td>Studies describing vocal cord injuries and/or hoarseness following short-term general anesthesia using an endotracheal tube or any type of laryngeal mask</td>
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<tr>
<td></td>
<td>Short-term, defined as &lt; 5 h</td>
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<td></td>
<td>Studies reporting both preoperative and postoperative measurements of vocal cord function</td>
</tr>
<tr>
<td>Exclusion</td>
<td>Data from children aged ≤ 18 y</td>
</tr>
<tr>
<td></td>
<td>Studies describing emergency intubation and rapid sequence induction</td>
</tr>
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<td></td>
<td>Studies including critically ill patients, patients with morbid obesity, or a history of disorders or operations in the neck, larynx, or airway</td>
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Table 2. Classification of Level of Evidencea

<table>
<thead>
<tr>
<th>Category</th>
<th>Evidence</th>
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</thead>
<tbody>
<tr>
<td>A1</td>
<td>Meta-analysis containing at least some trials of level A2 and of which the results of individual trials are consistent</td>
</tr>
<tr>
<td>A2</td>
<td>Randomized comparative clinical trials of good quality (randomized, double-blind controlled trials) of sufficient size and consistency</td>
</tr>
<tr>
<td>B</td>
<td>Randomized controlled trials of moderate (weak) quality or insufficient size or other comparative trials (nonrandomized, cohort studies, patient-control studies)</td>
</tr>
<tr>
<td>C</td>
<td>Noncomparative trials</td>
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<tr>
<td>D</td>
<td>Expert opinion</td>
</tr>
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</table>

Notes: aTranslated from the Dutch EBRO guideline (Evidence-Based Richtlijn Ontwikkeling [Guideline Development]).

METHODS

SEARCH STRATEGY

We performed a literature search using PubMed, the Cochrane Central Register of Controlled Trials, and EMBASE. The search was restricted to reports that were published in English, German, French, or Dutch until November 30, 2010. In PubMed, the Medical Subject Heading (MeSH) term intubation, intratracheal was combined with the MeSH terms laryngeal diseases or voice or speech or phonation or glottis. More detailed information on the MeSH terms is reported in Table 1.

The same search was used in the Cochrane Central Register of Controlled Trials. In EMBASE, the thesaurus terms endotracheal intubation or endotracheal tube or laryngeal mask were combined with voice or dysphonia or hoarseness or larynx disorder or phonation or glottis or vocal cord or voice change. To identify the most recent publications, the search was expanded by using free-text words (truncation or wildcard) voice* or vocal* combined with intub* in PubMed from November 17, 2008, until November 30, 2010. The reference lists of all included articles were searched for additional literature. Inclusion and exclusion criteria were defined before the systematic search (Table 2).

DATA COLLECTION AND ANALYSIS

Two reviewers (E.J.M. and J.W.B.) independently based their first selection on titles and abstracts. Differences in their findings were settled by discussion. Duplicate articles from the databases were excluded manually. The original articles were used to make the definitive decision on inclusion and were independently assessed by the 2 reviewers. Only vocal cord injuries and postoperative hoarseness as outcomes were extracted for analysis.

To determine the level of evidence of the included articles, the Dutch EBRO (Evidence-Based Richtlijn Ontwikkeling [Guideline Development]) guideline was used (Table 3).16 Level D articles presenting an expert opinion were excluded from this review.

The intention was to assess the quality of the randomized controlled trials on the basis of the methods, applied statistics, and conclusions of the authors, using the method described by Schulz et al17 in 1995. To assess the quality of the observational studies, the Dutch EBRO guideline was used.18

RESULTS

A total of 5079 articles were found: 2051 in PubMed, 2751 in EMBASE, 154 in the Cochrane Central Register of Controlled Trials, and 123 in PubMed using free-text words. Because of overlap, 960 articles were excluded, leaving 4119. Of these, 4037 articles were excluded when review of the title and abstract showed that they did not meet the inclusion criteria. Thirteen of 82 full-text articles met the inclusion criteria (Figure); review of the reference lists identified no additional eligible articles. The details of the included studies are described in Table 4.15,18-20

GENERAL RESULTS

Of the 13 included articles, 3 were considered to meet the criteria of level A2,18-20 4 of level B,21-24 and 6 of level C15,25-29 (Table 4). Two studies22,24 examined vocal cord injuries as well as hoarseness. Six studies16,19,23,25,26,29 examined vocal cord injuries, of which 226,29 investigated...
only vocal cord paralysis. Five studies 15,20,21,27,28 examined postoperative hoarseness. All studies included ET intubation; 21,22 also included LM insertion compared with ET intubation. The mean duration of intubation ranged from 65 to 195.5 minutes. The number of patients in the studies ranged from 6 to 235. All investigations (from 1976 to 2010) used descriptive statistics and several used statistical analysis to evaluate their results.

MEASUREMENT TOOLS

All studies used various measurement tools and outcome assessments (Table 4). For the measurement of vocal cord injury, laryngoscopy or videolaryngostroboscopy was used. For the measurement of hoarseness, various instruments were applied, including several subjective interviews, acoustic analysis, and audioperceptual analysis in voice recordings. The timing of postoperative follow-up measurements varied from once immediately after the operation to 6 months postoperatively.

OCCURRENCE OF POSTOPERATIVE VOCAL CORD INJURIES AND HOARSENESS

Postoperative vocal cord injuries and hoarseness were common in most studies using the ET. Vocal cord injuries ranged from none of 6 participants to 69 of 100 participants. Hoarseness ranged from 4 of 10 participants immediately after the operation to 54 of 167 patients within the first postoperative week.

In one study 22 using the LM, 1 participant of 21 was diagnosed as having vocal cord injury and 1 participant of 28 reported hoarseness. In the study of Hamdan et al., 21 hoarseness after use of the LM was also reported.

In all investigations, the number of participants having hoarseness or vocal cord injuries decreased after the first postoperative measurement. Not all studies described a follow-up until total resolution of hoarseness or vocal cord injuries had occurred. In the studies of Friedric h et al. 26 and Mencke et al., 18 both using an ET, persistent vocal cord injuries were described as varying from 1 week to 6 months. Jones et al. 28 reported on 5 participants with persistent hoarseness up to 99 days following the use of an ET. With use of laryngoscopy, vocal cord injuries were diagnosed in these patients. In Table 5 and Table 6, The included studies are summarized regarding available data on the occurrence and time of evaluation of vocal cord injuries and hoarseness.

TYPE OF INJURY

Seven studies 18,19,22,24-26,29 described the type of vocal cord injuries. The most frequent types of injuries were hematoma and thickening of the mucosa with edema, equally located bilaterally and unilaterally (left more than right). In 5 patients, granulomas were seen (Table 5).

COMMENT

The present systematic review aimed to evaluate the occurrence and type of vocal cord injury as well as the occurrence of hoarseness after short-term general anesthesia using an ET or an LM in adults. The systematic search generated a large number of articles on the occurrence of vocal cord injuries and/or hoarseness; however, few measured both hoarseness and vocal cord injuries preoperatively and postoperatively. Preoperative and postoperative assessments are necessary to measure the effects of ET or LM on vocal cord function and morphology.

It may be concluded that vocal cord injuries as well as hoarseness were common after short-term general anesthesia using an ET in most studies (Tables 5 and 6). Even vocal cord injuries following LM insertion were reported, 22 although the LM does not traverse the vocal cords. Furthermore, 5 patients from different studies were reported to have granulomas. In addition, persistent hoarseness was reported in several studies up to 6 months after routine short-term anesthetic care. However, the results of the included studies vary widely. Because of heterogeneous designs, such as different measurement tools, outcome variables, and postoperative measurement times, the included studies can hardly be compared with each other. Other methodologic shortcomings include, for example, the absence of a control group to identify confounders, 15,21,23,25-27,29 selection bias, 15,21,23,27 and loss to follow-up 21-24,27; these limitations result in weak overall conclusions.

TIMES OF MEASUREMENT

To evaluate and compare the results of studies examining vocal cord injuries and/or hoarseness, it is important to know the time of the postoperative measurement. If more time elapses between the end of anesthesia and the first measurement, more factors will interfere and affect the results. Six studies 18,22,27 used standardized times of postoperative measurement. Eight studies 18,22,24,27,29 performed the first postoperative measurement within 1 day. One author 23 did not report any information or included incom-
plete information on the time of postoperative measurement. A wide range of times of postoperative measurement, for example, within 1 to 5 days, 25 4 to 9 days, 26 and within 1 week 28 was observed in several studies, resulting in less-standardized study conditions.

MEASUREMENT TOOLS AND OUTCOME VARIABLES

Laryngoscopy is a routine procedure to examine the vocal cords. 22 Furthermore, videolaryngostroboscopy is a well-established technique that is used extensively for the analysis of vocal cords and voice disorders using visuo-perceptual outcome variables. It is able to reveal a number of abnormalities. 29-34 All studies examining the vocal cords used these universally accepted instruments. However, the definition of vocal cord injury was not uniform 18,19,25,26,29 and the classification of the type of injury varied 18,19,25,26,29. For example, one study 23 did not describe a classification and another 25 divided the vocal cord injuries into 5 subgroups (no, little, mild, moderate, and severe) as a result of a sum of points given to different types of vocal cord injuries. Furthermore, several studies reported whether lesions were present 22,24,29 or used classifications varying in detail concerning the type and location of the lesions. 18,19,28 Therefore, uniform nomenclature for vocal cord injury is necessary to compare the outcomes of future studies.

A classification can be made according to the impairment of the vibratory movement of the vocal cord and movement disorders of the vocal cords as suggested by the Phonosurgery Committee of the European Laryngological Society. 35 A revision in classification of lesions due to ET or LM insertion in general anesthesia is proposed (Table 7).

To evaluate hoarseness, several measurements are available. 36 Even though in many studies audioperceptual evaluation is considered the criterion standard for voice evaluation, it is a less reliable assessment technique because of its subjective nature. Audioperceptual evaluation involves problems such as the unstable internal standards for comparing speech stimuli and the lack of universally accepted definitions for perceptual concepts. 37 Because of this, some scope for subjectivity is left

<table>
<thead>
<tr>
<th>Source</th>
<th>Level of Evidence</th>
<th>Measurement Tools</th>
<th>Outcome Variables</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mencke et al,18 2003</td>
<td>A</td>
<td>VCI: videolaryngostroboscopy</td>
<td>VCI: location and type of injury</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Mencke et al,19 2006</td>
<td>A</td>
<td>VCI: videolaryngostroboscopy</td>
<td>VCI: location and type of injury</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Jaensson et al,20 2010</td>
<td>A</td>
<td>H: interview hoarseness</td>
<td>H: binary scale: yes/no</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Hamdan et al,21 2008</td>
<td>B</td>
<td>H: patient questionnaire of laryngopharyngeal discomfort</td>
<td>H: binary scale: yes/no</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Zimmert et al,22 1999</td>
<td>B</td>
<td>VCI: videoendoscopy, videolaryngostroboscopy</td>
<td>VCI: binary scale: yes/no, changes in vocal cord function</td>
<td>Descriptive</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H: preoperatively, audioperceptual analysis; postoperatively, interview hoarseness</td>
<td>H: preoperatively, irregular voice variables; postoperatively, “How do you do?” and specific questions concerning hoarseness (not further mentioned)</td>
<td></td>
</tr>
<tr>
<td>Lesser and Lesser,23 1987</td>
<td>B</td>
<td>VCI: laryngoscopy</td>
<td>NR</td>
<td>Descriptive</td>
</tr>
<tr>
<td>Beckford et al,24 1990</td>
<td>B</td>
<td>VCI: laryngoscopy, videostroboscopy</td>
<td>VCI: binary scale: yes/no</td>
<td>Descriptive</td>
</tr>
<tr>
<td>Chilla et al,25 1976</td>
<td>C</td>
<td>VCI: laryngoscopy</td>
<td>VCI: 5 subgroups (no, little, mild, moderate, severe) as a result of a sum of points given to different types of vocal cord injuries</td>
<td>Descriptive</td>
</tr>
<tr>
<td>Friedrich et al,26 2000</td>
<td>C</td>
<td>VCI: laryngoscopy</td>
<td>VCI: presence of movement and morphologic characteristics</td>
<td>Descriptive</td>
</tr>
<tr>
<td>Hamdan et al,27 2007</td>
<td>C</td>
<td>H: patient questionnaire of laryngopharyngeal discomfort</td>
<td>H: binary scale: yes/no</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Jones et al,28 1992</td>
<td>C</td>
<td>H: preoperatively and postoperatively, audioperceptual analysis; postoperatively, interview hoarseness</td>
<td>H: relating a visual analog scale for hoarseness of voice recording (assessed by speech analyst) to subjective assessment of hoarseness (assessed by patient)</td>
<td>Descriptive</td>
</tr>
<tr>
<td>Waits et al,29 1980</td>
<td>C</td>
<td>VCI: laryngoscopy</td>
<td>VCI: presence of paresis or paralysis</td>
<td>Descriptive and statistical analysis</td>
</tr>
<tr>
<td>Lesser and Williams,15 1988</td>
<td>C</td>
<td>H: acoustic analysis and interview hoarseness</td>
<td>H: relating fundamental frequency to a subjective assessment (asking patients how their voice had felt during reading, and marking responses this on a 10-cm linear analog scale)</td>
<td>Descriptive</td>
</tr>
</tbody>
</table>

Abbreviations: GRBAS, Grade, Roughness, Breathiness, Asthenia, Strain; H, hoarseness; NR, not reported; VCI, vocal cord injury.
Table 5. Characteristics, Occurrence, and Investigators’ Conclusions per Study Regarding VCIs

<table>
<thead>
<tr>
<th>Source</th>
<th>Patients Examined Postoperatively, n</th>
<th>Time of Postoperative Measurement</th>
<th>Mean Duration (Range) of Intubation, min</th>
<th>VCI Preoperatively, No.</th>
<th>VCI Postoperatively, No. (%)</th>
<th>Type of VCI, No.</th>
<th>Investigators’ Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mencke et al.,19 2003</td>
<td>G1: 37b</td>
<td>1. 24 h</td>
<td>Duration of operation</td>
<td>G1: 70.5 (20-195)</td>
<td>1. 3 (8.1)</td>
<td>Hematomas, 11; thickening, 9; granulomas, 2</td>
<td>Quality of tracheal intubation may have affected the incidence of laryngeal morbidity</td>
</tr>
<tr>
<td></td>
<td>G2: 38b</td>
<td>2. 72 h</td>
<td></td>
<td>G2: 65 (10-300)</td>
<td>2. 1 (2.7)</td>
<td></td>
<td>Adding atracurium improved the quality of intubation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. &gt;72 h</td>
<td></td>
<td></td>
<td>3. 0</td>
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<td></td>
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<tr>
<td>Mencke et al.,19 2006</td>
<td>G1: 27c</td>
<td>1. 24 h</td>
<td>Duration of operation</td>
<td>G1: 133 (35)</td>
<td>1. 5 (18.5)</td>
<td>Hematomas, 4; thickening, 13</td>
<td>Preoperative monitoring improved intubating conditions</td>
</tr>
<tr>
<td></td>
<td>G2: 25c</td>
<td>2. 72 h</td>
<td></td>
<td>G2: 146 (45)</td>
<td>2. 1 (3.7)</td>
<td></td>
<td>No decrease of VCI in regard to injection of atracurium at maximum neuromuscular block</td>
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<tr>
<td></td>
<td></td>
<td>3. &gt;72 h</td>
<td></td>
<td></td>
<td>3. 0</td>
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<tr>
<td>Zimmert et al.,22 1999</td>
<td>G1: 22d</td>
<td>NR</td>
<td>Duration of operation</td>
<td>G1: 87 (35-140)</td>
<td>G1: 6 (27.3)</td>
<td>G1: 2 Hematomas, 2; hyperemia, 1; supraglottic hematomas, 1; subglottic hematomas, 2</td>
<td>Lower incidence of laryngeal sequelae and fewer reports of laryngeal disorder</td>
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<tr>
<td>Lesser and Lesser,23 1987</td>
<td>6</td>
<td>NR</td>
<td>Duration of operation</td>
<td>78.3 (25-195)</td>
<td>0</td>
<td>0</td>
<td>Temporary harshness in speech following intubation was directly related to length of intubation and not to act of intubation</td>
</tr>
<tr>
<td>Beckford et al.,24 1990</td>
<td>9</td>
<td>Immediately after surgery</td>
<td>Duration of operation</td>
<td>66</td>
<td>0</td>
<td>1</td>
<td>Laryngoscopy did not demonstrate consistent changes in glottic mucosal function</td>
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<td></td>
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<td></td>
<td></td>
<td>Postoperative complications were dependent on intubation time, age, sex, and tube size</td>
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<tr>
<td>Chilla et al.,25 1976</td>
<td>100</td>
<td>1-5 d</td>
<td>Duration of operation</td>
<td>100</td>
<td>69</td>
<td>Not clear; intubation complications divided into 5 groups, from none to severe; VCI: 26 little, 24 mild, 19 moderate Hematomas, 3; edema, 7; granulomas, 3; hyperemia, 7; paralysis, 3</td>
<td>Experience of the anesthesiologist and difficulty and duration of intubation were not related directly to recurrent nerve palsy</td>
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<td></td>
<td>Although soft-tissue trauma detected, no patient had evidence of vocal cord paralysis</td>
</tr>
<tr>
<td>Friedrich et al.,20 2000</td>
<td>206</td>
<td>1. 4-9 d</td>
<td>Duration of operation</td>
<td>145 (50-420)</td>
<td>13</td>
<td>13 (5.6)</td>
<td>Experience of the anesthesiologist and difficulty and duration of intubation were not related directly to recurrent nerve palsy</td>
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<tr>
<td></td>
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<td>2. 2 wk</td>
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<td></td>
<td>Although soft-tissue trauma detected, no patient had evidence of vocal cord paralysis</td>
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<td></td>
<td></td>
<td>3. 6 mo</td>
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</tr>
<tr>
<td>Waits et al.,28 1980</td>
<td>100</td>
<td>&lt;2 h</td>
<td>Duration of operation</td>
<td>156 (25-430)</td>
<td>0</td>
<td>0</td>
<td>Experience of the anesthesiologist and difficulty and duration of intubation were not related directly to recurrent nerve palsy</td>
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<td></td>
<td></td>
<td></td>
<td>Although soft-tissue trauma detected, no patient had evidence of vocal cord paralysis</td>
</tr>
</tbody>
</table>

Abbreviations: ET, endotracheal tube; G, group; LM, laryngeal mask; NR, not reported; VCI, vocal cord injury.

aNeuromuscular agent group.
bSaline group.
cTwo-minute group.
dMonitor group.
eEndotracheal tube group.
fLaryngeal mask group.

to the rater in the discrimination of the ordinal audioperceptual variables. Furthermore, despite the fact that instrumental analysis is considered to be more objective, it also has limitations, including imperfection in acoustic analysis (eg, errors in pitch tracking, the inability to perform acoustic analysis in very aperiodic vocal vibrations, and the analysis of nonphysiologic speech samples, such as sustained vowels). For that reason, no measurement alone can diagnose or characterize dysphonia, and multidimensional voice assessment is recommended. Concerning the 7 included studies on postoperative hoarseness, 4 studies used audioperceptual measurements, including the Grade, Roughness, Breathiness, Asthenia, Strain scale used by Beckford et al. All studies used instrumental acoustic analysis measuring different variables. However, most investigations used different subjective measurements, including patient interviews and questionnaires varying in validity and reliability. For future research, combining the use of acoustic measurements and patient questionnaires—for example, the validated self-perception questionnaire Voice Handicap Index—is proposed. The Voice Handicap Index is a validated test used to quantify the patient’s perception of his or her vocal function.
This self-administered questionnaire consists of 30 questions; the patient responds according to the appropriateness of each item (0, never; to 4, always). The Voice Handicap Index is scored from 0 to 120, with the latter representing the maximum perceived disability due to voice difficulties based on the patient’s response. Acoustic analysis is performed by selecting a particular segment from a voice sample and analyzing it using defined acoustic algorithms: the percentage of jitter, shimmer, and noise to harmonic ratio. The percentage of jitter gives an indication of the variability of the pitch period within the analyzed voice sample. It represents the relative period-to-period variability. The percentage of shimmer gives an indication of the period-to-period variability of the peak-to-peak amplitude. The evaluation of the noise present in the signal is expressed as noise to harmonic ratio: the average ratio of energy of the inharmonic components in the 1500- to 4500-Hz range to the harmonic components’ energy in the 70- to 4500-Hz range.

An important condition to obtain sufficiently reliable study results is blinding of the raters combined with consensus training and independent scoring of the visuo perceptual or audioperceptual outcome variables for vocal cord injuries and hoarseness. Only 3 studies noted the presence of an expert rater. The remaining studies did not present clear information about the raters, resulting in less robust conclusions. Blinding of the raters and reliability analysis of their results are necessary to generate reliable conclusions.

<table>
<thead>
<tr>
<th>Source</th>
<th>Examined Postoperatively, No.</th>
<th>Time of Postoperative Measurement</th>
<th>Mean Duration (Range) of Intubation, min</th>
<th>Hoarseness, %</th>
<th>Investigators’ Conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lesser and Williams, 1988</td>
<td>G1: 22&lt;sup&gt;a&lt;/sup&gt; G2: 3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>NR</td>
<td>Approximately 33.5 (20-210)</td>
<td>Not clear</td>
<td>Subjective change in voice correlated well with objective measure of vocal cord trauma following intubation</td>
</tr>
<tr>
<td>Jaensson et al, 2010</td>
<td>G1: 48&lt;sup&gt;c&lt;/sup&gt; G2: 49&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3 Dropouts</td>
<td>G1: 195.5 NR</td>
<td>G1: 1. 38.3 2. 29.2 3. 12.5 4. 6.1 G2: 1. 46.9 2. 40.8 3. 12.2 4. 8.3</td>
<td>Use of ET size 6 instead of size 7 in women reduced incidence of sore throat as well as discomfort from sore throat in early postoperative recovery In some patients, sore throat and hoarseness lasted up to 96 h postoperatively</td>
</tr>
<tr>
<td>Hamdan et al, 2008</td>
<td>G1: 17&lt;sup&gt;e&lt;/sup&gt; G2: 10&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1. 2 h 2. 24 h</td>
<td>G1: 5.9 G2: 10</td>
<td>G1: 1. 47.1 2. 5.9 G2: 1. 44.4 2. 10.0</td>
<td>Both LM and ET insertion can be regarded as nontraumatic in view of lack of significant or permanent vocal symptoms and acoustic changes detected 24 h postoperatively</td>
</tr>
<tr>
<td>Zimmert et al, 1999</td>
<td>G1: 28&lt;sup&gt;e&lt;/sup&gt; G2: 28&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1. 4 h 2. 24 h</td>
<td>G1: 87 (35-140) G2: 89 (25-215)</td>
<td>Hoarseness was excluded G1: 1. n=8 2. n=3 G2: 1. n=1 2. n=0</td>
<td>Lower incidence of laryngeal sequelae and fewer reports of laryngeal disorder following LM vs ET insertion</td>
</tr>
<tr>
<td>Beckford et al, 1990</td>
<td>10</td>
<td>Immediately after surgery</td>
<td>G6 NR</td>
<td>G1: n=±4</td>
<td>Subjective speech analysis: decreased intensity, increased roughness, lowered affect Objective not to find: multifactorial dysphonia</td>
</tr>
<tr>
<td>Hamdan et al, 2007</td>
<td>35</td>
<td>1. 2 h 2. 24 h</td>
<td>NR (20-290)</td>
<td>17.1 1. 47.1 2. 11.5</td>
<td>Vocal changes shortly after ET insertion were significant but subsided within 24 h ET insertion variables: cuff mean pressure and volume are most important variables associated with increase in vocal symptoms</td>
</tr>
<tr>
<td>Jones et al, 1992</td>
<td>G1: 167&lt;sup&gt;a&lt;/sup&gt; G2: 68&lt;sup&gt;g&lt;/sup&gt;</td>
<td>&lt;1 wk</td>
<td>NR NR</td>
<td>G1: n=54 (32.3) n=5 (9, 10, 12, 54, 99 d; n=2 of 5, granulomas) G2: NR</td>
<td>Supports low incidence of prolonged hoarseness following short-term ET insertion</td>
</tr>
</tbody>
</table>

Abbreviations: ET, endotracheal tube; G, group; LM, laryngeal mask; NR, not reported; PACU, postanesthetic care unit.

<sup>a</sup> General anesthesia group.
<sup>b</sup> Local anesthesia.
<sup>c</sup> Endotracheal intubation using tube size 6.
<sup>d</sup> Endotracheal intubation using tube size 7.
<sup>e</sup> Endotracheal tube group.
<sup>f</sup> Laryngeal mask group.
<sup>g</sup> No anesthesia.
ANESTHESIA-RELATED FACTORS

Laryngeal injury caused by an ET may occur during induction of anesthesia as direct intubation trauma, an operation, or tracheal extubation.1,4 In addition, several risk factors leading to laryngeal injury have been described. These include ET size, cuff design, cuff pressure, type of tube, use of an introducer, use of a gastric tube, muscle relaxation, use of propofol, duration of the operation, intubation conditions, and movement of the tube, as well as demographic factors such as sex, weight, history of smoking and gastroesophageal reflux, or even the type of operation.1,4,7-11 Furthermore, removal of the LM with an inflated cuff, forced traction, or twisting of the LM may cause rotation of the larynx and possible dislocation of the arytenoids.21 Severe cranial nerve injuries arising from pressure trauma have been associated with the LM. More than 20 case reports of recurrent laryngeal nerve injuries have been published.22 Two studies applied a standardized anesthesia protocol.18,19 The remaining studies used a variety of anesthesia protocols15,20-22,24-29 One investigation did not mention details concerning the anesthesia technique used.23 Overall, this could have affected the outcomes. For future research, it is important to use a standardized anesthesia protocol and report potential contributing factors to vocal cord injuries.

The clinical objective examined by the present systematic review was to evaluate the occurrence and the type of vocal cord injury as well as the occurrence of hoarseness following short-term general anesthesia using an ET or LM in adults. All 13 of the included studies applied preoperative and postoperative measurements. Hoarseness and vocal cord injuries were common findings following the use of an ET applied for short-term anesthesia in most studies. In addition, several investigations reported persistent hoarseness and injury for up to 6 months. However, because of the heterogeneous study designs, such as different assessment tools, different outcome variables, and a wide range of postoperative measurement moments, the included studies could hardly be compared. Nevertheless, hoarseness and vocal cord injuries seem to be clinically relevant complications related to use of an ET or LM during short-term general anesthesia.

For future research, more well-designed prospective studies with both preoperative and postoperative examinations, validated measurement tools, and reliable outcome assessments are necessary to generate reliable data as well as develop techniques to reduce adverse laryngeal effects. Furthermore, a preoperative and postoperative standardized measurement protocol using acoustic analysis and the Voice Handicap Index is advised. We recommend that vocal cord lesions due to general anesthesia be categorized.

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Table 7. Lesions Due to Endotracheal Intubation or Laryngeal Mask Insertion

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Vocal cord lesions impairing vibratory movement</td>
</tr>
<tr>
<td>A</td>
<td>Epithelial</td>
</tr>
<tr>
<td>1.</td>
<td>Inflammation</td>
</tr>
<tr>
<td>2.</td>
<td>Pigmentation</td>
</tr>
<tr>
<td>B</td>
<td>Lamina propria</td>
</tr>
<tr>
<td>1.</td>
<td>Reinke space edema</td>
</tr>
<tr>
<td>2.</td>
<td>Hematoma</td>
</tr>
<tr>
<td>3.</td>
<td>Acquired scar/laceration</td>
</tr>
<tr>
<td>C</td>
<td>Arytenoid Granuloma</td>
</tr>
<tr>
<td>II</td>
<td>Movement disorders of vocal cords</td>
</tr>
<tr>
<td>A</td>
<td>Neurologic: paralysis/paresis of laryngeal nerve(s)</td>
</tr>
<tr>
<td>B</td>
<td>Cricothyroid joint disorders (arytenoid luxation)</td>
</tr>
</tbody>
</table>

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Author Contributions: Drs Mendels and Brunings contributed equally to this study. Dr 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. Study concept and design: Mendels, Brunings, Hamaekers, and Stokroos. Acquisition of data: Mendels, Brunings, and Baijens. Analysis and interpretation of data: Mendels, Brunings, Hamaekers, Stokroos, Kremer, and Baijens. Drafting of the manuscript: Mendels, Brunings, Stokroos, and Baijens. Critical revision of the manuscript for important intellectual content: Mendels, Brunings, Hamaekers, Stokroos, Kremer, and Baijens. Statistical analysis: Mendels and Brunings. Administrative, technical, and material support: Mendels and Brunings. Study supervision: Brunings, Hamaekers, Stokroos, Kremer, and Baijens.

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