


Indications for Direct Laryngoscopic Examination of Vocal Cord Function Prior to Anterior Cervical Surgery

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Abstract

Recurrent laryngeal nerve palsy (RLNP) is among the most common complications in both thyroid surgeries and anterior approaches to the cervical spine, having both a diverse etiology and presentation. Most bilateral paresis, with subsequent devastating impact on patients, are due to failure to recognize unilateral recurrent laryngeal nerve paralysis and, although rare, are entirely preventable with appropriate history and screening. Recurrent laryngeal nerve palsy has been shown to present asymptotically in as high as 32% of cases, which yields limitations on exclusively screening with physical examination. Based on the available literature, diagnosis of unilateral RLNP is the critical factor in preventing the occurrence of bilateral RLNP as the surgeon may elect to operate on the injured side to prevent bilateral paresis. Analysis of incidence rates shows postoperative development of unilateral RLNP is 13.1 (95% confidence interval [CI]: 6.1-28.1) and 13.90 (95% CI: 6.6-29.3) times more likely in anterior spine and thyroid surgery, respectively, in comparison with intubation. Currently, there is no consensus on when to order a preoperative laryngoscopic examination prior to anterior cervical spine surgery. The importance of patient history should be emphasized, as it is the basis for indications of preoperative laryngoscopy. Efforts to minimize postoperative complications must be made, especially when considering the rising rate of cervical fusion. This study presents a systematic review of the literature defining key causes of RLNP, with a probability-based protocol to indicate direct laryngoscopy prior to anterior cervical surgery as a screening tool in the prevention of bilateral RLNP.

Keywords

recurrent laryngeal nerve palsy, direct laryngoscopy, anterior cervical spine surgery, complications, etiology, incidence

Introduction

Recurrent laryngeal nerve palsy (RLNP) when occurring bilaterally is a devastating complication of neck and thoracic surgeries and is associated with significant patient morbidity.^{1,2} Patients with unilateral RLNP may be asymptomatic, but if they subsequently undergo an additional surgery, they are at risk for developing bilateral vocal cord paralysis with need for placement of a permanent tracheostomy for fixed airway obstruction.³ Adjusted rates of cervical fusion in the elderly have increased 206% from 1992 to 2005, making efforts to minimize complications especially important.⁴

Dysphonia is the most common complication in both thyroidectomy and anterior cervical spine surgeries and is believed to mostly occur due to RLNP.⁵⁻⁹ From the review of the literature, the incidence of unilateral and bilateral RLNP is estimated to be 3.26% and 0.29%, respectively, following anterior cervical spine surgeries.¹⁰⁻¹² The incidence of unilateral and bilateral recurrent laryngeal nerve injuries following

a thyroidectomy is estimated to be 3.46% and 2.30%, respectively.¹³⁻¹⁵ Symptoms of unilateral injury to the recurrent laryngeal nerve include dysphonia, hoarseness, cough, aspiration, or dysphagia, which may sometimes be permanent.¹⁰ However, asymptomatic unilateral recurrent laryngeal nerve lesions have

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Table 1. Articles Reporting Recurrent Laryngeal Nerve Palsy Etiologies.

Article	Article Type	Unilateral RLNP Cases	Bilateral RLNP Cases
Rosenthal et al ²³	Retrospective cohort study	368	189
Yumoto et al ²⁴	Retrospective cohort study	422	0
Benninger et al ²⁵	Retrospective cohort study	280	117
Terris et al ²⁶	Retrospective cohort study	84	0
Maisel and Ogura ²⁷	Prospective cohort study	127	54
Titche ²⁸	Retrospective cohort study	134	0
Netterville et al ²¹	Retrospective cohort study	289	0
Paniello et al ²⁹	Retrospective cohort study	238	0
Laccourreye et al ³⁷	Retrospective cohort study	325	0
Holinger et al ³⁸	Retrospective cohort study	0	389
Hillel ³⁴	Retrospective cohort study	0	92
Total		2267	841

Abbreviation: RLNP, recurrent laryngeal nerve palsy.

been shown to be as high as 32% of RLNP cases.¹⁶⁻¹⁹ The true incidence of this injury is often underestimated for this reason.^{20,21} In addition, other pathology can present in a similar fashion. Laryngoscopy is sensitive and specific as it can distinguish from other causes of dysphonia such as vocal cord trauma from intubation, postoperative acid reflux disease, and laryngeal edema.⁹ Populations greater than 65 years are shown to have greater incidence of postoperative complication from cervical surgery for degenerative disc disease (7.74% in ages 65-74 compared to 3.93% in all ages). Postoperative hoarseness has been found to increase in patients aged 65 to 74 years by 0.05% and in patients aged 74+ years by 0.9% when compared to that of all age groups.²²

Thyroidectomy and anterior cervical spine surgeries are suggested to be the most common etiologies of recurrent laryngeal nerve injury, comprising an average of 11.32% and 6.59%, respectively, of all unilateral recurrent laryngeal nerve injuries.^{21,23-29} In addition, remaining causes of this injury can be related to other surgeries, malignancy, trauma, or idiopathy.

Unilateral RLNP is not usually treated, though it may be managed by voice or surgical therapy for improvements in voice quality.³⁰ Bilateral RLNP may result in glottis airway obstruction and will present with stridor and respiratory insufficiency, although voice quality will be preserved unless the vocal fold is lateralized.³¹⁻³³ Permanent tracheostomy is typically indicated in the treatment of bilateral RLNP and will result in the loss of clear voice.^{30,34} Bilateral RLNP will usually occur subsequent to a previous, and often times undiagnosed, unilateral recurrent laryngeal nerve injury. Rarely, this injury may occur due to a bilateral injury at the same time, though this has not been evidenced in anterior cervical surgeries.³⁵ For this reason, increased attention is directed toward the history and physical examination before surgery to determine whether the patient is at risk for bilateral RLNP in order to prevent detrimental injury when considering anterior cervical surgery.

A screening preoperative laryngoscopy is the simplest way to identify a preexisting unilateral palsy such that an operating surgeon may elect to take the approach of the injured side and thereby reduce the chance of a bilateral vocal cord paresis.³⁶

This review examines the available peer-reviewed literature to identify the different etiologies of vocal cord paresis from the recurrent laryngeal nerve and incidence by etiology. The purpose of this process is to outline a probability-based protocol incorporating all evidence-based risk factors to screen patients with direct laryngoscopy prior to anterior cervical spine surgery. This review will also examine diagnostic procedures and examination utilized to identify these injuries.

Methods

A retrospective search was performed at our institution for all unilateral RLNP diagnoses from 2008 to 2016 via query of the Electronic Medical Record (EMR). The data were then stratified to yield the number of diagnoses that occurred 1 year following anterior cervical spine surgery and thyroid surgery. Total number of anterior cervical spine surgeries and thyroid surgeries were also collected to obtain incidence rates. Revision surgeries were not differentiated in this search.

The authors performed a literature search using the PubMed and Web of Science databases. The keywords that were used include “recurrent laryngeal nerve palsy,” “vocal cord paresis,” “etiology,” and “incidence.” The MeSH terms were considered, though it was found that these terms were not completely relevant to the purposes of this search. Authors excluded articles based on volume—those considered in etiology calculations were required to have at least 50 cases of RLNP studied and those considered in incidence calculations were required to have at least 50 total surgeries performed. Articles included in etiology analysis were required to have more than 1 etiology of RLNP. The authors’ reasoning for this criterion was so proportions may be created of RLNP by each etiology with respect to total RLNP of all causes.

The literature search yielded 27 prospective and retrospective scientific articles that were used in data collection and data analysis from 1974 to 2015. The articles that were used in the data collection process are summarized in Tables 1 and 2.

Articles that identified different etiologies of vocal cord paresis were first identified. The number of cases of unilateral

Table 2. Articles Reporting Recurrent Laryngeal Nerve Palsy Incidence.

Article	Study Type	Unilateral RLNP Cases	Bilateral RLNP Cases	Total Number of Surgeries
Apfelbaum et al ¹⁰	Retrospective cohort study with cross-sectional analysis	30	3	900
Fountas et al ¹²	Retrospective cohort study	32	0	1015
Morpeth and Williams ¹¹	Retrospective cohort study	21	1	411
Beutler et al ³⁹	Retrospective cohort study	9	0	328
Kilburg et al ⁴⁰	Retrospective cohort study	8	0	418
Orringer et al ⁴¹	Retrospective cohort study	8	0	410
Tewari et al ⁴²	Retrospective case series	5	0	421
Chan et al ¹³	Prospective cohort study	47	0	1000
Hermann et al ¹⁴	Prospective cohort study	538	0	15 865
Lo et al ¹⁵	Retrospective cohort study	26	0	787
Dimarakis and Protopapas ⁴³	Retrospective cohort study	33	0	2980
Curran et al ⁴⁴	Prospective cohort study	8	6	50
Yang et al ⁴⁵	Retrospective cohort study	1	0	50
Hsu and Hao ⁴⁶	Prospective cohort study	6	0	2511
Friedrich et al ⁴⁷	Retrospective cohort study	1	0	210
Jeannon et al ⁴⁸	Systematic review	0	575	25 011
Total		773	585	52 367

Abbreviation: RLNP, recurrent laryngeal nerve palsy.

and bilateral vocal cord paresis was collected as well as the population of each study stratified. The data were then categorized by each etiology and analyzed for weighted averages with respect to each etiology.

These data were analyzed by creating weighted averages of each etiology of RLNP by summing each cause of RLNP from various articles. Weighted averages were created by dividing the cases of RLNP by the population of RLNP cases in each article. Therefore, articles that had a larger population of cases would yield a larger weight of the average. This was performed for each etiology.

Articles that identified incidence rates of vocal cord paresis complications from common surgery were also identified. The number of specific surgeries performed was noted, as well as the number of cases of vocal cord paresis, both unilaterally and bilaterally. These data were then analyzed for the average incidence rate for each surgery. Odds ratio was created to assess the risk of iatrogenic RLNP by creating a ratio of incidence of that surgery with respect to intubation. Intubation was used as a control as it is a common factor among all surgeries.

Review of the literature was also conducted to determine other factors involved with this injury. This includes physical examination, effect of endotracheal cuff pressure, effect of sidedness, vertebral levels involved, recurrent laryngeal nerve visualization, and anatomical considerations.

Results

A total of 2267 cases of unilateral vocal cord palsy were collected of varied and identifiable etiologies. Surgeries accounted for 36.90% of cases, cancers accounted for 29.74% of cases, and 20.90% of cases were of idiopathic origin. These data are summarized in Figure 1 and Table 3. Given that weighted averages were used to create these data, etiologies are not a

direct proportion of the summed population. Larger sample size studies would comprise a greater portion of the average.

A total of 841 cases of bilateral vocal cord palsy were collected with varied etiologies. Surgeries accounted for 35.65% of cases, cancers accounted for 26.0% of cases, and 8.98% of cases were of idiopathic origin. These data are summarized in Figure 2 and Table 4.

The incidence rates among unilateral and bilateral nerve injuries for common procedures where laryngeal nerve palsy is a major complication are shown in Tables 5 and 6. The weighted average incidence of unilateral RLNP in anterior cervical spine surgery was 3.26%, whereas the weighted average incidence of unilateral RLNP in thyroid surgery was 3.46%.

Statistical analysis was performed using incidence rates of surgical procedures in relation to the incidence of RLNP after intubation. Odds ratios calculated are summarized in Table 7. From incidence rates in the literature, patients who undergo anterior cervical spine surgery and thyroid surgery have 13.1 (95% confidence interval [CI]: 6.1-28.1) and 13.9 (95% CI: 6.6-29.3) times the odds, respectively, to develop postoperative recurrent laryngeal nerve injury than a patient who develops the injury postintubation.

Data analysis from our institution are summarized in Table 8. Significantly, more anterior cervical spine surgeries were performed than thyroid surgeries during this time.

Discussion

Recurrent laryngeal nerve palsy has diverse etiologies; however, the majority can be grouped as iatrogenic, malignancy related, traumatic, and idiopathic. Recurrent laryngeal nerve palsy from malignancies, especially thyroid cancer, accounts for a significant number of cases and can be attributed to the

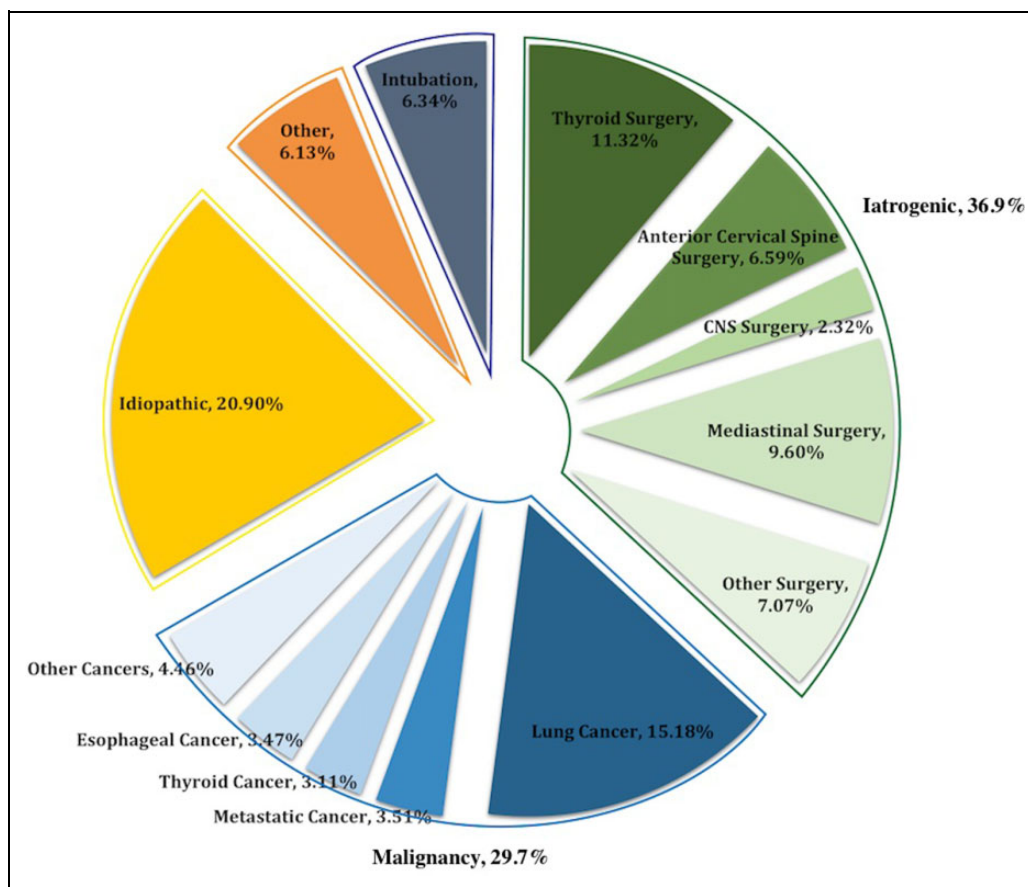


Figure 1. Etiology of unilateral recurrent laryngeal nerve palsy.

Table 3. Etiology of Unilateral Recurrent Laryngeal Nerve Palsy.

Procedure/Diagnosis	Number of Cases	Total Population	Average
Thyroid surgery	201	1415	11.3%
Anterior cervical spine	58	895	6.6%
CNS surgery	18	790	2.3%
Mediastinal surgery	98	924	9.6%
Other surgery	26	368	7.1%
Lung cancer	199	1281	15.2%
Metastatic cancer	42	1204	3.5%
Thyroid cancer	45	1204	3.1%
Esophageal cancer	28	790	3.5%
Other cancers	41	1135	4.5%
Idiopathic	357	1606	20.9%
Intubation	73	988	6.3%
Other	79	1249	6.1%
			100%

Abbreviation: CNS, central nervous system.

mass effect imposing compression of the RLN. In such cases, the medical history is critical in screening for the diagnosis of RLN prior to surgical intervention.

Iatrogenic causes of RLNP comprise more than one-third of bilateral RLNP etiologies. It is, therefore, most preventable through the use of physical examination, medical history, and

appropriate screening methods in diagnosing a unilateral nerve palsy prior to bilateral injury. This diagnosis is critical in avoiding the serious consequences of bilateral nerve damage as a surgeon may operate on the injured side to diminish the risk of a bilateral paresis.

Preoperative laryngoscopy is a common practice in the setting of thyroid surgery; however, it is often lacking in the setting of anterior cervical spine surgery. Based on available data, the incidence of this complication is similar between these 2 surgeries (3.26% in anterior cervical spine surgery and 3.46% in thyroid surgery). The odds ratio for postoperative complication of RLNP in anterior cervical spine surgery when compared to normal intubation is 13.1 (95% CI: 6.1-28.1). This is the third greatest ratio for iatrogenic causes of RLNP. Only thyroidectomies (OR: 13.9, 95% CI: 6.6-29.3) and carotid endarterectomies (OR: 73.85, 95% CI: 25.6-212.9) were found to be higher (Table 7). Intubation was used as a control for comparison of iatrogenic RLNP as it is a common cause of injury shared among all surgeries.

Recurrent laryngeal nerve palsy in the geriatric population has only been studied with respect to thyroid surgery. The rate of complication in geriatric population has not been shown to be statistically different than that in younger population groups.⁴⁹

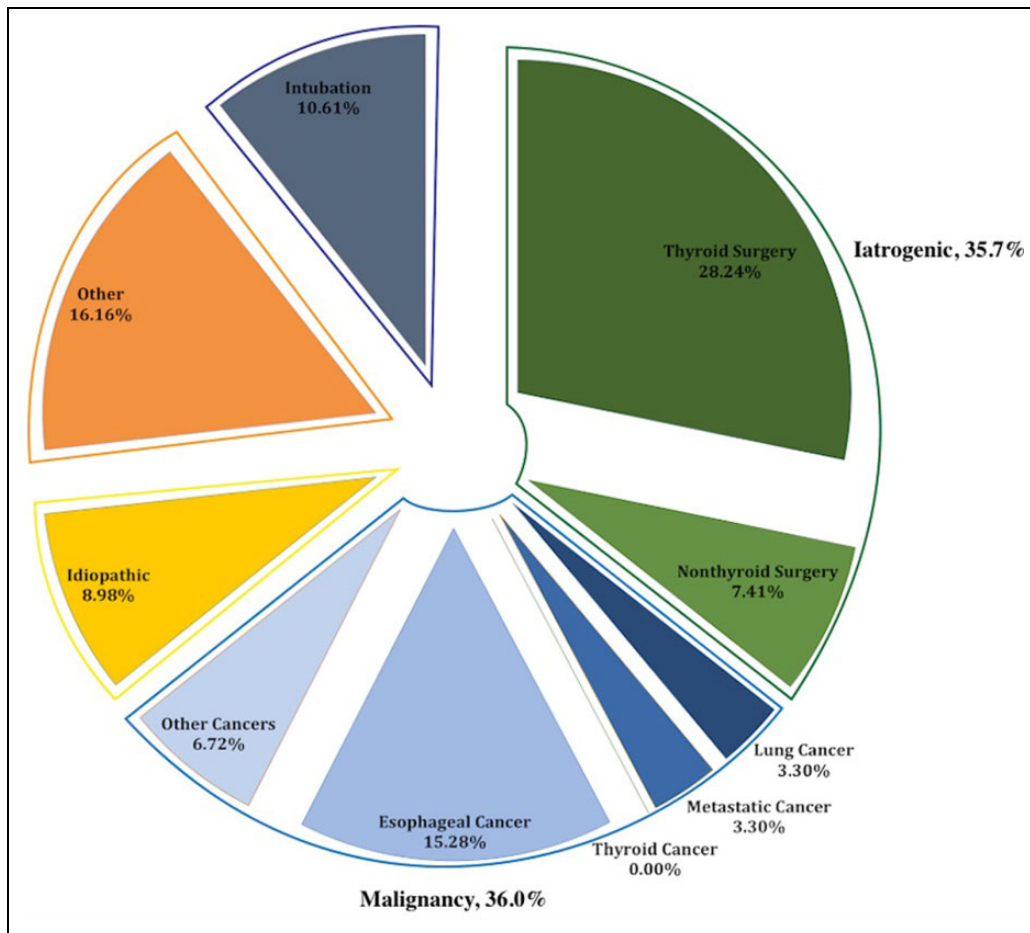


Figure 2. Etiology of bilateral recurrent laryngeal nerve palsy.

Table 4. Etiology of Bilateral Recurrent Laryngeal Nerve Palsy.

Procedure/Diagnosis	Number of Cases	Population of Study	Average
Thyroid surgery	253	841	28.2%
Nonthyroid surgery	14	189	7.4%
Lung cancer	15	360	3.3%
Metastatic cancer	10	306	3.3%
Thyroid cancer	0	189	0%
Esophageal cancer	11	189	15.3%
Other cancers	30	724	6.7%
Idiopathic	60	841	8.9%
Intubation	55	452	10.6%
Other	109	670	16.2%
			100%

Anatomy of the Recurrent Laryngeal Nerve

Anatomic considerations are important in understanding the mechanism of injury of the recurrent laryngeal nerve during anterior cervical spine surgery. Anatomical involvement of the recurrent laryngeal nerve during operation is shown in Figure 3. Haller et al relate the recurrent laryngeal nerve to vertebral levels through dissection of 11 cadaveric specimens. The right

RLN branches from the vagus nerve at the level of T1-T2 at the level of the subclavian artery, whereas the left RLN branches at the level of the aortic arch. The right RLN travels superiorly and medially toward the tracheoesophageal groove and invests the tracheoesophageal fascia inferior to C7-T1. The right RLN then enters the larynx inferior to C6-C7. The left RLN travels superiorly and medially toward the tracheoesophageal groove but invests the tracheoesophageal fascia inferior to T2. The left RLN also enters the larynx inferior to C6-C7.⁵⁰ From cadaveric dissection, Ebraheim et al found the right RLN to course at a steeper angle than the left and to also have a longer course within the tracheoesophageal groove.⁵¹ Weisberg et al found the right RLN to have greater variation in its anatomical course.⁵² In 1% of cases, the right RLN may be nonrecurrent and branch directly from the vagus to the larynx.⁵³ In such cases, it is more vulnerable to injury from the inferior thyroid artery. Anatomical preference between sidedness of approach is still a topic of debate with respect to RLNP.

Sidedness of Approach in RLNP

Given anatomical variations between the left and right recurrent laryngeal nerve, sidedness of approach in anterior cervical spine surgery can be considered in avoiding laryngeal injury.

Table 5. Incidence of Unilateral Recurrent Laryngeal Nerve Palsy.

Procedure/ Diagnosis	Number of Cases Unilateral	Number of Total Surgeries	Incidence	Reference
Anterior cervical spine surgery	30	900	3.3%	Apfelbaum et al ¹⁰
	32	1015	3.1%	Fountas et al ¹²
	21	411	5.1%	Morpeth and Williams, ¹¹
Thyroid surgery	9	328	2.7%	Beutler et al ³⁹
	8	418	1.9%	Kilburg et al ⁴⁰
	47	1000	4.7%	Chan et al ¹³
	538	15865	3.4%	Hermann et al ¹⁴
Transhiatal esophagectomy	26	787	3.3%	Lo et al ¹⁵
	8	410	2.1%	Orringer et al ⁴¹
Coronary artery bypass surgery	5	421	1.2%	Tewari et al ⁴²
Adult cardiac surgery	33	2980	1.1%	Dimarakis and Protopapas ⁴³
Carotid endarterectomy	8	50	16.0%	Curran et al ⁴⁴
Radical lymphadenectomy	1	50	2.0%	Yang et al ⁴⁵
Intubation	6	2511	0.2%	Hsu and Hao ⁴⁶
	1	210	0.5%	Friedrich et al ⁴⁷

Table 6. Incidence of Bilateral Recurrent Laryngeal Nerve Palsy.

Procedure/ Diagnosis	Number of Cases Bilateral	Number of Total Surgeries	Incidence	Reference
Anterior cervical spine surgery	3	900	0.33%	Kriskovich et al ⁷
	1	411	0.24%	Morpeth and Williams ¹¹
Thyroid surgery	575	25011	2.30%	Jeannon et al ⁴⁸
Carotid endarterectomy	6	50	1.19%	Curran et al ⁴⁴

Table 7. Calculated Odds Ratio of Postoperative RLNP With Respect to Postintubation.

Procedure/Diagnosis	Odds Ratio	95% Confidence Interval
Anterior cervical spine surgery	13.1	6.1-28.1
Thyroid surgery	13.9	6.6-29.3
Coronary artery bypass surgery	4.7	1.5-14.8
Transhiatal esophagectomy	7.7	2.8-21.4
Adult cardiac surgery	4.3	1.9-9.8
Carotid endarterectomy	73.9	25.6-212.9
Radical lymphadenectomy	7.9	0.9-65.5

Abbreviation: RLNP, recurrent laryngeal nerve palsy.

Table 8. Retrospective Institutional Analysis of RLNP.

	Anterior Cervical Surgery	Thyroid Surgery	Total
Cases of RLNP	103	33	1914
Total surgeries performed	4298	263	
Incidence	2.4%	12.5%	
Percentage of total RLNP cases	5.4	1.7	100

Abbreviation: RLNP, recurrent laryngeal nerve palsy.

Netterville et al found that 15 of 16 anterior cervical spine surgeries that resulted in RLNP were from the right-sided approach.²¹ Jung and Schramm found the right-sided approach to provide a reduction of 6.8% in the incidence of RLNP in a prospective study.²⁰ Beutler et al found no appreciable difference between the dexterity of approach.³⁹

Vertebral Level Involvement

Anterior cervical spine surgery involving multiple levels of vertebrae has greater incidence of RLNP. Jung et al found the incidence of palsy to increase from 3.3% in surgeries involving 2 to 3 vertebrae to 8.3% involving more than 3 vertebrae.¹ Paniello et al suggest that cases involving the C5-C6 and C6-C7 vertebrae had the greatest number of RLNP cases; however, cases involving the C3-C4 and C4-C5 vertebrae had the greatest relative risk, interestingly.²⁹

Endotracheal Cuff Pressure

Endotracheal cuff pressure must also be considered in the mechanism of injury. Sperry et al suggest that the RLN may become vulnerable to cuff injury as it reaches the superior aspect of the cricoid cartilage. In this area, it comes to lie close to the mucosal surface and may undergo compression from the rigid thyroid lamina. Sperry et al and Apfelbaum et al used a technique of ET inflation with subsequent deflation/inflation after placement of the retractor. Both studies found significant reductions in RLNP from this procedure.^{10,54} However, Audu et al performed a study that tested the same cuff manipulation and found that it had no significant change in the incidence of RLNP, though it prevented over inflation.⁵⁵ Regardless of manipulation, significant literature has suggested ovulation of cuff pressure above 20 mm Hg to be associated with an increased incidence of RLNP.^{20,56}

Recurrent Laryngeal Nerve Palsy in Revision Surgeries

It should be considered that secondary surgeries and/or revision surgeries are associated with significantly higher rates of RLNP, which should be taken into consideration in the preoperative evaluation of the vocal cords.^{15,47,57} The incidence of recurrent laryngeal nerve injury has been reported to be as high as 30% for revision thyroidectomy in 1 study.⁵⁸ There is limited literature

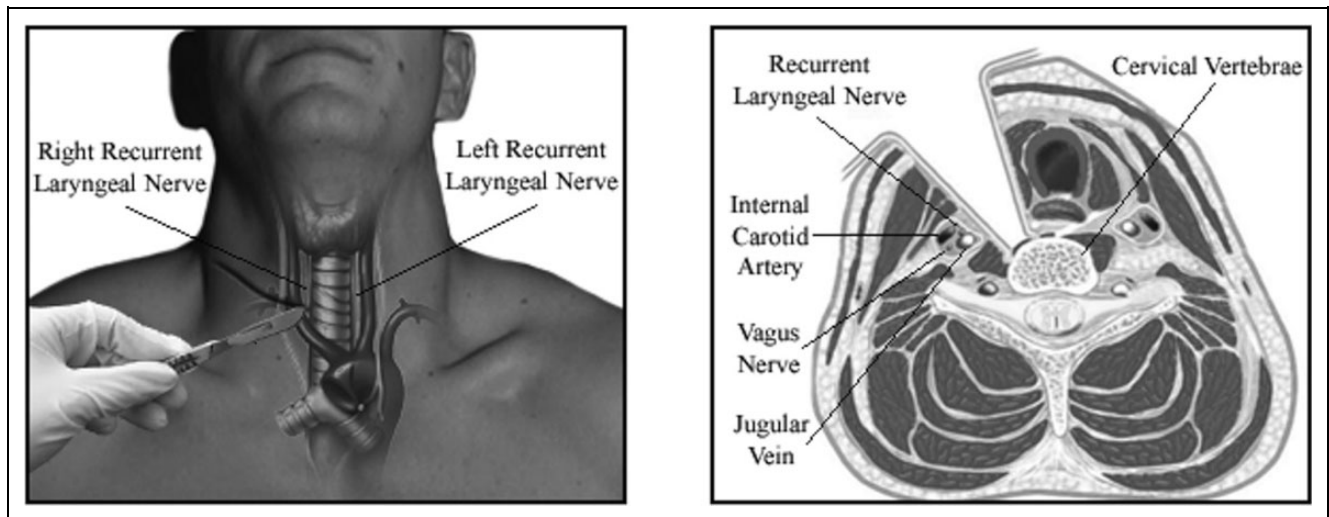


Figure 3. Recurrent laryngeal nerve anatomy in involvement with anterior approaches to the spine.

regarding the incidence of RLNP in anterior cervical spine revision surgeries. Beutler et al estimated the incidence to be 9.5% through the study of 21 revisions, whereas Coric et al estimated the incidence to be 10% in a study of 20 patients.^{39,59}

Additional Considerations

Bilateral RLNP following single anterior cervical surgery without a preexisting unilateral injury is not documented well in the literature. Such an injury would be unlikely in surgery because a unilateral approach is involved in anterior cervical spine discectomy and thyroidectomy surgeries. Case reports demonstrate the progression of bilateral RLNP from a preexisting unilateral injury in anterior cervical spine surgery or a contralateral injury.³¹

A posterior approach to cervical surgery is considered when a known unilateral lesion is present; however, the posterior approach has also been shown to lead to laryngeal edema in the prone position in 1 case report.⁶⁰

Classic symptoms of RLNP include voice hoarseness; however, there is large evidence in the literature of asymptomatic presentation of this injury. There have been reports of varied incidences regarding asymptomatic RLNP. Jung et al, Farrag et al, and Paniello et al, have shown asymptomatic patients to comprise 15.9%, 32%, and 45.5% RLNP cases in their study, respectively.^{1,16,29} Solely, symptomatic examination of a postoperative patient will miss a significant amount of RLNP that may impact patient care later on.

Because direct laryngoscopy is not commonplace in anterior cervical spine surgery, RLNP after surgery is likely to be underdiagnosed with respect to thyroid surgery where laryngoscopy is more common.

Using Physical Examination in Identification of RLNP

Physical examination may also be employed prior to ordering a screening test for RLNP in all patients who are

suspected of having injury or may be at high risk from consideration of their medical history. The perceptual evaluation of dysphonia using physical examination is important in the diagnosis of vocal cord dysfunction before surgery in addition to medical history.^{29,42} Symptoms may include voice hoarseness due to glottal incompetence, dyspnea, stridor, and wheezing without effective relief of symptoms from respiratory treatment.⁶¹ Should unilateral recurrent laryngeal nerve injury be involved, there will be disparities in vocal fold length, which will be demonstrated by high-pitched inspiratory stridor that is confined to the trachea.³⁰ The patient may present without symptoms, as well, should the paralyzed vocal fold not produce a sufficient obstruction. Under laryngoscopy, the patient should be asked to perform phonation, normal breathing, panting, and repetitive deep breaths without holding the breath. Inspiratory cord adduction of the anterior two-thirds of the vocal folds is consistent with paralysis; however, adduction may also be seen on expiration.⁶¹ Functionality of the vagus nerve should be checked, as a lesion may exist proximal to the branching of the recurrent laryngeal nerve. Unilateral vagus dysfunction will present with deviation of the palate to the noninjured side. Additional laboratory tests may be considered to rule out diseases of similar presentation. This includes a pulmonary function test for respiratory illness and neurogenic causes such as syphilis, Lyme disease, diabetes, thyroid dysfunction, collagen vascular disease, and myasthenia gravis.³⁰ If a tumor in the mediastina is suspected, then a chest X-ray film, computed tomography (CT) scan, or magnetic resonance imaging is indicated to identify whether there is an obstruction to the laryngeal nerve. A neck CT scan would also be beneficial for tumors in the neck.³⁴ Hoarseness may also not involve the recurrent laryngeal nerve, as it may be a symptom of vocal fold hematoma, postoperative laryngitis, postoperative varicose node, and even psychogenic dysphonia, among others. Patients may also be shown to have unilateral RLNP with no observed hoarseness.^{9,57}

Table 9. Indications for Direct Laryngoscopy.

Risk Factor	Suggested Cause of RLNP	Reference
Surgical history	Thyroid surgery; anterior cervical spine surgery; mediastinal surgery	Figure 1
Medical history	Lung cancer; mediastinal cancer; esophageal cancer	Figure 1
Sidedness of approach	Increase risk from the right-sided approach	Netterville et al ²¹ ; Jung et al ²⁰ ; Beutler et al ³⁹
Vertebral level	Greatest risk involving 3+ levels; C5-C6 and C6-C7 greatest number of cases	Paniello et al ²⁹
Endotracheal cuff pressure	Greater risk >20 mm Hg	Sperry et al ⁵⁴ ; Apfelbaum et al ¹⁰ ; Audu et al ⁵⁵
Revision surgery	Greater risk	Beutler et al ³⁹ ; Coric et al ⁵⁹

Abbreviation: RLNP, recurrent laryngeal nerve palsy.

Modes of Visualization of RLNP

Should physical examination pose concern in addition to patient history, laryngeal examination may be done using laryngeal video endostroboscopy to visualize the larynx, as this method distinguishes RLNP from other vocal cord dysfunction in regard to diagnosis and treatment and facilitates safe and effective nasotracheal tube intubation.^{42,57,62,63} An alternative and more cost-effective method of screening direct laryngoscopy may be performed through fiberscope, though specificity of indirect and direct laryngoscopy in comparison to endostroboscopy in the detection of recurrent laryngeal nerve injury is a potential area for further research.^{30,64} Laryngeal electromyography may also be a practical method to help explain clinical abnormalities in the event that an endostroboscopy is unavailable or infeasible.^{65,66}

Laryngoscopy in dysphonic patients is more accurate than history and physical examination in determining the etiology and diagnosis.⁶⁷ Separately, patient history and physical examination do not sufficiently assess the presence of RLNP. Significant medical history and/or presenting symptoms in physical examination serve as indications for direct laryngoscopy in patients undergoing elective spine surgery, as direct laryngoscopy has been found to reduce the occurrence of bilateral RLNP.

Overall Risk Factors for Direct Laryngoscopy

Given the aforementioned risk factors for RLNP, indications for laryngoscopy can be assessed on the following risk factors—surgical history, medical history, planned sidedness of approach, planned vertebral level, anticipated endotracheal cuff pressure, and revision surgery (Table 9).

Conclusion

Bilateral RLNP is a devastating complication that can often be avoided with appropriate screening. Patients who have

undergone prior thyroidectomy, anterior cervical surgery, or have a history of esophageal or thyroid malignancy are at highest risk and should undergo direct laryngoscopic examination prior to additional anterior cervical surgery. Additional risk factors for injury include sidedness of approach, vertebral level, and endotracheal cuff pressure. Given the varying presentation and diverse etiology for RLNP, it is not possible to prevent all cases of bilateral injury. However, it is possible to identify at-risk patients on history and physical examination with the potential to prevent this complication. For all patients considering anterior cervical surgery, history and physical examination should be performed with regard to prior surgery, history of thoracic, mediastinal, or neck malignancy, and problems with dysphonia after prior intubations. Direct laryngoscopic examination should be considered if patients with abnormalities on examination or history concerning for RLNP, and patients should be counseled on risks prior to surgical operation.

Declaration of Conflicting Interests

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