

Modified high cervical approach for C3-4 anterior pathology in difficult neck patients

ABSTRACT

Introduction: The anterior approach to cervical pathologies is a time-tested versatile approach. It is, however, associated with a number of pharyngo-tracheo-laryngeal complications (PTL complications) such as dysphonia, dysphagia, and aspiration, more commonly in high cervical C3-4 inclusive pathologies and even more so in patients with “difficult neck.” The modified high cervical approach was devised and employed to address these issues at our institution.

Materials and Methods: Patients who underwent surgery for anterior cervical C3-4 inclusive pathologies between January 2015 and April 2018 were included in the study. Parameters for considering difficult neck were defined. Patient subgroup with difficult neck underwent surgery through a modified high cervical approach, whereas others underwent surgery through a standard approach. The incidence of pharyngo-tracheo-laryngeal complications in both subgroups of this patient set was compared among itself as well with a similar patient set with the same two subgroups, both of which underwent surgery through standard approach alone from May 2010 to December 2014 – before the introduction of modified high cervical approach.

Results: A total of 280 patients underwent surgery for C3-4 level pathology between May 2010 and April 2018. There were 197 males and 93 females in this population. Mean age was 45.8 ± 6.3 years. Incidence of pharyngo-tracheo-laryngeal complications was 20.3% in patients who underwent surgery before the employment of modified high cervical approach – 32.4% of difficult neck and 16.6% of others developed features of pharyngo-tracheo-laryngeal complications. After employment of modified high cervical approach, 16.67% of difficult neck and 16.2% of other patients developed features of pharyngo-tracheo-laryngeal complications.

Conclusion: The modified high cervical technique is a good surgical option to prevent pharyngo-tracheo-laryngeal complications in cases of anterior C3-4 pathology when operating of patients with difficult neck.

Keywords: Anterior cervical, high cervical, high-pitch loss, swallowing difficulty

INTRODUCTION


Surgery of the cervical spine involves a myriad of approaches including anterior and posterior approaches. Since its introduction, anterior cervical approach has become staple procedure for pathologies such as disc prolapse ossification of the posterior longitudinal ligament and other disease processes involving anterior elements of the spine. The procedure is, however, not free of its share of complications, namely, hoarseness of voice, high-pitch loss and singing difficulty, decreased cough impulse, and aspiration and dysphagia.

Laryngeal nerve (LN) palsies are frequently cited cause of above-mentioned complications. Other factors implicated

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in causation of these complications are retraction injury to tracheoesophageal complex, laryngeal edema, and injury to microvasculature.

Among LN palsies, recurrent LN (RLN) palsy is the more commonly known. Superior LN (SLN) palsy is comparatively less well documented putatively because the immediate effect of SLN palsy may not be as evident as RLN palsy. In addition, the tests for evaluation of SLN palsy are tedious and less frequently performed.

In the same way, retraction injury to tracheoesophageal complex, laryngeal edema, and injury to microvasculature are difficult to evaluate directly as having caused the aforementioned “pharyngo-tracheo-laryngeal complications.”

These complications may be much more significant in cases of high cervical pathology such as C3-4 inclusive pathologies and may persist for significantly longer periods. In fact, Yue *et al.* reported significant rates of persistence of these complications at 5 years following an anterior cervical discectomy and fusion (ACDF) (singing difficulty persisted in up to 21.6% of cases) and these rates were significantly higher in pathologies around C3-4.^[1]

At our institution, we found overall rates of 16.3% of these pharyngo-tracheo-laryngeal complications in all patients who underwent cervical spine. The rates were slightly higher in C3-4 level inclusive pathologies to the tune of 20.3%, though these were still comparable to those reported in the literature. Retrospective analysis showed that the reason for higher incidence in this patient group was that there was a subset of patients who showed much higher incidence (up to 32%) of features of pharyngo-tracheo-laryngeal complications. In all these patients, there were a few features in common comprising what we call, “difficult neck.” This includes a constellation of features such as short neck, restricted mobility of neck, and poor extension of neck on operating table.

A higher incidence of complication in these patients led us to modify our technique of approaching cervical pathologies in this subset of patients with favorable results. This article presents a description of the aforementioned technique along with a comparison of results; inpatient subsets operated before and after introduction of this modified high cervical approach.

MATERIALS AND METHODS

Patient population

Patients who underwent surgery for anterior cervical C3-4 pathology from January 2015 to April 2018 were included

in the study. This group comprised patients with C₃ and/or C₄ body pathologies and/or C3-4 discal pathologies. This included patients with “difficult neck” in whom modified high cervical approach was employed. This subset of patients was compared with a similar patient population who underwent surgery for anterior cervical C3-4 pathology through a standard approach between May 2010 and December 2014.

We thus had three patient groups with C3-4 level pathology:

- Patients without difficult neck, who underwent surgery through a standard anterior cervical approach
- Patients with difficult neck, who underwent surgery through a standard anterior cervical approach, between May 2010 and December 2014
- Patients with difficult neck, who underwent surgery through a modified high cervical approach, between January 2015 and April 2018.

Difficult neck

Following parameters were considered when considering a patient as having a difficult neck.

- Distance between external occipital protuberance and C₇ spinous process. If the distance was less than below-mentioned values, it was taken as evidence of short neck
 - $10 \times (0.0349 \times \text{height})$
 - $9.65 \times (0.0669 \times \text{sitting height}).$ ^[2]
- Poor extensibility as evaluated by a Magill’s Grade III or more and a thyromental distance of <6 cm on Patil’s Test^[3]
- Hyoid below C3-4 level on plain cervical spine X-ray lateral view
- Evidence of torticollis or other neck abnormalities.

Exclusion criteria

- Patients who had undergone previous neck surgery, either for a cervical pathology or other neck pathologies such as thyroid were excluded from the study
- Patients with pathologies spanning more than two vertebral segments except C3-4 were not included in the study.

Surgical technique

The philosophy

We believe that the retraction injury that occurs in surgery of anterior cervical pathologies is caused by the pull of retractors against the elastic resistance of the skin, platysma, and the cervical fascia. The hindrance caused by the bony structures such as the hyoid contributes adversely to this. In higher cervical region, in the presence of the inherent crowding of the corridor, these factors assume even more relevance. If such patients happen to have a “difficult neck,”

the outcomes could be significantly worse than those in other patients as evident by the reported results.^[1] To this end, our modification begins from the skin level and focuses on minimizing the elastic resistance of various layers and has as its critical step release of hyoid to open up surgical corridor and to lessen retraction.

The technique

The patient is positioned in supine, head stabilized over a head ring, and neck extended with rotation of 30° to the contralateral side.^[4] As the head rotation mainly occurs at C1-C2 level, the lower levels stay in neutral position, allowing a perpendicular access.^[5] A “7-” shaped skin incision is marked with transverse limb being 2 cm below and parallel to the mandibular border starting from anterior border of sternocleidomastoid to slightly across the midline (to preserve marginal mandibular branch of facial nerve) and vertical limb continuing vertically downward, thus allowing skin to be retracted away from the surgical field like a flap giving wider exposure as well as allowing a greater split when incising the investing layer of deep cervical fascia.^[6,7]

Platysma is incised transversely, submandibular gland is exposed and retracted superiorly taking care to preserve its ducts, investing layer of the deep cervical fascia is split, and the retromandibular branches of the common facial vein are ligated. A submandibular gland resection for further exposure may lead to complications such as weakness of the lower lip depressor muscles, injury to lingual, and hypoglossal nerve.^[8,9] Facial artery is retracted superolaterally. Digastric muscle is seen attached to the greater cornu of hyoid with a facial sling which is released to mobilize the digastric muscle and expose the hypoglossal nerve lying deep to its posterior belly. Digastric release has another advantage of mobilizing hyoid away from the field causing wide exposure. The hypoglossal nerve is dissected along its course and retracted rostrally along with stylohyoid muscle which is divided and retracted.

Once the carotid sheath is retracted laterally and the trachea esophageal complex and pharyngeal constrictor muscles are retracted medially, we can see that there are two corridors at this stage to access the upper and lower cervical columns extending from C₂₋₆, superior and inferior to superior thyroid artery (STA) [Figure 1]. The supra STA corridor is a quadrilateral space, which is the corridor used primarily for high cervical pathologies and permits a safe entry route to C₂₋₄ levels. Its borders are superiorly, hypoglossal nerve; antero-superiorly, hyoid and internal SLN (ISLN); medially, stylopharyngeus muscle; and laterally, carotid sheath.^[6] The lingual artery comes across in this space often which can be either retracted superiorly or sacrificed for adequate exposure.

The infra-STA corridor may use in certain cases in conjunction with superior corridor in case the desired exposure is limited through the superior corridor.

It may be noted that it is the release of hyoid that enables a wider and easier access through supra-STA corridor by “uncovering” the space previously hidden beneath hyoid.

SLN descends medially toward the thyrohyoid membrane and lies in the paratracheal fascia covering the longissimus colli muscle and divides into internal and external branch at the level of carotid bifurcation. External SLN (ESLN) is found deep to STA. The internal branch of SLN identified just above the superior laryngeal artery (SLA) passes along with the SLA and enters the thyrohyoid membrane just inferior to the C₃ vertebral body.^[10] ISLN is superficial near the greater cornu of hyoid and thus care must be taken while dissecting the hyoid.

Once the vertebral body level is reached, the technique of discectomy and instrumentation is same as a standard Smith-Robinson approach.

RESULTS

A total of 280 patients underwent surgery for C3-4 level pathology between May 2010 and April 2018. There were 197 males and 93 females in this population. Mean age was 45.8 ± 6.3 years.

Of these, 163 patients underwent these surgical procedures before employment of the modified high cervical approach (between May 2010 and December 2014) and rest underwent surgery after its employment (between January 2015 and April 2018).

Overall, incidence of pharyngo-tracheo-laryngeal complications was 33 patients of 163 (20.3%) in patients who underwent surgery before employment of modified high cervical approach. Among these, 37 had difficult neck. Of these, 12 patients (32.4%) had features of pharyngo-tracheo-laryngeal complications. On the other hand, among 126 patients operated during this period, who did not have difficult neck, 21 (16.6%) developed features of pharyngo-tracheo-laryngeal complications. In contrast, among the 117 patients operated after employment of modified high cervical approach, 18 had difficult neck. Of these, 3 (16.67%) patients had features of pharyngo-tracheo-laryngeal complications. On the other hand, of the 99 patients operated during this period, who did not have difficult neck, 16 (16.2%) developed features of pharyngo-tracheo-laryngeal complications [Table 1].

Table 1: Overview of results including complications

Approach	Difficult neck		Type of complication
	No	Yes	
May 2010 - December 2014			
Standard	126	37	
Complications	21	12	Total
	8	3	Hoarseness
	5	9	High-pitch loss
	13	5	Swallowing difficulty
	4	5	Decreased cough impulse and aspiration
January 2015 - April 2018			
Standard	99		
Complications	16		Total
	6		Hoarseness
	4		High-pitch loss
	6		Swallowing difficulty
	2		Decreased cough impulse and aspiration
Modified high cervical		18	
Complications		3	Total
			Hoarseness
		2	High-pitch loss
		2	Swallowing difficulty
		2	Decreased cough impulse and aspiration

As there is no significant difference between the incidences of pharyngo-tracheo-laryngeal complications such as high-frequency loss or dysphagia in patients without difficult neck in the two time periods, it is indicated that the other factors such as technological paraphernalia, skill of surgeon, and standards of care that may govern these results have had no confounding effect on the results.

On comparing the results between patients with difficult neck who underwent surgery with standard approach to those with difficult neck who underwent surgery through modified high cervical approach, we see that there is a significant difference ($P = 0.009$) between the proportions of patients who developed pharyngo-tracheo-laryngeal complications. In fact, by employing modified high cervical approach for patients with difficult neck, we see that the rates of complications are similar to those without difficult neck.

DISCUSSION

Anatomy

SLN branches off from the vagus nerve as the nerve exits from the jugular foramen, and it travels deep to the carotid artery. At the level of carotid bifurcation, SLN divides into ISLN and ESLN.

ISLN travels more medially in an oblique pathway, and it exits the investing layer at the level of C3-4. Then, it takes a more transverse course, passes just inferior to the greater cornu of hyoid, and pierces the thyrohyoid membrane at the same level. ISLN gives off sensory fibers to the laryngeal mucosa and motor fibers to interarytenoid muscle.

ESLN exits the investing layer at the level C₄₋₅, travels inferomedially toward the pole of thyroid, deep to the STA, and supplies cricothyroid muscle.

Pharyngo-tracheo-laryngeal complications

Anterior approach to cervical was described first by Robinson and Smith and later made popular by work of Cloward.^[11,12] Hoarseness of voice was recognized early on to be a complication of the approach and was reported to range between 2.2% and 7.1% and was reported to recover between 48 h and 4 months.^[11,13-16] A number of otolaryngologic studies later reported hoarseness to range from 0.3% to 51%.^[17-19] Heeneman reported the first significant series on vocal cord palsies and found rates of transient palsy and permanent palsy to be 11% and 3.5%, respectively.^[20] Dysphagia was first focused on in 1987 by Welsh and was found to range from 1.7% to 60% in various studies.^[17-19,21-23]

Incidence of dysphonia reported in the literature ranges from 2% to 30%.^[24-27]

It was Flynn, who first recognized the importance and gravity of LN palsy in relation to these complications and found that though uncommon by itself, the LN palsy forms the largest number of complications of the anterior approach.^[28] LN injury can happen either due to direct injury due to retraction, postoperative hematoma causing secondary stretching, or ischemic injury due to insult to the neural vascularity.^[29,30] Need for increased exposure may make the surgeon retract excessively or to ligate vessels that come across the field. The same happens when the fascial dissection is not adequate or during re-surgery where extensive adhesions are present.

RLN is at risk while retracting the tracheoesophageal complex medially when the nerve gets compressed between the thyroid lamina and endotracheal tube. Furthermore, the nerve sustains injury during excessive retraction. Direct trauma may happen sometimes which is more common in the right side where the nerve takes a more lateral course.^[31]

The SLN palsy is less documented in literature probably because the immediate effect of SLN palsy may not be as evident as RLN palsy.^[32] In addition, evaluation of SLN palsy is a relatively tedious and often incompletely fruitful task.

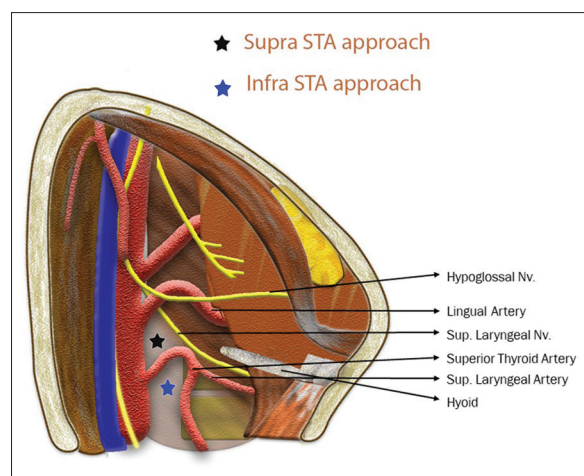


Figure 1: Artistic rendition of the operative field view after mobilisation of hyoid with supra- and infra-superior thyroid artery corridors

Excessive retraction can cause nerve damage at the level of carotid bifurcation. SLN palsy can produce impaired cough reflex, hoarseness, voice fatigability, and impaired high pitch phonation. Incidence of overt SLN palsy in all ACDF procedures has been reported to be nearly 1%.^[13,17]

ISNL can get injured either directly while dissecting the hyoid where the nerve is close to the greater cornu or indirectly due to retraction injury. ISLN is much thinner and lax compared to ESLN which makes ISLN less susceptible for retraction injury.^[30] ISLN mediates cough reflex by providing sensory supply to the laryngeal mucosa and motor supply to the interarytenoids, thus preventing aspiration. ISLN palsy causes impaired cough reflex which can lead to a postoperative risk of aspiration, reported as high as 3.2% in ACDF.^[18] Even though laryngeal mucosa has bilateral innervation, unilateral ISLN palsy can cause significant symptoms sometimes when there is an anatomical variation of one side ISNL being dominant. SLA supplies laryngeal mucosa and branches of ISLN. Damage to SLA can cause ischemic injury to the ISLN.

ESLN provides motor supply to the cricothyroid muscle which makes the vocal cord tense by rotating the cricoid cartilage an important aspect in producing high pitched sounds.^[19] Damage to ESLN palsy can cause impaired high-pitch phonation, voice fatigability, and dysphonia with an intact cough reflex.^[33] The nerve is more susceptible to retraction injury since it is thicker and less lax than ISLN.^[30] ESLN injury is associated with singing difficulty due to impaired high-pitched phonation and difficulty in varying pitches and has been reported in particular, in C3-4 level ACDF where excessive retraction may be needed.^[1]

It must, however, be borne in mind that not all cases of pharyngo-tracheo-laryngeal complications of dysphagia,

hoarseness, impaired cough, or high-pitch loss are due to LN palsy nor all cases of LN palsy lead to these complications.^[17]

The complications may result from a number of other factors not the least of which are graft or implant protrusion, infection, hematoma, or injuries to other nerves such as pharyngeal plexus, vagus, glossopharyngeal, or hypoglossal.^[22-34] Direct retraction injury to tracheoesophageal complex, laryngeal edema, and injury to microvasculature may also contribute to these complications. This becomes especially relevant in cases of higher cervical pathologies where the normal anatomic crowding makes retraction more necessary and puts the structure at greater risk. In fact, while Yue *et al.* reported 21.6% incidence of singing difficulty in 5-year post-ACDF follow-up, it was as high as 57.1% in if C3-4 level was included in surgery.^[1]

Avoidance

In standard ACDF surgery, right RLN is at risk while operating the lower cervical levels and thus left side is preferred in such cases, whereas there is no such consideration for side in high cervical approach as there is no significant anatomical difference between both sides.^[14] SLN is at risk near the carotid bifurcation area where the nerve lies in the paratracheal fascia and it can get injured while placing the retractor to expose the upper levels. This can be avoided by dissecting the medial border of longissimus colli so that a groove is made for safe retraction and this prevents accidental slippage of the retractor causing nerve injury.^[1,7] ESLN courses adjacent to the STA and just deep to the vessel. Ligation or coagulation of STA may sometimes cause inadvertent injury to ESLN. This can be avoided by identifying cricothyroid muscle and upper pole of thyroid, followed by tracing the nerve rostrally. Greater cornu of the hyoid should be dissected carefully where the ISLN is very close to hyoid. Frequent release of retraction, avoidance of excessive retraction, and adequate facial dissection, especially while operating multiple levels or during re-surgeries, are other important techniques to prevent retraction injury to the nerves.^[7] Intraoperative neuromonitoring with electromyography can be used in difficult cases which is about 97% effective in identifying the SLN and its branches.

Implications and present technique

A careful consideration of all the factors enumerated in available literature to prevent pharyngo-tracheo-laryngeal complications reveals the need of adequate exposure, fascial dissection, and minimal retraction. These nuances, however, are difficult to employ in cases where the neck mobility is affected on account of it being short, poorly extensible, or otherwise being difficult to manipulate, such as cases with torticollis, to name a few. The best efforts of

surgeon in these cases to achieve a good surgical exposure and thus to avoid retraction despite an adequate fascial dissection may fail and thus these cases are more prone to develop pharyngo-tracheo-laryngeal complications. This is evident in our results wherein a significantly higher proportion of patients with difficult neck developed pharyngo-tracheo-laryngeal complications when employing a standard approach. The modified high cervical approach developed in consequence to these higher incidences of pharyngo-tracheo-laryngeal complications of dysphagia, high-frequency loss, etc., successfully provides adequate exposure and negates the detriments to preserving these functions and integrity of LNs in patients with difficult neck.

CONCLUSION

The modified high cervical technique is a good surgical option to prevent pharyngo-tracheo-laryngeal complications such as dysphagia and high-frequency loss when operating on patients with difficult neck for anterior C3-4 pathologies.

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Conflicts of interest

There are no conflicts of interest.

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