VIA MEDICA

ORIGINAL ARTICLE

Vol. 66, No. 2, pp. 120–125

ISSN 0015–5659
www.fm.viamedica.pl

The ansa cervicalis revisited

M. Loukas[1, 2], A. Thorsell[1], R.S. Tubbs[3], T. Kapos[4], R.G. Louis Jr.[1], M. Vulis[1], R. Hage[1], R. Jordan[1]

[1]*Department of Anatomical Sciences, St. George's University, School of Medicine, Grenada, West Indies*
[2]*Department of Education and Development, Harvard Medical School, Boston, MA, USA*
[3]*Department of Cell Biology and Paediatric Neurosurgery, University of Alabama at Birmingham, USA*
[4]*Department of Advanced Graduate Prosthodontics, Harvard School of Dental Medicine, Boston, MA, USA*

[Received 9 January 2007; Revised 8 March 2007; Accepted 8 March 2007]

Recurrent laryngeal nerve paralysis represents a major complication in oesophageal cancer surgery. Nerve-muscle transplantation to the paraglottic space after resection of the recurrent laryngeal nerve with the ansa cervicalis (AC) has recently become the procedure of choice. The aim of this study was to investigate the anatomical variations of AC in order to avoid iatrogenic injuries and facilitate surgical procedures. We examined 100 adult human formalin-fixed cadavers. The ansa cervicalis showed a great degree of variation regarding origin and distribution. The origin of the superior root of AC was found to be superior to the digastric muscle in 92% of the cases. Its vertical descent was found to be superficial to the external carotid artery in 72% and superficial to the internal carotid artery in 28% of the specimens. The inferior root of AC was derived from the primary rami of C2 and C3 in 38%, from C2, C3 and C4 in 10%, from C3 in 40% and from C2 in 12% of the cases. The inferior root passed posterolaterally to the internal jugular vein in 74% and anteromedially in 26% of the cases. The roots of AC were long (70%) or short (30%), and the union between the two roots was situated inferior or superior to the omohyoid. Not only is knowledge of the anatomy of the ansa cervicalis important for nerve grafting procedures, but surgeons should be aware of AC and its relationships to the great vessels of the neck in order to avoid inadvertent injury during surgical procedures of the neck.

Key words: ansa cervicalis, omohyoid, recurrent laryngeal nerve paralysis, laryngeal reinnervations

INTRODUCTION

Recurrent laryngeal nerve paralysis (RLNP) represents one of the most serious complications in oesophageal cancer surgery [22]. The decrease in the quality of life associated with eating and drinking may lead to postoperative malnutrition; symptoms which compromise communication, such as hoarseness and a shortening of phonation, may result from unilateral vocal cord paralysis [3]; pneumonia caused by aspiration as a result of RLNP is a potential cause of death among long-term survivors of oesophageal cancer surgery [10–12].

Laryngeal reinnervation using the ansa cervicalis (AC) for neurotisation of the recurrent laryngeal nerve (AR) has become an important procedure for use in RLNP. The ansa cervicalis is an ideal nerve for reconstruction of the recurrent laryngeal nerve, since it is located in close proximity to the larynx and is active during phonation, and since sacrificing the nerve causes no serious functional or cosmetic consequences. The laryngeal nerve neurotisation is a minimally invasive procedure and results in excellent recovery of muscle tonus and symmetrical vocal cord mass and tension and phonation [8, 22,

Address for correspondence: Dr. M. Loukas, MD, PhD, Assoc. Prof., Department of Anatomical Sciences, St. George's University, School of Medicine, Grenada, West Indies, tel: 473 444 4175 × 2556, fax: 473 444 2887, e-mail: edsg2000@yahoo.com, mloukas@sgu.edu

23, 25, 29, 31, 33]. In order to avoid iatrogenic injuries and facilitate surgical procedures it is necessary to understand the clinical anatomy of AC.

It is important for the surgeon to identify the course and morphological variations of AC during surgical procedures because of the danger of inadvertent injury to the great vessels of the neck [7, 20, 30, 32, 34]. The aim of this study was to investigate the anatomical variations of AC in order to avoid iatrogenic injuries and to facilitate surgical procedures such as AC.

MATERIAL AND METHODS

The anatomy of AC was examined in 50 human cadavers during the gross anatomy course at Harvard Medical School (2005) and in 50 cadavers during the gross anatomy course at St. George's University School of Medicine in Grenada (2005–2006). The specimens examined, 44 female and 56 male with an age range of 65–83 years and a mean of 70 years, were without any grossly evident pathologies or surgical procedures in the neck region. All the cadavers were routinely fixed in formalin/phenol/alcohol solution.

Following preliminary examination, images from all the dissected specimens were recorded with a Sony digital camera (model: Sony Cyber-Shot DSC-f717) and studied using a computer-assisted image analysis system (Lucia software 5.0 [2000, edition for Windows XP], made by Nikon [Laboratory Imaging Ltd.]). The digital camera was connected to an image processor (Nvidia GeForce 6800 GT) and linked to a computer. Digitised images of AC, together with the surrounding structures, were stored in the Lucia program (2048 × 1536 pixels) and converted to intensity grey levels from 0 (darkest) to 32 bit (lightest). After a standard 1 mm scale had been applied to all pictures, the software was able to use this information to calculate pixel differences between two selected points, such as origin and termination of a given nerve, as previously described [19]. The purpose of the software was to allow easy and accurate translation of pixel differences into metric measurements.

Specifically, the distance of AC was measured. Additionally, at the midpoint of AC the nerve was transected, the lumen photographed and the diameter measured. The distances of the ascending and descending roots of AC were also measured.

RESULTS

The ansa cervicalis was identified in all the specimens and demonstrated a great degree of variation with regard to origin and distribution. The origin of the superior root of AC was found to be superior to the digastric muscle in 92% of the cases. Its vertical descent was found to be superficial to the external carotid artery in 72% (Fig. 1) and superficial to the internal carotid artery in 28% of specimens (Fig. 2).

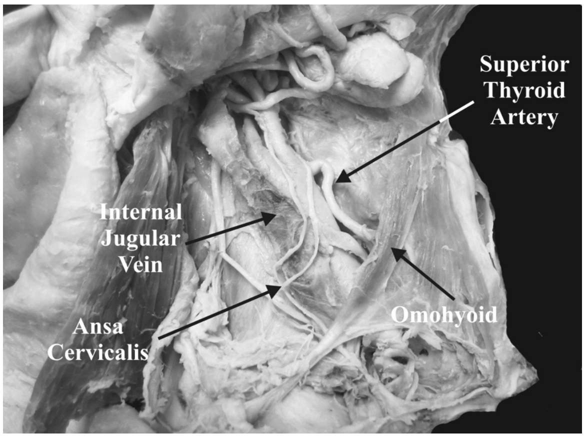

Figure 1. A case of an ansa cervicalis in which both roots are passing around the external carotid artery. The ansa cervicalis is located anterior to the internal jugular vein.

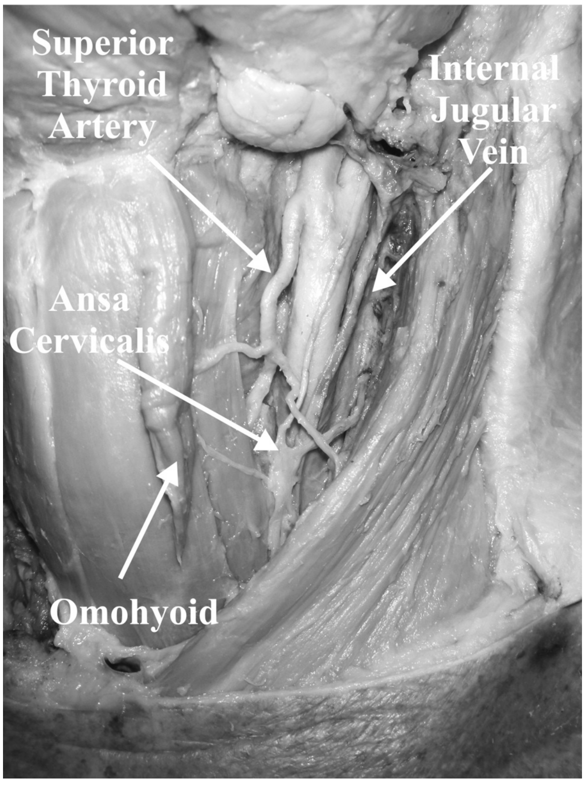

Figure 2. A specimen with an ansa cervicalis that is located anterior to the internal jugular vein and the common carotid artery. Other important landmarks such as the common carotid artery and the superior thyroid artery are evident.

The inferior root of AC was derived from the primary rami of C2 and C3 in 38%, from C2, C3 and C4 in 10%, from C3 in 40% and from C2 in 12%, of the cases. The inferior root passed posterolaterally to the internal jugular vein in 74% (Fig. 3) and anteromedially in 26% of the cases (Figs. 4, 5). The roots of AC were long (70%) or short (30%), and the union between the two roots was situated inferior (long) (Fig. 6) or superior to the omohyoid (short).

The ansa cervicalis morphologically was classified according to the Caliot and Dumont classification patterns [6]: 35% of specimens as had a double classic form (Type I); 20% had a simple classic form (Type II); 20% were double with two separate roots

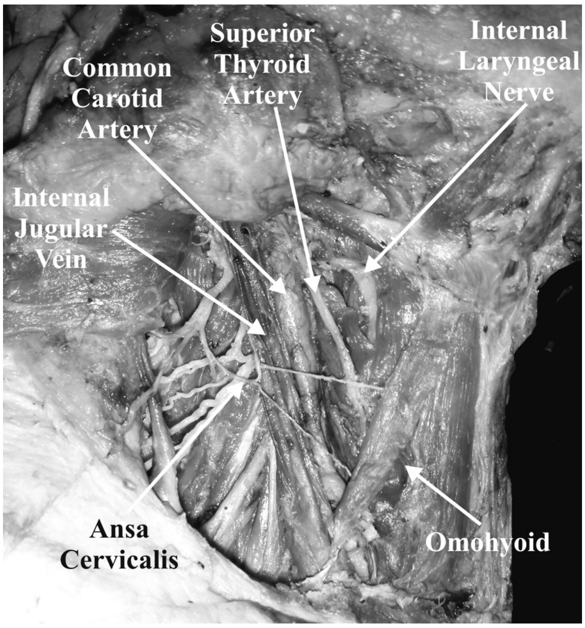

Figure 3. An ansa cervicalis located posterolateraly to the internal jugular vein.

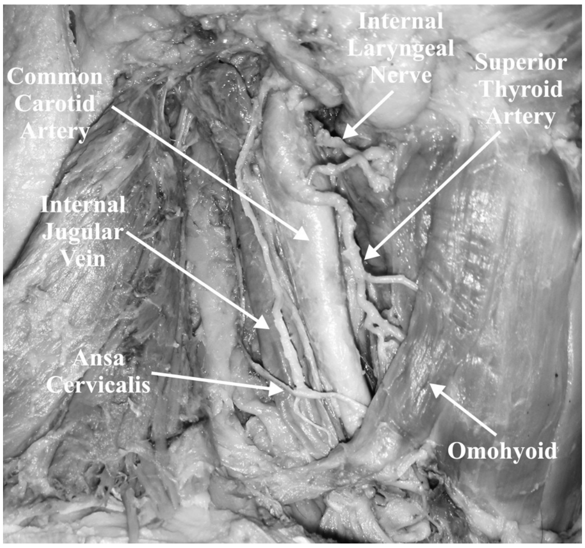

Figure 5. A case of an ansa cervicalis which is located anterior to the internal jugular vein. Other important landmarks such as the common carotid artery, the superior thyroid artery and the internal laryngeal nerve are evident.

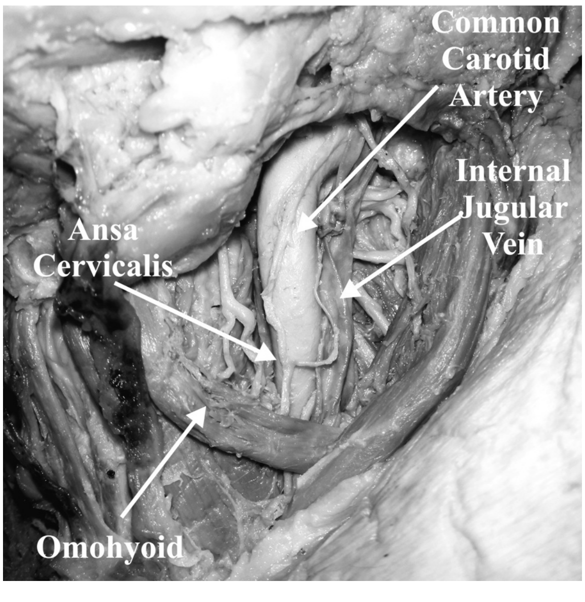

Figure 4. An ansa cervicalis located anterior to the common carotid artery and medial to internal jugular vein.

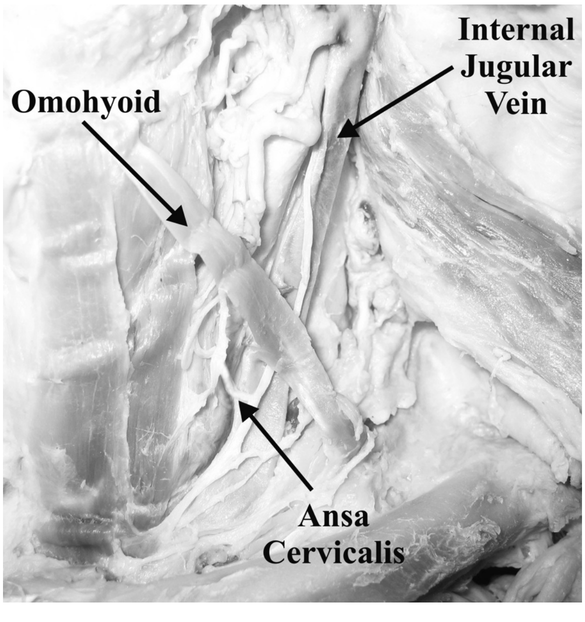

Figure 6. The ansa cervicalis is located inferior to the omohyoid muscle.

(Type III); 10% exhibited a triple form (Type IV); 8% were the double short form (Type V); 4% exhibited the quadruple from (Type VI); 3% of specimens exhibited a single short form (Type VII).

The results of the morphometric analysis were as follows: the mean length of AC was 3.44 cm with a range of 1.1 cm to 5.6 cm; the mean length of the ascending root was 7.6 cm with a range of 5.5 cm to 12.5 cm; the mean length of the descending root was 7 cm with a range of 5.1 cm to 11.6 cm. The mean diameter of AC was 1.3 mm with a range of 0.8 mm to 2.2 mm.

DISCUSSION

According to a literature review by Chhetri and Berke [7], three main components contribute to the morphological variations of AC. The first is the morphological variations of the inferior root, resulting from various cervical root combinations, although it is agreed that C2 and C3 contribute most frequently and C1 and C4 less frequently [5]. The second variation of AC is the length of the loop in relation to the omohyoid muscle. A long AC is described when the loop is located inferior to the omohyoid muscle, and a short AC is described when the loop is located superior to the omohyoid muscle [9, 13]. The ansa loop can be located overlying the carotid sheath where the omohyoid muscle crosses over the internal jugular vein [27]. However, if the inferior root courses medial to the internal jugular vein, the ansa loop may occur between the internal jugular vein and the common carotid artery. In this case it may be necessary to dissect the carotid sheath to find AC. The third variation consists of the various patterns of innervation to the infrahyoid muscles [5]. Interestingly enough, a report by Abu-Hijleh [1] described absence of AC, creating a potential rare fourth variation.

Although the literature reports a multitude of topographical and morphological variations for AC, the main nerve roots and branches are found in relatively conventional locations. The superior root emerges from the medial portion of the arc of the hypoglossal nerve as it turns around the occipital artery to assume a horizontal course toward the tongue and descends along the anterolateral aspect of the internal jugular vein, often embedded within the carotid sheath [17]. Our results indicate that the superior root of AC most often originates superior to the digastric muscle, demonstrated in 92% of the cases, and descends vertically superficial to the external carotid artery (72%) or the internal carotid artery (28%).

The inferior root most commonly arises from the junction of C2 and C3, although C1 and C4 of the ventral cervical rami may also contribute [26]. According to the results published by Caliot and Dumont [6], C3 was the most frequent contributor to the inferior root. Similarly, our results demonstrated that C3 most often contributed to the inferior root, in 40% of the cases, and C2 and C3 together contributed to the inferior root in 38% of the cases.

The descending course of the inferior root occurs in two main patterns that both relate to the internal jugular vein: the root may pass first posterior, then lateral and then anterior to the internal jugular vein, or it may pass medial to the internal jugular vein and continue anteriorly between the internal jugular vein and the common carotid artery [35]. Our results indicated that the inferior root passed posterolaterally to the internal jugular vein in 74% of the cases and anteromedially in 26% of the cases.

The superior and inferior roots form a loop at the location of their anastomosis, determined by the length of the loop and its association with the internal jugular vein. Caliot and Dumont [6] report that the most frequent position of the loop is just deep to the site where the superior belly of the omohyoid muscle crosses the great vessels of the neck. In contrast, our results determined that the union of the two roots was inferior to the omohyoid muscle in 70% of the cases, described as a long AC. Only 30% of the cases exhibited a short AC, where the two roots united superior to the omohyoid muscle.

The nerves to the sternohyoid and sternothyroid are terminal nerves that arise from a common nerve trunk of AC [6, 16, 17]. The nerve to the inferior belly of the omohyoid usually arises from the loop of AC and follows a position adjacent to the intermediate tendon of the muscle [8].

The sternohyoid and sternothyroid muscles are frequently cut in surgery exposing the thyroid gland, often severing nerve branches of AC that enter the superior portions of the muscle at the level of the thyroid cartilage [7, 18, 24]. In patients with thyroid cancer the vocal cords may be paralysed at the time of presentation, or the recurrent laryngeal nerve may need to be sacrificed because of the invasion of cancer, even if the vocal cords had functioned properly before surgery [21]. Recurrent laryngeal nerve paralysis is also commonly seen in patients with oesophageal cancer following lymphadenectomy along the recurrent laryngeal nerve. Additionally, hypoglossal nerve injuries, AC resection and injuries to the sternocleidomastoid vessels are common complications of carotid endarterectomy [4]. The intimate association of AC to the common carotid artery and the internal jugular vein necessitate an appreciation of the clinical anatomy of AC in order to avoid injury to these vessels during AR neurotisation procedures. In addition to this surgical manoeuvre, other surgical procedures such as thyroplasty [14], arytenoid adduction [15], Teflon injection [2] and nerve-muscle pedicle implantation [28] have been reported to cause iatrogenic injuries to AC.

CONCLUSION

The formation of AC is complex and its anatomical course and location along the great vessels of the neck vary. In order to avoid iatrogenic injuries and facilitate surgical procedures that use AC neurotisation procedures in repairing RLNP, the course and morphological variations of AC must be appreciated. We hope that the results of our study will assist surgeons in avoiding inadvertent injury to the great vessels of the neck, namely the internal jugular vein and the common carotid artery, by establishing the clinical anatomy and complex variations of AC.

REFERENCES

1. Abu-Hijleh MF (2005) Bilateral absence of ansa cervicalis replaced by vagocervical plexus: case report and literature review. Ann Anat, 187: 121–125.
2. Arnold GE (1962) Vocal rehabilitation of paralytic dysphonia. VIII. Phoniatric methods of vocal compensation. Arch Otolaryngol, 76: 76–83.
3. Baba M, Aikou T, Natsugoe S, Kusano C, Shimada M, Nakano S, Fukumoto T, Yoshinaka H (1998) Quality of life following esophagectomy with three-field lymphadenectomy for carcinoma, focusing on its relationship to vocal cord palsy. Dis Esophagus, 11: 28–34.
4. Bademci G, Batay F, Tascioglu AO (2005) Non-traumatic elevation techniques of the hypoglossal nerve during carotid endarterectomy: a cadaveric study. Minim Invas Neurosurg, 48: 108–112.
5. Bergman R, Thompson SA, Afifi AK (1988) Compendium of Human Anatomic Variation. Urban and Schwarzenberg, Inc. Baltimore, pp. 137.
6. Caliot P, Dumont D (1983) A contribution to the morphological study of the ansa cervicalis. Rev Laryngol Otol Rhinol (Bord), 104: 441–444.
7. Chhetri DK, Berke GS (1997) Ansa cervicalis nerve: review of the topographical anatomy and morphology. Laryngoscope, 107: 1366–1372.
8. Chhetri DK, Gerratt BR, Kreiman J, Berke GS (1999) Combined arytenoid adduction and laryngeal reinnervation in the treatment of vocal fold paralysis. Laryngoscope, 109: 1928–1936.
9. Clemente CD (1985) Gray's anatomy. 30th American ed. The peripheral nervous system. Lea and Febiger, Philadelphia, pp. 1190–1192.
10. Crumley RL (1991) Update: ansa cervicalis to recurrent laryngeal nerve anastomosis for unilateral laryngeal paralysis. Laryngoscope, 101: 384–388.
11. Crumley RL, Izdebski K (1986) Voice quality following laryngeal reinnervation by ansa hypoglossi transfer. Laryngoscope, 96: 611–616.
12. Hirano M, Tanaka S, Fujita M, Fujita H (1993) Vocal cord paralysis caused by esophageal cancer surgery. Ann Otol Rhinol Laryngol, 102: 182–185.
13. Hollinshead WH (1968) Anatomy for surgeons. Vol. 1, 2nd ed. Harper and Row, New York, pp. 542–544.
14. Isshiki N, Okamura H, Ishikawa T (1975) Thyroplasty type I (lateral compression) for dysphonia due to vocal cord paralysis or atrophy. Acta Otolaryngol, 80: 465–673.
15. Isshiki N, Tanabe M, Sawada M (1978) Aretynoid adduction for unilateral vocal cord paralysis. Arch Otoralyngol, 104: 555–558.
16. Kikuchi T (1970) A contribution to the morphology of the ansa cervicalis and the phrenic nerve. Acta Anat Nipon, 45: 242–281.
17. Kuniak B, Klacansky J (1982) A contribution to topographic anatomy of ansa cervicalis with reference to reinnervation of the larynx. Cesk Otolarynogl, 31: 170–175.
18. Liguoro D, Vital JM, Guerin J, Senegas J (1992) Anatomical basis of the anterior cervical spine approach: topographic study of the nerve structure. Surg Radiol Anat, 14: 203–208.
19. Loukas M, Hullet J, Louis RG Jr, Holdman S, Holdman D (2006) The gross anatomy of the extrathoracic course of the intercostobrachial nerve. Clin Anat, 19: 106–111.
20. Miyauchi A, Matsusaka K, Kawaguchi H, Nakamoto K, Maeda M (1994) Ansa-recurrent nerve anastomosis for vocal cord paralysis due to mediastinal lesions. Ann Thorac Surg, 57: 1020–1021.
21. Miyauchi A, Matsusaka K, Kihara M (1998) The role of ansa-to-recurrent-laryngeal nerve anastomosis in operations for thyroid cancer. Eur J Surg, 164: 927–933.
22. Miyauchi A, Yokozawa T, Kobayashi K, Hirai K, Matsuzuka F, Kuma K (2001) Opposite ansa cervicalis to recurrent laryngeal nerve anastomosis to restore phonation in patients with advanced thyroid cancer. Eur J Surg, 167: 540–541.
23. Natsugoe S, Okumura H, Matsumoto M, Ishigami S, Owaki T, Nakano S, Aikou T (2005) Reconstruction of recurrent laryngeal nerve with involvement by metastatic node in esophageal cancer. Ann Thorac Surg, 79: 1886–1890.
24. Olry R, Haines DE (2002) Ansa hypoglossi or ansa cervicalis? That is the question. J Hist Neurosc, 11: 302–304.
25. Olsen D, Goding G, Dierdre D (1998) Acoustic and perceptual evaluation of laryngeal reinnervation by ansa cervicalis transfer. Laryngoscope, 108: 1767–1772.
26. Poviraev NP, Chernikov YF (1967) Anatomy of the ansa cervicalis. Exerpta Medica, 21: 219.
27. Standring S (2005) Gray's anatomy. 39th ed. Chapter 31. Neck. Elsevier, Churchill, Livingstone, Edinburgh, pp. 555.
28. Tucker H (1981) Laryngeal reinnervation for unilateral vocal cord paralysis. Arch Otol Rhinol Laryngol, 90: 457–459.
29. Ushio H (1981) Clinical and experimental studies on recurrent laryngeal nerve paralysis. Part 1. Clinical studies

(no. 2). Relation between misswallowing and recurrent laryngeal nerve paralysis. J Jpn Surg Soc, 82: 1307–1313.

30. Ushio H (1982) Clinical and experimental studies on recurrent laryngeal nerve paralysis. Part 1. Clinical studies (no. 3). Comparison of phonation ability between end-to-end anastomosis of severed unilateral recurrent laryngeal nerve and severed unilateral recurrent laryngeal nerve. J Jpn Surg Soc, 83: 425–433.
31. Vacher C, Caix P (2004) Anatomie du couple nerf hypoglosse, anse cervicale. Rev Stomatol Chir Maxillofac, 105: 160–164.
32. van Lith-Bijl JT, Mahieu HF (1998) Reinnervation aspects of laryngeal transplantation. Eur Arch Otorhinolayngol, 255: 515–520.
33. van Lith-Bijl JT, Stolk RJ, Tonnaer J, Groenhout C, Konings PN, Mahieu HF (1997) Selective laryngeal reinnervation with separate phrenic and ansa cervicalis nerve transfers. Arch Otolaygol, 123: 406–411.
34. Wang R, Puig CM, Brown DJ (1998) Strap muscle neurovascular supply. Laryngoscope, 108: 973–976.
35. Warwick R, Williams PL eds. (1973) Gray's anatomy. 35th British ed. WB Saunders, Philadelphia, pp.1025–1027.