Nonrecurrent laryngeal nerve during carotid artery surgery: Case report and literature review

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The anomalous position of a nonrecurrent inferior laryngeal nerve predisposes it to injury during surgery in the neck. We present the case of a patient who underwent a carotid endarterectomy in which a rare left nonrecurrent laryngeal nerve was found intraoperatively. This abnormality, which occurs much less often on the left than the right side of the neck, should be familiar to vascular surgeons. Historical, embryologic, and surgical significance of this anomaly is addressed. (J Vasc Surg 2000;32:192-6.)

Nonrecurrent inferior laryngeal nerves are rarely observed during carotid surgery. Arising directly from the vagus nerve, the nonrecurrent inferior laryngeal nerve lies in a vulnerable position far away from its normal location. Several reports in the literature have described an incidence of nonrecurrent inferior laryngeal nerves of 0.3% to 0.8%, with most occurring on the right side.[1,2] The anomalous position of the nonrecurrent inferior laryngeal nerve makes it more susceptible to compression or significant trauma during surgery in the neck. Intimate knowledge of normal and anatomic variants will reduce the potential for nerve injury and resultant vocal cord paralysis. We report a case of a left nonrecurrent inferior laryngeal nerve discovered during carotid endarterectomy. The surgical importance of recognizing this aberrant anatomy is discussed.

CASE REPORT

A 67-year-old man with a history of hypertension, type 2 diabetes mellitus, hypothyroidism status-post thyroidectomy, and ischemic cardiomyopathy went to the emergency department with new-onset garbled speech. The patient was admitted to the hospital for evaluation. The patient underwent a computed tomography scan of the head, which demonstrated no evidence of infarction or intracranial hemorrhage. Duplex scanning examination demonstrated a greater than 70% internal carotid artery (ICA) stenosis on the left, and an ICA occlusion on the right. The ICA velocities obtained demonstrated a left peak systolic velocity of 321 cm/s and an end-diastolic velocity of 128 cm/s. The ratio of the left ICA to the common carotid artery peak systolic velocity was 5:1. Bilaterally, the vertebral arteries were patent with antegrade flow.

A subsequent arteriogram confirmed occlusion of the right ICA. The right external carotid artery branches resulted in retrograde filling of the ophthalmic artery, which filled branches of the superior division of the right middle cerebral artery. In addition, there were transmural penetrating collaterals arising from the right external carotid artery, resulting in the filling of the inferior division of the right middle cerebral artery distribution. A 70% narrowing of the left ICA was noted. The left intracranial circulation was within normal limits.

A left-sided carotid endarterectomy was planned. The patient's preoperative chest x-ray film demonstrated cardiomegaly and surgical clips in the neck from a prior thyroidectomy (Fig 1). Review of prior echocardiograms revealed normal left ventricular size with mild-to-moderate concentric left ventricular hypertrophy and mildly decreased global left ventricular systolic function. His preoperative ejection fraction was 50%.

The patient was taken to the operating room for a left-sided carotid endarterectomy. Intraoperatively, he had an anatomic variation of the recurrent laryngeal nerve (Fig 2). The vagus nerve was anterolateral to the carotid artery and was associated with a branching nonrecurrent laryngeal nerve, which crossed anterior to the carotid artery, proximal to the bifurcation, and coursed into the larynx. The nerves were carefully traced and preserved. The patient was shunted, and an uneventful carotid endarterectomy was performed in the standard manner with a Hemashield patch.

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Competition of interest: nil.

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Fig 1. The patient's preoperative chest x-ray film. There is cardiomegaly, but no evidence of situs inversus.

A completion intraoperative duplex scan demonstrated patency of the common, internal, and external carotid arteries without evidence of significant stenosis. There was a mild drop-out effect in the region of the patch. The ICA distal to the repair had a peak systolic velocity of 80 cm/s and an end-diastolic velocity of 27 cm/s. The vessel was also examined under B-mode examination in both longitudinal and transverse planes, and no anatomic abnormalities were identified, including intimal flaps or other filling defects.

The patient's postoperative course was unremarkable, and he was discharged from the hospital the following morning. He had no hoarseness or dysphagia and remained otherwise neurovascularly intact. In follow-up 2 years later, a duplex scanning examination demonstrated no significant recurrent disease.

Fig 2. Intraoperative photograph of variant anatomy taken during a left-sided carotid endarterectomy. An *arrow* depicts a nonrecurrent laryngeal nerve branching from the left vagus nerve.

DISCUSSION

Historical perspective. In 1823, Stedman[3] was the first to describe the nonrecurrent laryngeal nerve, a variant of the recurrent inferior laryngeal nerve. He identified this nerve and described its path as arising from the right vagus nerve and coursing directly into the larynx. This particular case was associated with a right subclavian artery arising from the aortic arch to the left of the left subclavian artery. The right subclavian artery of this cadaver dissection passed posterior to the esophagus and trachea.

Later, Hart[4] in 1826 and Hilton[5] in 1837 followed with further reports of nonrecurrent laryngeal nerves. All early reported cases were located on the right side in association with an anomalous right subclavian artery. The surgical importance of the nonrecurrent inferior laryngeal nerve, however, was not introduced to the surgical literature until 1932.[6] This case, reported by Pemberton and Beaver, confirmed the earlier literature that a right nonrecurrent laryngeal nerve was associated with an abnormal origin of the right subclavian artery. More recently, other investigators have reported sporadic cases of nonrecurrent laryngeal nerves.[7,8]

Embryologic basis. Nonrecurrence of the recurrent inferior laryngeal nerve has its primary basis in embryologic development.[9] The recurrent laryngeal nerves arise from the vagus nerve in proximity to the fourth branchial arches. In general, the muscles of the pharynx and larynx are supplied by motor fibers from the vagus nerve. The exception is the cricothyroid muscle, which is supplied by the external branch of the superior laryngeal nerve. The vagus nerve branches are derivatives of the fourth and fifth pairs of branchial arches. In close associa-

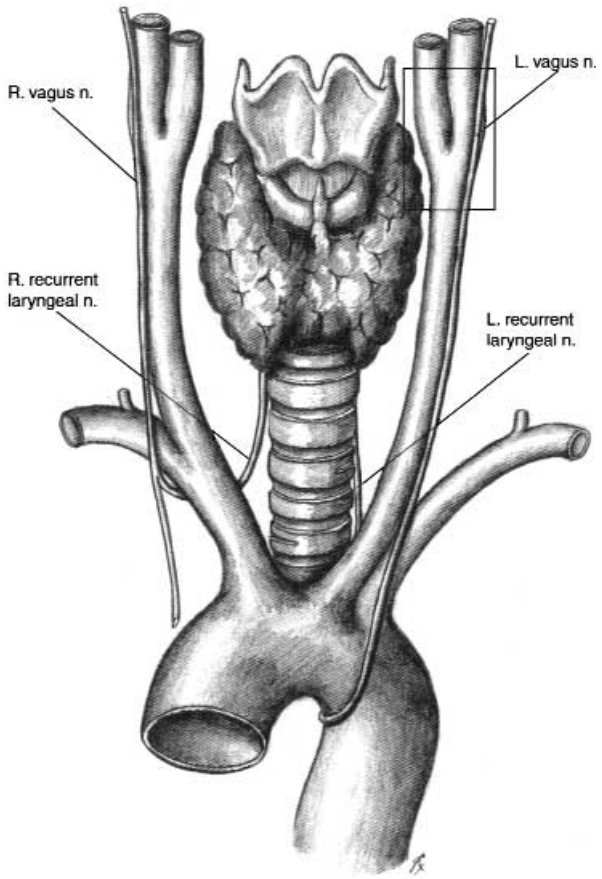

Fig 3. Normal anatomic location and course of the recurrent laryngeal nerves.

tion with the recurrent laryngeal nerves are the large vessels of the thorax. Of the six paired primitive aortic arches, only the fourth on each side remains.[10] The right remains as the subclavian artery, and the left persists as the aortic arch. As the embryo develops and elongates and the thoracic organs descend, the nerves assume their natural recurrent courses.

The typical course of the recurrent laryngeal nerve on each side of the neck is different. Both arise from the vagus nerve, and the right passes from anterior to posterior around the right subclavian artery. The left recurrent laryngeal nerve curves around the aortic arch, reaching the tracheoesophageal groove more quickly. The left nerve also ascends more vertically and lies deeper in the tracheoesophageal groove than the right. Both nerves ordinarily enter the larynx at the cricothyroid articulation through the fibers of the inferior constrictor muscles of the pharynx. The right recurrent nerve assumes its location beneath the right subclavian artery, and the left courses beneath the aortic arch (Fig 3).

The right recurrent inferior laryngeal nerve migrates upward and becomes nonrecurrent as it passes directly from the main vagal nerve trunk to the larynx. Figure 4, *A*, *B*, depicts the normal anatomy and the anomalous position of a nonrecurrent laryngeal nerve as seen during a carotid endarterectomy. An aberrant right subclavian artery is associated with a right nonrecurrent inferior laryngeal nerve during development. Indeed, the most commonly associated vascular abnormality is absence of the innominate artery and dorsal origin of the right subclavian artery from the aortic arch distal to the left subclavian artery, with or without a course posterior to the trachea and esophagus.[3] This posterior course of the subclavian artery may lead to significant esophageal compression. Embryologically, this vascular anomaly is observed when the right fourth aortic arch and the proximal dorsal aorta are obliterated. Because of the aberrant course of the subclavian artery, Arkin named it the "arteria lusoria" or "quirky artery" in 1936.[12] It is believed that the existence of a right arteria lusoria is sufficient to allow cephalad displacement of the recurrent inferior laryngeal nerve, leading to a right-sided nonrecurrent inferior laryngeal nerve. Rarely, a right-sided nonrecurrent inferior laryngeal nerve may also be associated with a recurrent branch in absence of vascular malformation.[1]

In the literature before 1935, there were no reports of a left-sided nonrecurrent laryngeal nerve. Since then, there have been four reported accounts of left-sided nonrecurrent laryngeal nerves.[11,12] The relative paucity of reported cases is understandable on developmental grounds, because displacement of the left-sided recurrent laryngeal nerve during development would require malpositioning of the fourth arch remnants on the left. As the fourth arch persists as the aortic arch, this may be associated with situs inversus, a right-sided aortic arch, and right-sided ligamentum arteriosum.[1,7,8,12] In 1935, Weatherford was the first to describe a cadaver dissection that revealed a right-sided aorta and a left-sided nonrecurrent laryngeal nerve.[13]

Although our patient had clinical evidence of a left-sided nonrecurrent inferior laryngeal nerve (Fig 2), he had no situs inversus or right-sided aortic arch, according to the preoperative chest x-ray film (Fig 1), echocardiography, and arteriogram. To our knowledge, this may be the first described case of a left-sided nonrecurrent inferior laryngeal nerve occurring in absence of the typical fourth arch remnant anomalies on the left (situs inversus, a right-sided aortic arch, and a

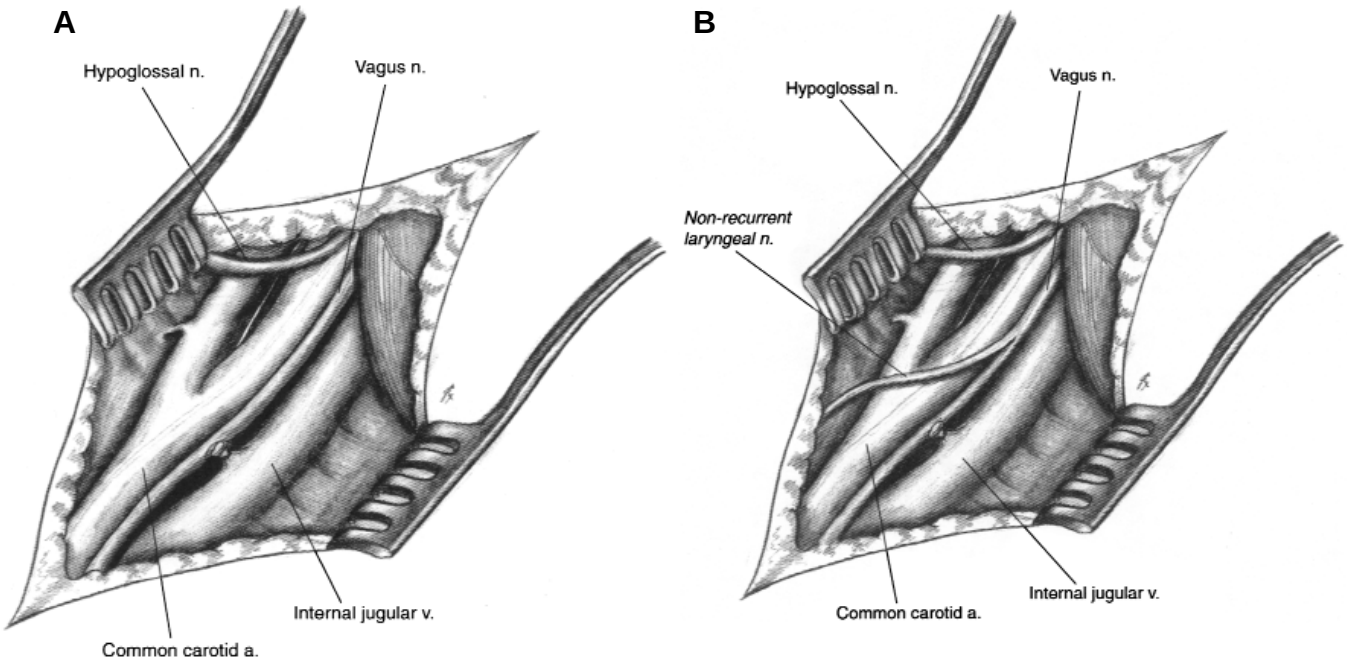

Fig 4. A, View of left neck depicting normal anatomy. B, View of left neck depicting the origin of the nonrecurrent laryngeal nerve.

right-sided ligamentum arteriosum). Because a left-sided carotid endarterectomy was performed, a concomitant recurrent laryngeal nerve was not sought. However, a left-sided recurrent laryngeal nerve in this patient cannot be ruled out, especially in absence of vascular anomalies.

Surgical significance. In 1972, Stewart et al[14] summarized their study of the incidence of nonrecurrent laryngeal nerves identified during 2101 thyroid operations. A total of 3496 recurrent laryngeal nerves were identified and exposed. Of the 1776 visualized nerves on the right side, six were found to be nonrecurrent. Of the 1720 nerves visualized on the left side, there were no nonrecurrent laryngeal nerves.

If the recurrent laryngeal nerve is divided, the corresponding vocal cord assumes a midline position, remaining motionless. If both nerves are divided, there is resultant respiratory embarrassment, as both cords assume a fixed midline position. According to Reeve et al,[15] there are many recurrent laryngeal nerve branches at the level of the larynx. Injury to any one of these branches may result in cord paralysis. Damage to these nerves may result from stretching, ligation, or division and may include branches or the entire nerve. Direct laryngoscopy at the conclusion of the carotid endarterectomy should be carried out if there is any question about the integrity of the recurrent laryngeal nerve or its nonrecurrent variant.

There are no reliable clinical symptoms and signs or investigations to indicate the possibility of a nonrecurrent nerve preoperatively.[11] Nonrecurrent inferior laryngeal nerves have only been suspected twice preoperatively, both times in patients with proved situs inversus.[12] The presence of situs inversus on preoperative chest x-ray film should alert the surgeon to the possibility of a left-sided nonrecurrent inferior laryngeal nerve.[12] However, because our patient demonstrated a left-sided nonrecurrent inferior laryngeal nerve in the absence of situs inversus, a right-sided aortic arch or right-sided ligamentum arteriosum, these findings alone should not be considered a sine qua non for the presence of a left-sided nonrecurrent inferior laryngeal nerve. Nonrecurrent laryngeal nerves have been demonstrated to occur in association with an ipsilateral recurrent laryngeal nerve in absence of vascular anomalies.[12] This may well be the case in our patient.

Aortography has been used to identify associated subclavian artery anomalies, but only retrospectively. A right-sided nonrecurrent inferior laryngeal nerve should be suspected preoperatively in those patients with an aberrant retroesophageal right subclavian artery, the so-called arteria lusoria. Barium swallow

has also been used, and the retroesophageal subclavian artery may be seen on barium swallow as a distortion of the esophagus resulting in a "bayonet" image.[12]

During operations on the carotid artery, the surgeon should proceed with the dissection in an orderly manner, carefully identifying and mobilizing the vagus nerve before vascular dissection. The vagus nerve may be gently elevated with the use of elastic loops before performing an arteriotomy, endarterectomy, or arterial reconstruction. Careful mobilization and handling of the nerve in a systematic way will aid in defining a nonrecurrent inferior laryngeal nerve should it exist.

CONCLUSION

Because of the relative rarity of the nonrecurrent laryngeal nerve, its identification in association with the carotid artery may be an unexpected finding for the vascular surgeon. We emphasize that careful dissection and intimate knowledge of normal and aberrant anatomy allow for avoidance of nerve injury during surgery in the neck.

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REFERENCES

1. Sanders G, Uyeda RY, Karlan MS. Nonrecurrent inferior laryngeal nerves and their association with a recurrent branch. Am J Surg 1983;146:501-3.
2. Proyce CA, Carnaille BM, Goropoulos A. Nonrecurrent and recurrent inferior laryngeal nerve: a surgical pitfall in cervical exploration. Am J Surg 1991;162:495-6.
3. Stedman GW. A singular distribution of some of the nerves and arteries of the neck and the top of the thorax. Edin Med and Surg J 1823;19:564-5.
4. Hart J. A case of irregular origin and course of the right subclavian and right inferior laryngeal nerve; with remarks. Edin Med Surg J 1826;25:286.
5. Hilton J. On the distribution and probable function of the superior and recurrent laryngeal nerves: as demonstrated by dissection in the human subject. Guys Hosp Rep 1837;2: 514.
6. Pemberton JD, Beaver MG. Anomaly of the right recurrent laryngeal nerve. Surg Gynecol Obstet 1932;54:594-5.
7. Nobles ER. Nonrecurrent laryngeal nerve. Arch Surg 1970; 100:741-2.
8. Friedman M, Toriumi DM, Grybauskas V, Katz A. Nonrecurrent laryngeal nerves and their clinical significane. Laryngoscope 1986;96:87-90.
9. Langman J. Medical embryology. Baltimore: Williams and Wilkins; 1981 p. 184-91.
10. Doyle JL, Watkins HO, Halbert DS. Undescended laryngeal nerve. Tex Med 1967;63:53-6.
11. Srinivasan V, Premachandra DJ. Non-recurrent laryngeal nerve: identification during thyroid surgery. ORL J Otorhinolaryngol Relat Spec 1997;59:57-9.
12. Henry J-F, Audiffret J, Denizot A, Plan M. The nonrecurrent inferior laryngeal nerve: review of 33 cases, including two on the left side. Surgery 1988;104:977-83; discussion 983-4.
13. Berlin DD. The recurrent laryngeal nerves in relation of the normal thyroid gland. Surg Gynecol Obstet 1935;60:19-26.
14. Stewart GR, Mountain JC, Colcock B. Non-recurrent laryngeal nerve. Br J Surg 1972;59:379-81.
15. Reeve TS, Coupland GAE, Johnson DC, et al. The recurrent and external laryngeal nerves in thyroidectomy. Med J Aust 1969;1:380-2.

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