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Review Article

Vocal cord palsy after anterior cervical spine surgery: a qualitative systematic review

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Abstract

BACKGROUND CONTEXT: Vocal cord palsy (VCP) is a known complication of anterior cervical spine surgery. However, the true incidence and interventions to minimize this complication are not well studied.

PURPOSE: To conduct a systematic review to identify the incidence, risk, and interventions for VCP after anterior cervical spine surgery.

STUDY DESIGN: This is a qualitative systematic literature review.

SAMPLE: Prospective and retrospective trials of patients undergoing anterior cervical spine surgery that reported on postoperative VCP or recurrent laryngeal nerve palsy.

OUTCOME MEASURES: Primary: incidence of VCP after anterior cervical spine surgery; secondary: risk factors and interventions for prevention of VCP after anterior cervical spine surgery.

METHODS: Electronic searches were conducted on Ovid Medline, EMBASE, Cochrane Central Register of Controlled Trials, and Cochrane Database of Systemic Reviews for clinical studies reporting VCP in anterior cervical spine surgery, limited to studies published between 1995 and June 2013 in English and French languages. After selection of studies independently by two review authors, data on incidence, risk, and interventions were extracted. Qualitative analysis was performed on three domains: quality of studies, strength of evidence, and impact of interventions.

RESULTS: Our search has identified 187 abstracts, and 34 studies met our inclusion criteria. The incidence of VCP ranges from 2.3% to 24.2%. Significant heterogeneity in study design and definition of VCP were used in the published studies. There is good evidence that reoperation increases the risk of VCP. One study of moderate strength suggests that operating from the right side may increase the risk of VCP. Among the interventions studied, endotracheal tube (ETT) cuff pressure monitoring with deflation during retraction has shown to reduce the incidence from 6% to 2%, but this result was not confirmed by randomized control trials. Limited evidence exists for other interventions of intraoperative electromyographic monitoring and methylprednisolone.

CONCLUSIONS: Vocal cord palsy is a significant morbidity after anterior cervical surgery with incidence up to 24.2% in the immediate postoperative period, with a higher risk in reoperation of the anterior cervical spine. Moderate evidence exists for ETT cuff pressure adjustment in preventing this complication.

Keywords: Vocal cord palsy; Anterior cervical spine surgery; Endotracheal tube; Electromyography; Laryngeal nerve; Dysphonia

FDA device/drug status: Not applicable.

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Introduction

Smith and Robinson [1] introduced the anterior approach to the cervical spine for the management of symptomatic degenerative cervical disease. This approach had steadily grown in popularity that in the decade from 1990 to 1999, more than 500,000 anterior cervical discectomy and fusion (ACDF) was performed in the United States alone [2].

Vocal cord palsy (VCP) as a consequence of the anterior cervical spine surgery had long been recognized. Vocal cord palsy encompasses a spectrum of vocal cord dysfunction (VCD) from partial dysfunction (vocal cord paresis) to complete immobility (vocal cord paralysis) [3].

Cloward [4] reported 8% to 10% incidence of temporary hoarseness and 2% risk of vocal cord paralysis. Heeneman [5] retrospectively reviewed 85 patients and found 11% risk of dysphonia and 7% risk of VCP. Bulger et al. [6] followed 102 patients with indirect laryngoscopies and detected a 1% risk of recurrent laryngeal nerve palsy (RLNP).

Since the publication of these articles, newer studies had shown varying incidence of VCP ranging from as low as 0.2% up to 24% [7,8]. Spanu et al. [9] found that VCP is the most common complication in anterior cervical spine surgery, whereas Fountas et al. [10] suggest that it is the third largest complication after ACDF [9,10].

Given such varying incidence of this common and important complication after anterior cervical spine surgery, a clearer understanding of this complication by systematically reviewing the literature is needed.

This review will attempt to answer the following clinical questions:

1. What is the incidence of postoperative VCP after anterior cervical spine surgery?
2. What are the risk factors associated with postoperative VCP with these surgeries?
3. What interventions could reduce the incidence of postoperative VCP in anterior cervical spine surgeries?

Methods

The guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses were followed for conducting systematic reviews [11].

Data source

Electronic searches were conducted on Ovid Medline, EMBASE, Cochrane Central Register of Controlled Trials, and Cochrane Database of Systemic Reviews using the following free-text and associated medical subject heading terms: ACDF, anterior cervical surgery, or anterior spine surgery. This was combined with the Boolean AND with the terms of vocal cord palsy or vocal cord paralysis or vocal cord paresis or recurrent laryngeal nerve.

Studies were limited to articles published in English and French languages from 1995 to June 2013, as studies before 1995 had been previously described [12].

Study eligibility was independently determined by reading the title and abstracts by the authors (TPT and APG). After abstract screening, studies meeting eligibility criteria were subjected to a full-text review. Articles were also retrieved for abstracts that did not provide enough information for inclusion/exclusion at the first stage of screening. References within all identified studies were checked for eligibility for inclusion. Studies failing to meet eligibility criteria after full-text review were excluded.

Inclusion and exclusion criteria

We included prospective or retrospective studies, with at least 10 patients, which reported on postoperative VCP or RLNP, as defined as abnormal vocal cord movements examined with direct or indirect laryngoscopy, or documented VCP or dysphonia in surgical notes, in patients who had undergone any types of anterior cervical spine surgery. Case series of less than 10 patients, case reports, cadaveric studies, and studies with unclear reporting of methods or results were excluded.

Analysis

We analyzed the characteristic and quality of every article by extracting the following information: year of publication, number of patients in the study, definition and incidence of VCP, interventions, surgical factors (side of approach, level, multilevel, duration, outpatient), type of study (prospective vs. retrospective), and any other pertinent results as reported by the authors. Data were summarized and presented in tables.

Quantitative analysis was not possible because of the significant heterogeneity in study design and definitions of VCP of the extracted articles. Hence, qualitative analysis was performed on three domains: quality of studies (Oxford Center for Evidence-Based Medicine Levels of Evidence) [13], strength of evidence, and impact of interventions (Table 1).

Results

Initial database search revealed 177 citations, and with further review of the reference lists, 10 additional studies were identified. One hundred and forty-eight records were excluded after review of title and abstracts, and 39 studies were included for full review. Five studies were excluded: one grouped the incidence of VCP of anterior and posterior cervical spine surgery [14], two had unclear methodology [15,16], one listed the incidence of VCP in the discussion section but not in the results section [17], and one was published in Mandarin [18].

Table 1
Methods for grading the strength of evidence and impact of interventions

Grade	Definitions
Strength of evidence	
Good	Evidence consistently results from well-designed, well-conducted studies
Moderate	Evidence is sufficient to determine the effects on outcomes. However, the strength of evidence is limited by methodology issues
Poor	Evidence is insufficient to assess the effect on outcome because of limited power of studies, inconsistent result between studies, flaws in design of studies, or lack of relevant information
Impact of interventions	
High	Clear evidence that the intervention will produce a net positive clinical effect. The evidence comes from multiple well-designed trials
Moderate	Some evidence that the interventions will likely produce a positive clinical effect, limited by conflicting evidence from other trials
Unknown	No clear evidence if the intervention will have a positive or negative effect

Thirty-four trials met the study inclusion criteria: 3 randomized control trials, 10 prospective observation trials, and 21 retrospective reviews (Fig. 1). Summary of the relevant studies were included in Tables 2 and 3.

Question 1: what is the incidence of postoperative VCP after anterior cervical spine surgery?

Postoperative VCP

Three randomized control trials studied the incidence of postoperative VCP. Audu et al. [19] reported a 14.9% rate of VCP in 94 patients, whereas 2 other RCTs did not record any patient with VCP [20,21]. In 10 prospective observation trials, studying a total of 1,445 patients, the incidence of VCP ranges from 2.3% to 24.2% [8,22–30].

We identified 21 retrospective trials (17 trials studying VCP, 4 trials studying dysphonia). The incidence of VCP ranges from 0.2% to 22% in these 17 trials, studying a total of 11,113 patients [7,9,10,31–43]. Dysphonia as a surrogate for VCP was studied in four retrospective trials, with incidence ranging from 5.4% to 51% [44–47].

Significant heterogeneity exists between trials in the methodology to determine VCP. No standard methods for defining postoperative VCP exist. For prospective trials, VCP was diagnosed by flexible fiber-optic otolaryngological examination, videolaryngoscopy, or videolaryngostroboscopy. However, the timing of examination differs significantly between trials, from the time of extubation [29] to a few hours postoperatively [19] and few days postoperatively (days 3–7) [8,24,26] (Table 2).

In the retrospective studies, the definition of VCP used differed significantly between trials (Table 3). In some trials, VCP was diagnosed after performing laryngological examinations in symptomatic patients [10,32,36,43]. In other retrospective trials, surgical notes of VCP obtained via chart review were used to define the incidence of VCP [9,12,38,42]. The lowest incidence of VCP of 0.2% was obtained from the Cervical Spine Research Society Database from 1989 to 1993, where complications were voluntarily self-reported by surgeons [7]. These differences in the methodology between trials in defining postoperative VCP likely cause the wide range of published incidence of VCP.

Asymptomatic versus symptomatic VCP

We identified one prospective trial that looked specifically into the difference between asymptomatic and symptomatic VCP. Jung et al. [8] report the incidence of asymptomatic VCP (15.8%) to be two times the incidence of symptomatic VCP (8.3%) for a total incidence of 24% at days 3–7 postoperatively. At 3 months, 11.3% of patients had persistent VCP (10.8% were asymptomatic and 2.5% symptomatic).

Preoperative VCP

We identified four trials that reported on the incidence of preoperative VCP. Three prospective trials reported on preoperative VCP incidence of 1.3% to 1.6%, related to previous thyroidectomy and spinal metastases [8,22,25]. Paniello et al. [40] detected 22% incidence of VCP in 47 patients before undergoing revision anterior cervical spine surgery.

Summary: The incidence of VCP from prospective trials ranges from 2.3% to 24.2%. The incidence of VCP may be underestimated because of underdiagnosis of asymptomatic VCP. Significant heterogeneity in the study design in prospective and retrospective trials likely contributes to the very wide range of reported incidence of VCP. For patients having repeat anterior cervical surgery, the preoperative incidence of VCP is 22% and thus may prompt considerations for preoperative laryngological screening in this subgroup.

Quality of studies: predominately 2b.

Strength of evidence: moderate.

Question 2: what are the risk factors associated with postoperative VCP with these surgeries?

Side of surgical incision (right vs. left)

We identified four trials: two prospective observation trials and two retrospective review of cases.

Jung and Schramm [28] compared their left-sided cohort of 242 patients with their right-sided cohort of 120 patients [8]. They noted a 6.5% incidence of VCP at 3 months with the left-sided approach compared with 13.3% with the right-sided approach.

Two retrospective studies specifically looked into the effect of the approach side. Beutler et al. [35] reviewed 173 right-sided approach and 155 left-sided approach. Kilburg et al. [37] reviewed 278 right-sided approach and 140 left-sided approach. No difference in VCP symptoms was found in either retrospective review.

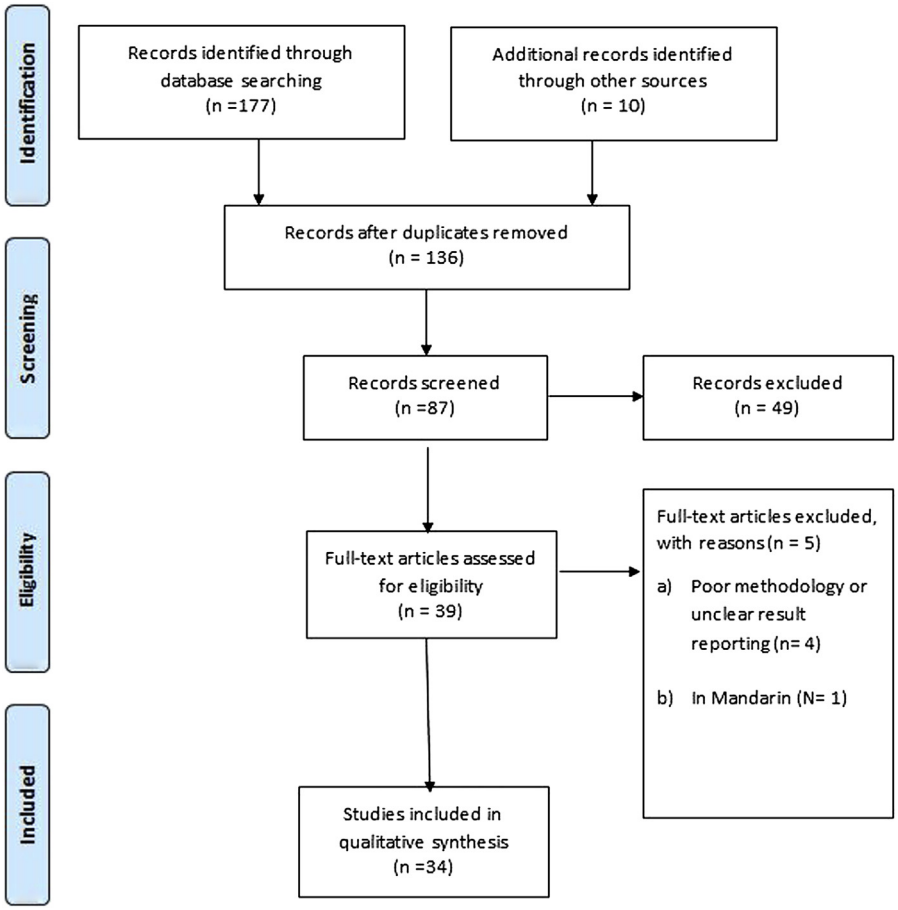

Fig. 1. Schematic diagram of the literature search.

Level of intervention

We identified three retrospective trials. Relative risk of VCP at C3–C4 is 2.0 compared with C5–C6, with a lower relative risk at each lower cervical level in one trial [40]. However, Apfelbaum et al. [32] showed an increased rate of VCP at each lower cervical level from C5 (1.3%) to T1 (12%). They only achieved statistical significance at T1. Similarly, Razfar et al. [43] showed an increased odds ratio (OR) of 1.42 for surgeries performed at C6–C7, OR 3 for C7–T1 but failed to achieve statistical significance.

Single-level versus multilevel surgeries

We identified six trials: two prospective observation trials and four retrospective review of cases.

Multiple prospective and retrospective trials failed to show an increased risk of VCP in patients having one-level ACDF versus two or even three-level ACDF [8,10,24,32,37]. However, Danto et al. [47] in their retrospective review of 149 patients demonstrated an increased OR of 4 in patients having four to five levels of ACDF compared with single-level ACDF.

De novo surgery versus reoperation

We identified one prospective observation trial and three retrospective reviews of cases.

Patients with previous surgery are at increased risk of VCP (9.5%) compared with patients having a de novo surgery (2.3%) [35]. Statistically significant increase in risk of VCP was also found in patients with failed fusion needing reoperation in the retrospective analysis by Apfelbaum et al. [32].

Dimopoulos et al. [27] also found that there are increased electromyographic (EMG) discharges in patients undergoing reoperation, indicating potential increased risk of VCP. Razfar et al. [43] failed to demonstrate that reoperation was independently correlated with VCP after controlling for kyphosis surgery in their logistic analysis.

Duration of surgery

We identified one prospective and one retrospective trials. There are no clinical correlation between duration of surgery and clinical symptoms of dysphonia [47]. However, the duration of surgery is correlated with increased EMG discharge [27].

Anterior discectomy versus corpectomy

We identified one retrospective trial that did not detect any difference in VCP between anterior cervical corpectomy and anterior cervical discectomy [35].

Table 2
Summary of prospective and RCTs

Study	Year	n	Incidence of VCP	%	Type	LOE	Side, surgical approach	Methodology	Comments
Francois et al.	1998	125	6/125	4.8	Prospective	2b	N/A	Fiber-optic ENT examination preop and at 24 h	All patients intubated for 24 h. Two VCP measured before surgery
Jellish et al.	1999	60	23/60*	38	Prospective	2b	N/A	Dysphonia postop and at 24 h. If persistent symptom at 1 wk, referral to ENT	First EMG trial
Frempong-Boadu et al.	2002	23	2/23	8.7	Prospective	2b	R	Videolaryngoendoscopy preop and postop at 1 wk and 1 mo	
Pedram et al.	2002	Control 158 Intervention 78	Control 6/158 Intervention 2/78	Control 3.8 Intervention 2.5	Prospective	2b	R 198 L 38	Fiber-optic ENT examination preop and at 24 and 36 h postop	Methylprednisolone 1 mg/kg given at the end of surgery and at 12 and 24 h postop to intervention group
Ratnaraj et al.	2002	51	0/51	0.0	RCT	1b	N/A	Dysphonia measured at 1 h, 24 h, and 1 wk postop. No documentation of methodology to measure VCP	ETT cuff pressure trial
Jung et al.	2005	120	29/120	24.2	Prospective	2b	R	Preoperative laryngoscopy and postop laryngoscopy at days 3–7 and at 3 mo if symptomatic	
Audu et al.	2006	Control 39 Intervention 55	Control 6/39 Intervention 8/55	Control 15.4 Intervention 14.5	RCT	1b	L 83 R 11	Nasal ENT examination preop and at 1–2 h postextubation	ETT cuff pressure trial
Kim and Shin	2006	50	0/50	0.0	RCT	1b	N/A	Dysphonia measured at 4 h, 24 h, and 1 wk postop. No documentation of methods to determine VCP or RLNP	ETT cuff pressure trial
Tervonen et al.	2007	114	Early 6/50 Late 2/64	Early 6.0 Late 3.1	Prospective	2b	N/A	Videolaryngostroboscopy preop and postop at discharge	Divided cohort into early follow-up (at discharge) and late (3–9 mo)
Dimopoulos et al.	2009	298	7/298	2.3	Prospective	2b	R	Indirect laryngoscopy preop and immediate postop	Largest EMG monitoring in anterior cervical surgery
Jung and Schramm	2010	242	17/242	7.0	Prospective	2b	L	Postop laryngoscopy (days 3–7)	Follow-up to their 2005 trial
Garg et al.	2010	37	1/37	2.7	Prospective	2b	N/A	Nasal fiber-optic examination at the time of extubation	Continuous cuff pressure monitoring
Tisdall et al.	2010	19	1/19	5.2	Prospective	2b	N/A	Laryngoscopic examination for symptomatic patient	EMG observation study

ENT, otolaryngological; L, left; LOE, level of evidence (Oxford); N/A, not applicable; postop, postoperative; preop, preoperative; RCT, randomized controlled trial; R, right; RLNP, recurrent laryngeal nerve palsy; VCP, vocal cord palsy.

* Number of patients with dysphonia.

Table 3
Summary of retrospective studies

Study	Year	n	Incidence of VCP	%	Type	LOE	Side, surgical approach	Methodology	Comments
Netterville et al.	1996	16	16/?	-	Retrospective	4	R>L	Review of VCP database	
Zeidman et al.	1997	4,589	92/4,589	0.2	Retrospective	3b	N/A	No documentation of methodology	Cervical Spine Research Society database (Voluntary database of >100 surgeons)
Apfelbaum et al.	2000	900	Control 17/250 Intervention 13/650	Control 6.8 Intervention 2.0	Retrospective	2b	R	Flexible laryngoscopy in patients with persistent or notable dysphonia	Intervention to control ETT cuff pressure
Morpeth and Williams	2000	411	21/411	5	Retrospective	2b	R	Flexible fiber-optic laryngoscopy or videostroboscopy on average 32 d postop	85.7% right-sided VCP 61.1% resolution of VCP within 6 mo
Viejo-Fuertes et al.	2000	535	14/535	2.6	Retrospective	2b	R	ENT examination confirmation of VCP	
Beutler et al.	2001	328	9/328	2.7	Retrospective	2b	L 155 R 173	Defined as persistent dysphonia for 2 wk or documented VCP by otolaryngologic consultation	
Winslow et al.	2001	176	89/176*	51.0	Retrospective	2b	N/A	Questionnaire survey of dysphonia	
Mayr et al.	2002	261	1/261	0.7	Retrospective	2b	N/A	Flexible laryngoscopy in patient with severe hoarseness	Chart review
Baron et al.	2003	100	2/100	2.0	Retrospective	2b	L 58 R 42	Chart review. No documentation of ENT examination	
Edwards et al.	2004	166	10/166*	6.0	Retrospective	2b	L 125 R 41	Chart review of surgeon's notes of dysphonia, compared with patient's survey of recollection of symptoms	
Yue et al.	2005	74	14/74*	18.9	Retrospective	2b	L	Follow-up at 7 y or more postop. Patient asked about dysphonia symptoms	Only two patients had otolaryngological examination with normal vocal cord
Spanu et al.	2005	229	18/229	7.9	Retrospective	2b	R	Chart review. No documentation of ENT examination	17/18 patients recovered within 3 mo
Kilburg et al.	2006	418	8/418	1.9	Retrospective	2b	L 140 R 278	Chart review. Documented VCP by laryngeal endoscopy, videostroboscopy, or indirect examination of the vocal cord	Mean duration 2.2 mo between surgery and referral
Schlosser et al.	2006	219	1/219	0.4	Retrospective	2b		Chart review. No documentation of ENT examination	
Fountas et al.	2007	1,015	32/1,015	3.1	Retrospective	2b	R	Indirect laryngoscopy in symptomatic patients	
Kahraman et al.	2007	235	3/235	1.27	Retrospective	2b	R	Laryngoscopy examination performed on symptomatic dysphonia patients	
Paniello et al.	2008	47	11/47	22	Prospective	2b	N/A	Chart review. Videolaryngoscopy preop	Preoperative screening for patients coming for repeat anterior cervical surgery
Garringer and Sasso	2010	645	0/645	0.0	Retrospective	2b	N/A	Chart review	Data at 48 h postop
Joseffer et al.	2010	390	4/390	1.0	Retrospective	2b	N/A	Chart review from first postop visit (27 d postop). No documentation of type of ENT examination	Outpatient ACDF

(*Continued*)

Table 3
(Continued)

Study	Year	n	Incidence of VCP	%	Type	LOE	Side, surgical approach	Methodology	Comments
Razfar et al.	2012	815	9/815	1.1	Retrospective	2b	R	Flexible laryngoscopy in patients with severe or persistent symptoms	
Danto et al.	2012	149	8/149*	5.4	Retrospective	2b	N/A	Chart review. Symptoms noted <1 wk after surgery was recorded in notes	Dysphonia

ACDF, anterior cervical discectomy and fusion; ENT, otolaryngological; ETT, endotracheal tube; L, left; LOE, level of evidence (Oxford); N/A, not applicable; postop, postoperative; preop, preoperative; R, right; RLNP, recurrent laryngeal nerve palsy; VCP, vocal cord palsy.

* Number of patients with dysphonia.

Outpatient surgery

We identified two retrospective trials with incidence of VCP of 0% and 1%, respectively [41,42].

Summary of evidence: Good evidence for the increased risk of VCP in patients coming for reoperation of anterior cervical spine. One prospective study showed moderate evidence that operating via the right incision may increase risk compared to a left incision, but not confirmed by other studies with retrospective designs. Poor evidence that there is increased with the level of incision and extent of surgery (single- vs. multilevel), type of surgery (anterior discectomy vs. corpectomy), setting (outpatient) and duration of surgery.

Quality of studies: predominately 2b and no randomized control trial.

Strength of evidence: overall moderate.

Question 3: what are the interventions that could prevent or reduce the incidence of postoperative VCP in anterior cervical spine surgeries?

Endotracheal tube cuff pressure monitoring

We identified six trials: three randomized control trials, two prospective observation studies, and one retrospective trial [19–21,28–30,32]. Audu et al. [19] studied 94 patients divided into a control group and an intervention group where the endotracheal tube (ETT) cuff pressure was maintained at or below 20 mmHg. During maximum retraction, the cuff was deflated and then reinflated at ''just-to-seal'' pressure. The incidence of VCP was 15.4% in the control group and 14.5% in the intervention group with no statistical difference between groups. Unfortunately, this study was underpowered to detect a true difference between groups.

Two other randomized control trials with similar interventional group, with 50 patients each, did not detect any incidence of VCP and had no statistical difference in the incidence of dysphonia between the groups in their trials [20,21].

Apfelbaum et al. [32] compared 650 patients who had their ETT cuff pressure monitored with a historical 250 patients where no ETT cuff pressure monitoring was used. The incidence of VCP in the intervention group was 2.0% compared with the control 6.8%. They noted an increase of ETT cuff pressure from 15 mmHg up to 40 mmHg in both laboratory and clinical setting.

Similar pressure difference was noted by other studies [28,29]. Interestingly, Jung and Schramm [28] noted that in their cohort of 242 patients, they were unable to adjust the ETT cuff pressure to below 20 mmHg in 93 patients. In these 93 patients, the incidence of VCP was 13/93 (13.9%) in the early period compared with just 4/149 (2.6%) in patients with whom they could adjust the ETT cuff pressure. These differences persist at 3 months (6.5% unadjusted vs. 1.3% adjusted).

Quality of studies: predominately 2b with a few 1b randomized control trials.

Strength of evidence: moderate; good consistent results from trials, limited by negative randomized control trials.

Impact of interventions: moderate and low risk intervention with potential net clinical effect.

Electromyographic monitoring

We identified three prospective observation trials. Jellish et al. [23] prospectively studied 60 patients with EMG electrode inserted parallel to the posterior pharyngeal wall. One patient had 15 increase in EMG activity compared with baseline during surgery and had severe symptoms requiring Teflon injections to the vocal cords. Electromyographic activity could not be positively correlated with postoperative complications.

Dimopoulos et al. [27] employed ETT EMG in 298 patients undergoing ACDF. Surgeons were alerted if EMG activity increased and maneuvers to decrease stimuli such as reposition of ETT and alteration in surgical technique. They found that intraoperative EMG activity was recorded in 14.4% of patients with 2.3% of patients developed postoperative VCD.

Tisdall et al. [30] reported their experience with EMG monitoring in 19 patients. In 11 patients, 58% of the RLN was identified at the inferior aspect of the operative wound with caudal retraction procedure altered accordingly (100% at C6/C7 level and 36% at C5/C6 level). In one case, nonrecurrent RLN was identified crossing the surgical level resulting in transient symptomatic RLNP with hoarseness of voice. Stimulation was possible before discectomy but not at the end.

Quality of studies: predominately 2b.

Strength of evidence: moderate.

Impact of interventions: unknown and needs further trials to elucidate the role of EMG in anterior cervical spine surgeries.

Methylprednisolone

We identified one trial that studied the use of methylprednisolone. Pedram et al. [25] compared 78 patients who received 1 mg/kg of intravenous methylprednisolone at the end of anterior cervical surgery and at 12 and 24 hours postoperatively with 236 control patients. No statistical difference was found between the two groups in terms of VCP (2.6% vs. 3.8%).

Quality of studies: 2b.

Strength of evidence: poor.

Impact of interventions: unknown, and no clear evidence of benefit of methylprednisolone in the prevention of VCP.

Discussion

Vocal cord palsy is defined as partial (paresis) or complete (paralysis) immobility of the vocal cords [3]. It is a significant morbidity after anterior cervical spine surgery with incidence up to 24.2% in the immediate postoperative period. The incidence from the published prospective trials ranges from 2.3% to 24.2%. The majority of the VCP in patients are temporary or asymptomatic with a small subset with residual permanent vocal cord paralysis [8].

Objective evaluation of VCP in anterior neck surgery will require direct or indirect visualization of the vocal cords, whereas symptoms of hoarseness or dysphonia are subjective evaluation of possible VCP [3]. Lack of standardized definition of postoperative VCP, especially pertaining to methods and optimal time to diagnose VCP, is one reason for the wide range in the published incidence of VCP. It is known that some cases of VCP will resolve spontaneously with time [8,43], and it is possible that difference between the trials in the timing of the vocal cord examination may capture a different picture of an evolving and potentially resolving morbidity (Table 2).

In addition, there were likely significant number of cases not recorded or obtained via chart reviews in retrospective studies, which could underestimate the incidence of VCP. Edwards et al. [45] conducted a retrospective review of 166 patients who had anterior cervical surgery and found that poor correlation between surgeon's record and patient survey. For example, dysphonia was recorded only 10 times in surgical record but was noted 77 times in patient questionnaire.

Significant underestimation of the true incidence also occurs because of the presence of asymptomatic VCP that is likely to be two to three times more frequent than symptomatic VCP [8]. Despite the high risk of VCP in the immediate postoperative period, it is reassuring that VCP is not frequently associated with acute airway deterioration after anterior cervical spine surgery [48].

It is interesting to note that the incidence of preoperative VCP is 1.3% [8,25]. In patients undergoing repeat surgery, the incidence preoperatively reaches 22% [26]. This has led some authors to suggest routine preoperative laryngoscopic surveillance of patients before having anterior cervical spine surgery [22,40]. This is especially pertinent in patients who are undergoing reoperation as it is likely a significant risk factor of developing VCP [32,35].

We summarized the risk factors and interventions to prevent VCP (Table 4). Commonly proposed mechanisms that could account for VCDs include direct pressure of the nerve by ETT, pinching of the nerve by surgical retractor, overstretching of recurrent nerve, and traumatic division of divisions of vagus nerve [5].

Direct pressure of the recurrent laryngeal nerve by ETT has been postulated to be a major cause of VCP. The anterior branch of the recurrent laryngeal nerve commonly innervates the lateral cricoarytenoid and thyroarytenoid muscles. The ETT can exert pressure onto this nerve and the submucosal surface especially when it is fixed at the mouth with tape and within the trachea with a distended tube and thus inducing nerve ischemia [49].

With retractor placement, ETT cuff pressure increases significantly from 15 to 40 mmHg [50]. Movement of

Table 4
Risk factors and interventions for VCP in anterior cervical spine surgery

Strength of evidence	Risk factors	Interventions
Good	Reoperation	None
Moderate	Side of surgery	ETT cuff pressure EMG
Poor	Level of intervention Multilevel surgery Duration Type of surgery Outpatient surgery	Methylprednisolone

EMG, electromyography; ETT, endotracheal tube; VCP, vocal cord palsy.

ETT that compresses the laryngeal wall was noted in cadaveric fluoroscopic studies [32]. This is likely secondary to transmitted pressure through the soft tissues of the neck via the compliant posterior wall. ETT cuff deflation and reinflation to just seal may decrease the incidence of VCP from 6.8% to 2% [32]. Among interventions reviewed, ETT cuff adjustment is the best studied, requires minimal resources, and has low risk [20,32].

Another possible mechanism of injury to the recurrent laryngeal nerve is because of distension of the nerve during surgical traction. Retraction of a Cloward retractor generates significant pressure [51] and can cause significant stretch of the recurrent laryngeal nerve up to 24% [52]. Stretch of nerve of 15% or more in animal models may cause irredeemable injury [53,54].

The stretch of the recurrent laryngeal nerve was noted on the right but not on the left [52] and suggests the possibility of minimizing injury if the anterior neck was approached from the left [31]. Cadaveric studies present conflicting results with some showing that the left recurrent laryngeal nerve is longer and ascends the esophagotracheal groove in a more vertical direction with a small angle relative to the coronal plane and thus better protected (Fig. 2) [55]. The right recurrent laryngeal nerve ascends obliquely. The higher origin, shorter length, and the oblique course would produce significant stretch during surgical retraction [56,57]. These findings were not supported by others [58]. In our review, we found one prospective study with moderate evidence that operating from the right might increase the rate of VCP, but not supported by retrospective studies. There are no randomized control trials to provide definitive evidence to this question.

The use of EMG monitoring had been well established in other types of surgery [59]. Dimopoulos et al. [27] had shown in their series that they obtained a sensitivity of 100%, specificity 87%, positive predictive value of 16%, and negative predictive value of 97%. Despite this, no positive correlation had been shown between EMG value and the likelihood of VCP [23]. This may be because of the fact that a negative EMG response can indicate a non-nerve structure, an altered function of the RLN, or equipment set-up malfunction. Tisdall et al. [30] had described a four-step recurrent laryngeal nerve stimulation protocol to identify the presence of recurrent laryngeal nerve and alter surgical approach accordingly. There is a paucity of trial data to recommend the routine use of EMG. Use of EMG monitoring in thyroid surgeries had not been demonstrated to reduce RLN nerve injury but may be useful in complex cases such as reoperation [60,61].

There are some limitations to this review. There is a paucity of well-designed studies on this subject. Most

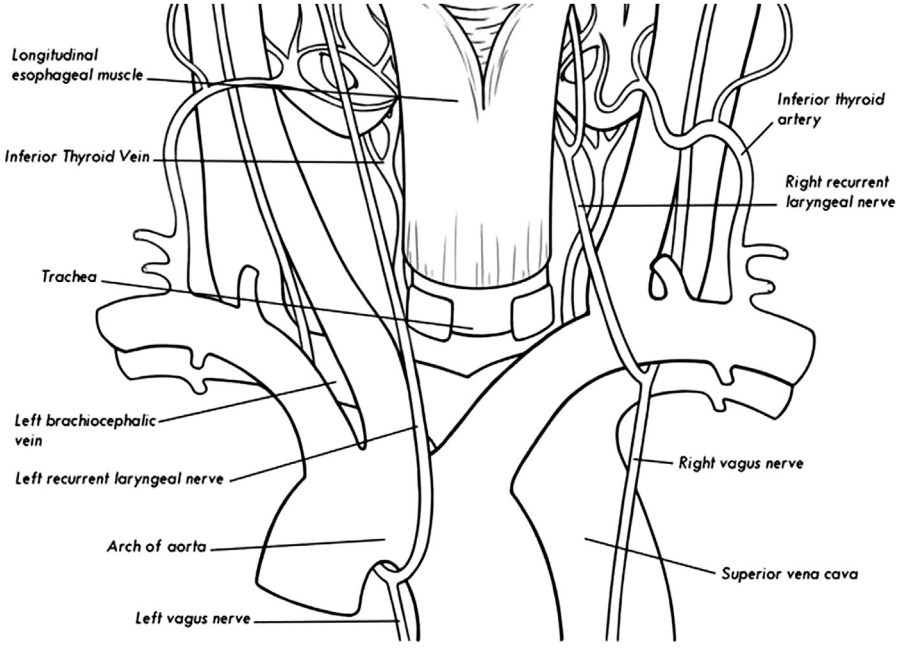

Fig. 2. Anatomy of the recurrent laryngeal nerve at the neck, viewed from posterior to anterior.

studies are prospective observation or retrospective review of patient notes with significant methodology differences leading to imprecise estimation of the true incidence of VCP. Thus, we are unable to provide a quantitative review of the literature.

Large-scale, well-designed, double-blind randomized control trials studying VCP in anterior cervical spine surgery are certainly warranted given the potential high morbidity of VCP and the current clinical equipoise with regard to risk factors such as the side of the surgical incision or the use of electromyography. These trials should be multicentered with uniform recruitment criteria like the same side with specific indication for surgery and have standardized diagnostic criteria for the symptoms and presentations.

In conclusion, VCP is a significant morbidity after anterior cervical spine surgery with incidence up to 24.2% in the immediate postoperative period. Among the risk factors reviewed, reoperation increases the risk of VCP, whereas one study of moderate evidence suggests that right-sided surgery is a risk factor. Endotracheal tube cuff pressure monitoring and adjustment are the best-studied interventions that may reduce the risk of VCP.

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