Vascular Health and Risk Management

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ORIGINAL RESEARCH

Assessment of Voice Quality and Vocal Cord Paralysis After Endarterectomy

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Introduction: Recurrent laryngeal nerve palsy is a rare but important complication after endarterectomy (CEA). The impact on voice quality after this procedure is also important. The aim of the study was to assess voice quality and vocal cord function after CEA.

Material and Methods: 200 patients were enrolled in the study. Inclusion criteria were indications for CEA and patient consent to the procedure. Endoscopic examination of the larynx was performed before the procedure, immediately after the procedure, on the 2nd day after the procedure, then 3 month and 6 months after the procedure. Voice was assessed by maximum phonation time (MPT), GRBAS scale, Voice Handicap Index (VHI) and the Voice-Related Quality of Life (V-RQOL) questionnaire.

Results: In the study group, the results on the GRBAS scale were significantly worse and the average MPT was shorter compared to the control group. In the V-RQOL assessment, patients rated their voice as fair or good, significantly more often noticed that they had difficulty speaking loudly and being heard, and that they felt short of air when speaking. In VHI-30, the total score was significantly higher in the study group compared to the control group. Voice disorders after the procedure were reported by 68 patients, while a disorder of the recurrent laryngeal nerve was observed immediately after the procedure in 32 patients. Most vocal cord disorders were transient. Ultimately, 3% of patients were diagnosed with vocal cord paralysis.

Conclusion: Cranial nerves paralysis, including the recurrent laryngeal nerve, are a common complication after CEA. Majority the paralysis is transient, but requires appropriate diagnostic and therapeutic procedures. Vocal cord evaluation is a non-invasive and widely available examination and should be performed pre- and postoperatively after all neck surgeries. The incidence of voice disorders after CEA significantly affects the quality of life of patients and requires voice rehabilitation and patient care with psychological support.

Keywords: carotid stenosis, endarterectomy, vocal cord paralysis, hoarseness, voice quality

Introduction

Carotid artery stenosis, depending on the severity and clinical symptoms of the patient, may be treated conservatively or surgically. In order to control the progression of the disease resulting from atherosclerosis, regular imaging tests are used to assess the stenosis and morphology of atherosclerotic plaques. Carotid artery stenosis may be asymptomatic or present with typical neurological symptoms such as sensory disability and movement disorders, vision or speech disorders.[1,2] Surgical treatment in the form of endarterectomy (removal of atherosclerotic plaque, CEA) or endovascular carotid artery stenting (CAS) can prevent the occurrence of severe complications in the central nervous system, severe disability or even death of the patient.[1,2] However, surgical treatment always involves the risk of complications. The cardiovascular and neurological complications of CEA and CAS have been thoroughly investigated.[3–6] Complications of CEA also include cranial nerve palsies.[7–9] However, the assessment of vocal cord paralysis after CEA has not been thoroughly assessed, and there are few studies in the literature dealing with this topic.[10–12] Paralysis (immobile cord) or paresis (hypomobile cord) of the vocal cords is caused by damage to the innervation of the recurrent or superior laryngeal nerves or the vagus nerve and is a serious complication of surgery of the neck and chest. The damage may be unilateral or

Received: 23 February 2024
Accepted: 18 July 2024
Published: 21 August 2024

bilateral, depending on the type and extent of the surgery. Diagnosis and treatment of this condition is a challenge for an otolaryngologist. The aim of the study was to assess the voice quality and vocal cord function after CEA.

Materials and Method

200 patients (68 women and 132 men), aged 62 to 80 years (mean $M = 70.9$, $SD = 9.1$) and and 100 healthy volunteers in the control group (37 women and 63 men, aged 62 to 75 years (M=68.6, SD=6.8), were enrolled in the study. The study was conducted in the Department of Vascular Surgery and the Department of Otolaryngology of the University Clinical Hospital in Wrocław, Poland. The patients were enrolled in the study consecutively. The study was conducted in 2022–2023. Men constitute the majority of the study group (66%). All patients in the study group underwent CEA under local anesthesia. Inclusion criteria were indications for CEA and patient consent to the procedure. Patients who had previously undergone neck surgery (thyroidectomy, other neck operations that may affect the function of the recurrent laryngeal nerve) and patients with paralysis or paresis of the vocal cords before the procedure were excluded from the study. Patients working professionally with voice or with a medical history including voice problems were also excluded from the study.

Each patient underwent an ultrasound examination of the carotid arteries, a neurological examination and an endoscopic examination of the larynx. Voice was assessed by the GRBAS scale,[13] maximum phonation time (MPT-the patient phonated the sound "a" in three attempts, the best result was taken into account), Voice Handicap Index (VHI-30 polish version)[14] and the Voice-Related Quality of Life questionnaire (V-RQOL polish version).[15] The GRBAS scale was used for the purpose of auditory voice assessment according to Hirano - where G means grade - the degree of hoarseness, R - roughness, B - breathiness, A - asthenic, S - strained. The intensity of the disorder was assessed on a scale of 0 to 3, where 0 means normal voice, 1 - slightly severe voice disorders, 2 - moderate voice disorders, 3 - severe voice disorders.

The VHI-30 Voice Handicap Index was used for voice self-assessment. The questionnaire consisted of 30 questions divided into 3 parts - I - self-assessment of the functional state, II - self-assessment of the emotional state, III - self-assessment of the physical condition. The patient answers the questions on a scale of 0 to 4. Where 0 means never, 1 - almost never, 2 - sometimes, 3 - almost always, 4 - always. An overall score between 0 and 30 indicates a minimal voice disability, 31–60 a moderate voice disability, and 61–120 a severe voice disability.

V-RQOL consisted of 10 statements in the first part and assessed voice quality in the second part. The patient evaluates the statements marking them as 1- none, not a problem, 2- a small amount, 3- a moderate problem, 4- a lot, 5- problem is "a bad as it can be" He evaluates the voice quality as excellent/very good/good/fair/poor. V-RQOL is rated as excellent at 10–15 points, very good at 16–20, good at 21–25, fair at 26–30, poor at over 30 points.

CEA was performed under local anesthesia by an experienced team of vascular surgeons.

Endoscopic examination of the larynx was performed before the procedure, immediately after the procedure, on the 2nd day after the procedure, then 3 month and 6 months after the procedure.

During the endoscopic examination of the larynx with strobovideolaryngoscopy, the mobility of the vocal cords, the position of the vocal cords, the vibration of the vocal cords, and the width of the glottal fissure were examined. The voice was also assessed 2 days after the procedure and after 3 and 6 months. Statistical significance was assessed using the Student's *t*-test. P>0.05 was considered a statistically significant difference.

The study was approved by the bioethical committee of Wroclaw Medical University, Poland. The study was conducted in accordance with the Declaration of Helsinki, and all participants were informed about the purpose of the study and gave their written consent.

Results

Analysis of the Study Group and the Control Group

The study group, similarly to the control group, was dominated by men (66% in the study group, 63% in the control group). The mean age of patients in both groups did not differ statistically significantly. In the study group, patients were statistically more likely to suffer from diabetes, hypertension and hypercholesterolemia. Carotid artery stenosis occurred

unilaterally in 72 (36%) patients from the study group, and in 128 (68%) - bilaterally. In the control group, the carotid arteries had normal flow during Doppler ultrasound examination. The basic statistics characterizing the groups are presented in Table 1.

In the next analysis, the study group and the control group were compared in endoscopic examination of the larynx and voice assessment.

Endoscopic examination of all patients from the study and control groups revealed normal vocal cord mobility.

In the GRBAS analysis, significantly worse results were obtained for the G, R and A parameters in the study group compared to the control group. In the study group, the average MPT phonation time was 7.2 seconds (range 4.5–10.2), compared to the control group - 10.8 (range 7.1–12.3), the difference was statistically significant p<00 0.5. In the VHI-30 assessment, patients from the study group rated their voice worse, they obtained an average score of 31.8, compared to the control group of 5.52 - The difference was statistically significant. Particular differences concerned self-assessment of functional and physical status. In the V-RQOL assessment, patients assessed their voice as fair or good significantly more often than in the control group, noticed that they had difficulty speaking loudly and being heard, and that they felt short of air when speaking. The results are presented in Table 2.

Analysis of the results in the study group before and after CEA treatment.

The next analysis compared the results before and after the CEA procedure - on the 1st and 2nd day after the procedure, and 3 and 6 months after the procedure.

Immediately after the procedure, endoscopic examination revealed normal vocal cord mobility in 168 (84%), 11 (5.5%) patients had unilateral vocal cord paresis on the site operated, and 21 (10.5%) had unilateral vocal cord paralysis on the site operated. In the group with laryngeal dysfunction, anti-inflammatory and anti-edematous treatment, as well as supporting nutrition and nervous system functions (dexamethasone, B vitamins, galantamine) were implemented. On the second day after the procedure, vocal cord paralysis was noted in only 14 (7%) patients; in the remaining patients, normal vocal cord mobility was achieved. Patients with vocal cord paralysis continued pharmacological treatment and phoniatric rehabilitation. After treatment, improvement was achieved after 3 months in 8 patients (57%), in the remaining 6 patients (3% of the entire study group) the paralysis persisted, the phonation time was shortened, and the voice quality in the questionnaires was significantly worse compared to the group of patients with proper laryngeal function. After 6 months, the statistics did not change - 6 patients had vocal cord paralysis, but the patients' voice quality improved significantly thanks to rehabilitation.

In the analysis of the voice before and after the CEA procedure, it was noticed that the number of patients reporting symptoms of laryngeal dysfunction was much greater than the number of patients with vocal cord paralysis. After the

Table 1 General Characteristics of Patients in the Study and Control Groups

Variable	Study Group (S) N = 200	Control Group (C) N = 100	S vs C p-value
Gender:			0.196
Male, *n* (%)	132 (66.0%)	63 (63.0%)	
Female, *n* (%)	68 (34.0%)	37 (37.0%)	
Age (years):			0.749
M ± *SD*	70,9 ± 9.1	68.6 ± 6.8	
			0.001
Diabetes t.2	84 (42%)	2 (2.0%)	
Hypertension	168 (84%)	58 (58.0%)	
Hypercholesterolemia	184 (92%)	43 (43%)	
Carotid stenosis:			
Unilateral stenosis of the carotid artery	72 (36.0%)	0 (0.0%)	
Bilateral carotid artery stenosis	128 (64.0%)	0 (0.0%)	

Abbreviations: n, number; (%), percentile; *M*, mean; *SD*, standard deviation; *p*, test significance level.

Table 2 Comparison of Vocal Cord Functions and Voice Assessment in the Control Group and in the Study Group Before the CEA, After CEA, 2 Days, 3 Months and 6 Months After CEA

Variable	Control Group N=100	Study Group Before CEA N=200	Study Group after CEA, N=200	Study Group 2 Days After CEA N=200	Study Group 3 Months After CAE N=200	Study Group 6 Months After CAE N=200
Endoscopic examination of the larynx:						
Normal mobility and function of the vocal cords, *n* (%)	100	200 (100.0%)	168 (84%)	184 (92%)	194 (97%)	194 (97%)
Unilateral vocal cord paresis, *n* (%)		0	11 (5.5%)	0	0	0
Unilateral vocal cords paralysis, *n* (%)		0	21 (10,5%)	14 (7%)	6 (3%)	6 (3%)
MPT, *s*	10.8	7.2	–	6.3	6.9	7.5
GRBAS:						
Grade (G)						
G0, *n* (%)	93 (93%)	166 (83%)		125 (62.5%)	142 (71%)	158 (79%)
G1, *n* (%)	7 (7%)	34 (17%)		32 (16%)	58 (29%)	42 (21%)
G2, *n* (%)	0	0		38 (19%)	0	0
Roughness (R)						
R0, *n* (%)	97 (97%)	192 (96%)		168 (84%)	183 (91.5%)	186 (93%)
R1, *n* (%)	2 (2%)	8 (4%)		32 (16%)	17 (8.5%)	14 (7%)
R2, *n* (%)	0	0		2 (1%)	0	0
Breathiness (B)						
B0, *n* (%)	100 (100%)	200 (100%)		168 (84%)	200 (100%)	200 (100%)
B1, *n* (%)	0	0		10 (5%)	0	0
B2, *n* (%)		0		22 (11%)		
Asthenia (A)						
A0, *n* (%)	100 (100%)	180 (90%)		158 (79%)	179 (89.5%)	179 (89.5%)
A1, *n* (%)	0	20 (10%)		18 (9%)	21 (10.5%)	21 (10.5%)
A2, *n* (%)	0	0		24	0	0
Strain (S)						
S0, *n* (%)	98 (98%)	197		190 (95%)	195 (95%)	195 (95%)
S1, *n* (%)	2 (2%)	3 (1.5%)		19 (9.5%)	5 (2.5%)	5 (2.5%)
VHI-30:						
Functional, *M*	1.23	12.6		16.4	14.2	13.1
Emotional, *M*	0.97	3.4		6.4	4.2	3.6
Physical, *M*	3.32	15.8		18.3	16.1	14.3
VHI- Total, *M*	5.52	31.8		41.1	34.5	31.0
V-RQOL score						
10–15 excellent, *n* (%)	100 (100%)	182 (91%)		141 (70.5%)	175 (87.5%)	178 (89%)
16–20 very good, *n* (%)	0	18 (9%)		35 (17.5%)	21 (10.5%)	22 (11%)
26–30 fair, *n* (%)	0	0		24 (12%)	4 (2%)	0
Quality of voice, V-RQOL:						
Very good, *n* (%)	98 (98%)	162 (81%)		132 (66%)	151 (75.5%)	152 (76%)
Good, *n* (%)	2 (2%)	28 (14%)		48 (24%)	37 (18.5%)	36 (18%)
Fair, *n* (%)	0	10 (5%)		18 (9%)	12 (6%)	10 (5%)
Poor, *n* (%)	0	0		24 (12%)	0	0

procedure, 68 patients (34%) reported hoarseness, of which 36 (18%) had no functional disorders. The MPT in the study group was also shorter, but this difference was not statistically significant for the entire study group. In the GRBAS analysis of the entire study group on the 2nd day after CEA, significantly worse results were obtained for all parameters, the differences were statistically significant. VHI-30 patients rated their voice worse - total score 41.1 compared to the pre-treatment score of 31.8, the difference was statistically significant, after 3 and 6 months the results were no longer significantly different. In the V-RQOL analysis, significantly worse results were obtained compared to the assessment before CEA. Before the procedure, 162 (81%) patients rated their voices as very good, 28 (14%) as good, and 10 (5%) as

fair. After the procedure, 132 (66%) patients rated their voice as very good, 48 (24%) as good, 18 (9%) as fair, 24 (12%) as poor.

It can be concluded that after the procedure, patients whose laryngeal function did not deteriorate also noted deterioration of their voice, despite normal laryngeal function in endoscopic examination. These disorders may indicate a psychogenic cause, postoperative dysphonia.

Discussion

Atherosclerosis is a systemic disease that constitutes a very serious clinical problem. Stroke is the most common neurological disease that threatens the patient's life. It is the third cause of death in Europe and the USA.[1,16] The most common symptoms of carotid artery stenosis in patients are related to ischemia of the central nervous system and include visual disturbances, headaches and dizziness, balance disorders, tinnitus, short-term loss of consciousness, and progressive memory disorders.[1,2,16] The diagnosis of cerebrovascular diseases caused by atherosclerosis of the carotid arteries is based on the subjective, physical and neurological examination. There are no studies in the literature assessing voice quality in patients with carotid arteries stenosis. However, the blood supply and nutrition of the nervous system and the larynx itself can also significantly affect the patient's quality of life. In the discussed study, significantly worse voice quality was obtained with normal anatomical and functional structure of the larynx in patients with carotid artery stenosis before surgery, which may indicate a significant impact of atherosclerosis on the quality of voice, voice and phonation time or may indicate subjective psychogenic disorders. Clinically significant stenoses of the carotid arteries should be treated surgically.[1,2,17] During surgical procedures performed under local anesthesia, the patient's neurological condition is continuously monitored. Complications of surgical treatment of carotid artery stenosis appear in most cases within 24 hours after the procedure. Neurological complications include transient cerebral ischemia, cerebral strokes, intracranial bleeding, rupture of an intracranial aneurysm, and damage to cranial nerves, primarily the hypoglossal, facial and vagus nerves and their branches.[1,18] In most cases, cranial nerve palsy is temporary, but appropriate treatment and rehabilitation are often necessary.[19] The risk of permanent damage is low.[19] Complications such as vocal cord paralysis are rarely discussed. The recurrent laryngeal nerve, as a branch of the vagus nerve, may be damaged directly during the procedure by mechanical damage, traction, thermal damage, and its blood supply may also deteriorate as a result of swelling of the operated area immediately after the procedure. Similar causes are observed in thyroid surgery, where the function of the larynx and the risk of its damage have been thoroughly studied, neuromonitoring has become a common procedure to avoid complications.[20–22] Symptoms of unilateral laryngeal nerve palsy include hoarseness, impaired cough reflex, or dysphagia. Many patients after thyroidectomy report voice disorders, despite the lack of changes in endoscopic examination and normal laryngeal function; this syndrome is assessed as subjective disorders after thyroidectomy.[23,24] In this study, similar symptoms were observed after CEA; patients more often reported deterioration of voice quality compared to the frequency of functional disorders during endoscopic examination. AbuRahm et al[25] assessed the frequency of laryngeal nerve damage after repeated CEA, laryngeal nerve damage was confirmed in 7%, 88% of these damages were transient and lasted from 2 to 28 weeks. Ballot et al[26] assessed the function of cranial nerves after CEA, the frequency of damage to the recurrent laryngeal nerves was estimated at 4%, the study did not assess the frequency of voice dysfunction symptoms in relation to confirmed vocal cord paralysis. Thermann et al [27] in their study assessed the occurrence of transient vocal cord paralysis after CEA, which is associated with the administration of local anesthetic in larger amounts, from 20 mL to 40 mL. The authors recommend assessing the vocal cords before planned CEA, because paralysis of one vocal cord during the procedure and the existing vocal cord palsy on the opposite side may cause sudden, severe laryngeal dyspnea, posing a risk to the patient's life. In the literature, the risk of vagus nerve damage ranges from 2 to 4%; in the present study, it ultimately affected 3% of patients.[27] Transient paresis occurred in 16% of patients, and due to the poor quality of voice in this group, these symptoms were not significant for patients.

Paralysis of the laryngeal nerves is also observed after cervical spine surgery, other neck surgery, and thoracic surgery.[28–30] When differentiating the causes of voice disorders, psychogenic hoarseness associated with emotions should be taken into account. Neri et al [31] estimated that among patients with hoarseness after thyroidectomy 55.3% did not present somatic symptoms, but only psychogenic ones. Voice dysfunctions reported by patients in relation to quality of life before surgery may also have a significant psychogenic component. In the present study, 18% of patients reported

dysphonia without any abnormalities during endoscopic examination of the larynx. The problem of voice disorders, laryngeal function and quality of life patients with dysphonia seems to be important in perioperative care after CEA. The voice and larynx as an organ of communication and a personal identifier, defines the patient's well-being. Vocal cord paralysis is a serious complication of neck surgery, including CEA, and requires diagnosis and appropriate treatment that allows for improvement or complete remission of symptoms and return of normal laryngeal function.

Conclusions

Cranial nerves paralysis, including the recurrent laryngeal nerve, are a common complication after CEA. Majority the paralysis is transient, but requires appropriate diagnostic and therapeutic procedures.

Vocal cord evaluation is a non-invasive and widely available examination and should be performed pre- and postoperatively after all neck surgeries.

The incidence of voice disorders after CEA significantly affects the quality of life of patients and requires voice rehabilitation and patient care with psychological support.

Funding

The research was funded by the Wrocław Medical University, Poland (Grant No. STM.C250.20.160).

Disclosure

The authors report no conflicts of interest in this work.

References

1. Arasu R, Arasu A, Muller J. Carotid artery stenosis: an approach to its diagnosis and management. *Aust J Gen Pract*. 2021;50(11):821–825. doi:10.31128/AJGP-10-20-5664
2. Lanzino G, Rabinstein AA, Brown RD. Treatment of carotid artery stenosis: medical therapy, surgery, or stenting? *Mayo Clin Proc*. 2009;84 (4):362–87;quiz367–8. doi:10.1016/S0025-6196(11)60546-6
3. Reiff T, Eckstein HH, Mansmann U, et al. SPACE-2 Investigators. Carotid endarterectomy or stenting or best medical treatment alone for moderate-to-severe asymptomatic carotid artery stenosis: 5-year results of a multicentre, randomised controlled trial. *Lancet Neurol*. 2022;21 (10):877–888. PMID: 36115360. doi:10.1016/S1474-4422(22)00290-3
4. Skrypnik D, Vinogradov R, Falco C, Baryshev A, Porhanov V. Early-term complications after carotid endarterectomy and their risk factors: eight-year employment of local treatment protocol of a Russian high-volume center. *Eur Surg Res*. 2020;61(4–5):101–112. PMID: 33333536. doi:10.1159/000512457
5. Li Y, Yang JJ, Zhu SH, Xu B, Wang L. Long-term efficacy and safety of carotid artery stenting versus endarterectomy: a meta-analysis of randomized controlled trials. *PLoS One*. 2017;12(7):e0180804. PMID: 28708869; PMCID: PMC5510818. doi:10.1371/journal.pone.0180804
6. Cho JS, Song S, Huh U, et al. Comparing carotid endarterectomy and carotid artery stenting: retrospective single-center analysis. *Ann Palliat Med*. 2022;11(11):3409–3416. PMID: 36366894. doi:10.21037/apm-22-797
7. Sannella NA, Tober RL, Cipro RP, Pedicino JF, Donovan E, Gabriel N. Vocal cord paralysis following carotid endarterectomy: the paradox of return of function. *Ann Vasc Surg*. 1990;4(1):42–45. PMID: 2297473. doi:10.1007/BF02042688
8. Tamaki T, Node Y, Saitou N, Saigusa H. Observation of vocal fold and pharyngeal paralysis after carotid endarterectomy using a magnifying laryngoscope. *World J Surg*. 2013;37(4):911–914. PMID: 23358594. doi:10.1007/s00268-013-1920-1
9. Espinoza FI, MacGregor FB, Doughty JC, Cooke LD. Vocal fold paralysis following carotid endarterectomy. *J Laryngol Otol*. 1999;113 (5):439–441. PMID: 10505157. doi:10.1017/s0022215100144160
10. Doig D, Turner EL, Dobson J, et al. ICSS Investigators. Incidence, impact, and predictors of cranial nerve palsy and haematoma following carotid endarterectomy in the international carotid stenting study. *Eur J Vasc Endovasc Surg*. 2014;48(5):498–504. PMID: 25344019; PMCID: PMC4225222. doi:10.1016/j.ejvs.2014.08.002
11. Kakisis JD, Antonopoulos CN, Mantas G, Moulakakis KG, Sfyroeras G, Geroulakos G. Cranial nerve injury after carotid endarterectomy: incidence, risk factors, and time trends. *Eur J Vasc Endovasc Surg*. 2017;53(3):320–335. PMID: 28117240. doi:10.1016/j.ejvs.2016.12.026
12. Cevik OM, Usseli MI, Babur M, et al. The carotid endarterectomy cadaveric investigation for cranial nerve injuries: anatomical study. *Brain Sci*. 2021;11(2):211. PMID: 33578632; PMCID: PMC7916403. doi:10.3390/brainsci11020211
13. Hirano M. *Clinical Examination of Voice*. Springer; 1981.
14. Miaśkiewicz B, Gos E, Dębińska M, et al. Polish translation and validation of the voice handicap index (VHI-30). *Int J Environ Res Public Health*. 2022;19(17):10738. PMID: 36078459; PMCID: PMC9518103. doi:10.3390/ijerph191710738
15. Sielska-Badurek E, Rzepakowska A, Sobol M, Osuch-Wójcikiewicz E, Niemczyk K. Adaptation and validation of the voice-related quality of life measure into Polish. *J Voice*. 2016;30(6):773.e7–773.e12. PMID: 26739855. doi:10.1016/j.jvoice.2015.11.014
16. Mozzaffarian D, Benjamin EJ, Go AS; i wsp. American Heart Associaton Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics 2015, a report from the American Heart Association. *Circulation*. 2015;131(4):29–322.
17. Halliday A. Treatment of asymptomatic carotid artery stenosis. *Lancet Neurol*. 2022;21(10):858–859. doi:10.1016/S1474-4422(22)00348-9
18. Reddy RP, Karnati T, Massa RE, Thirumala PD. Association between perioperative stroke and 30-day mortality in carotid endarterectomy: a meta-analysis. *Clin Neurol Neurosurg*. 2019;181:44–51. doi:10.1016/j.clineuro.2019.03.028

19. Greenstein AJ, Chassin MR, Wang J, et al. Association between minor and major surgical complications after carotid endarterectomy: results of the new york carotid artery surgery study. *J Vasc Surg*. 2007;46(6):1138–1144. doi:10.1016/j.jvs.2007.08.026
20. Sun W, Liu J, Zhang H, et al. A meta-analysis of intraoperative neuromonitoring of recurrent laryngeal nerve palsy during thyroid reoperations. *Clin Endocrinol*. 2017;87(5):572. doi:10.1111/cen.13379
21. Liu YC, Shen CL, Fu ZY, et al. Effectiveness of the recurrent laryngeal nerve monitoring during endoscopic thyroid surgery: systematic review and meta-analysis. *Int J Surg*. 2023;109(7):2070–2081. doi:10.1097/JS9.0000000000000393
22. Jeannon JP, Orabi AA, Bruch GA, Abdalsalam HA, Simo R. Diagnosis of recurrent laryngeal nerve palsy after thyroidectomy: a systematic review. *Int J Clin Pract*. 2009;63(4):624–629. doi:10.1111/j.1742-1241.2008.01875.x
23. Lombardi CP, Raffaelli M, D'Alatri L, et al. Voice and swallowing changes after thyroidectomy in patients without inferior laryngeal nerve injuries. *Surgery*. 2006;140:1026–1032. doi:10.1016/j.surg.2006.08.008
24. Sinagra DL, Montesinos MR, Tacchi VA, et al. Voice changes after thyroidectomy without recurrent laryngeal nerve injury. *J Am Coll Surg*. 2004;199:556–560. doi:10.1016/j.jamcollsurg.2004.06.020
25. AbuRahma AF, Choueiri MA. Cranial and cervical nerve injuries after repeat carotid endarterectomy. *J Vasc Surg*. 2000;32:649–654. doi:10.1067/mva.2000.109751
26. Ballotta E, Da Giau G, Renon L, et al. Cranial and cervical nerve injuries after carotid endarterectomy: a prospective study. *Surgery*. 1999;125:85–91. doi:10.1016/S0039-6060(99)70292-8
27. Thermann F, Ukkat J, John E, Dralle H, Brauckhoff M. Frequency of transient ipsilateral vocal cord paralysis in patients undergoing carotid endarterectomy under local anesthesia. *J Vasc Surg*. 2007;46(1):37–40. doi:10.1016/j.jvs.2007.02.071
28. Jung A, Schramm J, Lehnerdt K, Herberhold C. Recurrent laryngeal nerve palsy during anterior cervical spine surgery: a prospective study. *J Neurosurg Spine*. 2005;2:123–127.50. doi:10.3171/spi.2005.2.2.0123
29. Jung A, Schramm J. How to reduce recurrent laryngeal nerve palsy in anterior cervical spine surgery: a prospective observational study. *Neurosurgery*. 2010;67:10–15.51. doi:10.1227/01.NEU.0000370203.26164.24
30. Zhao J, Xu H, Li W, Chen L, Zhong D, Zhou Y. Intraoperative recurrent laryngeal nerve monitoring during surgery for left lung cancer. *J Thorac Cardiovasc Surg*. 2010;140:578–582. doi:10.1016/j.jtcvs.2010.01.045
31. Neri G, Castiello F, Vitullo F, DE Rosa M, Ciammetti G, Croce A. Post-thyroidectomy dysphonia in patients with bilateral resection of the superior laryngeal nerve: a comparative spectrographic study. *Acta Otorhinolaryngol Ital*. 2011;31:228–234.