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ORIGINAL ARTICLE

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Tip of the greater horn of the hyoid bone: a landmark for cervical surgery

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Abstract The purpose of this study was to assess the relevance of the tip of the greater horn of the hyoid bone (THB) in the localization of the carotid bifurcation, the superior thyroid and lingual arteries, and the hypoglossal and superior laryngeal nerves. Measurements of these structures with respect to the THB were also made. Thirty perfusion-fixed human cadavers (60 specimens) were studied. Sharp measurements were made along two orthogonal axes crossing exactly on the THB. The vertical axis was parallel to the craniocaudal axis of the body. Taking the THB as a landmark, the five structures were identified in all the specimens. The mean value, standard deviation, and range of measurements for each structure studied are given in the text. This study shows the THB to be a useful landmark which is an aid to locating the aforementioned structures with confidence, and concludes that knowledge of this landmark would be beneficial for the surgeon dealing with the mid neck area.

Keywords Carotid artery · Superior laryngeal nerve · Hypoglossal nerve · Hyoid bone · Anatomical landmark

Introduction

The hyoid bone is a structure that is easily identified even in greatly altered cervical regions. It has been shown to have a very constant position with respect to the cervical vertebrae [2] while being asymmetric in nearly half of the cases [17]. Its location makes it an important structure for the surgeon dealing with the base of the tongue or the neck area.

Lingeman and Shellhamer stressed the importance of the greater horn of the hyoid bone as a useful landmark to identify the hypoglossal nerve and the external carotid artery [15]. On the other hand, Guerrier described the tip of the greater horn of the hyoid bone (THB) as a key point in mid neck surgery [8]. The objective of this study was to assess the relevance of the THB in the localization of the carotid bifurcation, the superior thyroid artery, the lingual artery, the hypoglossal nerve, and the superior laryngeal nerve. In addition, the distances between these five structures and the THB were measured in order to improve the accuracy of this surgical landmark.

Materials and methods

Thirty perfusion-fixed human cadavers (60 preparations) of both sexes ranging in age from 53 to 84 years (mean 71 years) with no history of neck surgery nor any sign of abnormality in this region were dissected. The heads were placed in hyperextension and 60° contralateral rotation. The superficial layers and the sternocleidomastoid muscle were retracted to allow optimal exposure of the region under study. Preserving the surrounding soft tissue, the carotid axis with its branches, the hypoglossal nerve, and the superior laryngeal nerve were identified in the neck and dissected into the neighborhood of the hyoid bone (Fig. 1a).

All measurements were made by the same person using a pair of compasses. In order to simplify the results, two orthogonal axes crossing exactly on the THB were chosen, with the vertical axis being parallel to the craniocaudal axis of the body. Measurements that were posterior or inferior to the THB were recorded as negative. The carotid bifurcation and the origin of the superior thyroid artery (points *A* and *B*, respectively) were marked by measurements on each axis. The lingual artery was studied at two different points on its path—its

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origin (point *C*) and the culminating point of its first arch (point *D*)—each marked by a measurement on both axes. The hypoglossal nerve was located and measured as it crossed the vertical axis (point *E*). Finally, the internal branch of the superior laryngeal nerve (*IBSLN*) was studied at two different points: behind the THB on the horizontal axis (point *F*) and under the THB on the vertical axis (point *G*). Figure 1b shows the points of measurement.

Data analysis consisted in calculation of the mean and standard deviation for each measurement with identification of minimum and maximum values. In addition, the mean values of the left and right sides were compared in the search for statistically significant asymmetry ($P < 0.05$).

Results

Taking the THB as landmark, the five structures were identified in all the preparations (Table 1). No anatomic variation was observed, except the level of emergence of the superior thyroid artery.

The carotid bifurcation (point *A*) was always located inferior and posterior to the THB: 13.2 ± 5.6 mm inferior and 8.8 ± 2.6 mm posterior. Similarly, the origin of the superior thyroid artery (point *B*) lay 13 ± 4.5 mm below and 4.7 ± 2.7 mm behind the THB. It was located on the external carotid artery in 42 cases (70%), on the carotid bulb in 14 cases (23%), and on the common carotid artery in four cases (7%). The lingual artery derived from the external carotid artery in each dissection. Its origin (point *C*) was located at -0.5 ± 4.4 mm on the vertical axis and -5.6 ± 2.6 mm on the horizontal axis. This artery was also sought more distally along its path, at the highest point of its first arch (point *D*). This point was always located within the submandibular triangle, 7.9 ± 2.7 mm on the vertical axis and 0 ± 2.1 mm on the horizontal axis. The hypoglossal nerve was constantly superior to the THB. It was measured as it crossed the vertical axis (point *E*) at an average of 6.3 ± 1.8 mm. In each specimen, the superior laryngeal nerve was divided into its internal and external branches as it passed at the level of the hyoid bone, with the external branch being deep to the internal one. The IBSLN described its classical curve around the THB. As it passed behind the THB (point *F*), it was situated at a mean distance of 8.4 ± 3.3 mm. It was also identified under the THB on its horizontal segment before piercing the thyrohyoid membrane (point *G*). At this level, it crossed the vertical axis at an average distance of 9.6 ± 1.7 mm. There was no significant difference between the averages of the right and left sides for any measurement.

Discussion

Although experienced head and neck surgeons can easily locate neurovascular structures during neck dissection, reproducible anatomical landmarks remain useful. Indeed, during some procedures with quite limited access, accidental neurovascular lesions are a risk. On the other hand, precise preoperative localization of neurovascular structures allows limited surgical access for selected procedures. Limited cervicotomy for microvascular anastomosis is a direct application of this concept.

The upper margin of the thyroid cartilage is considered a landmark for localization of the carotid bifurcation (point *A*). However, the level of this structure can

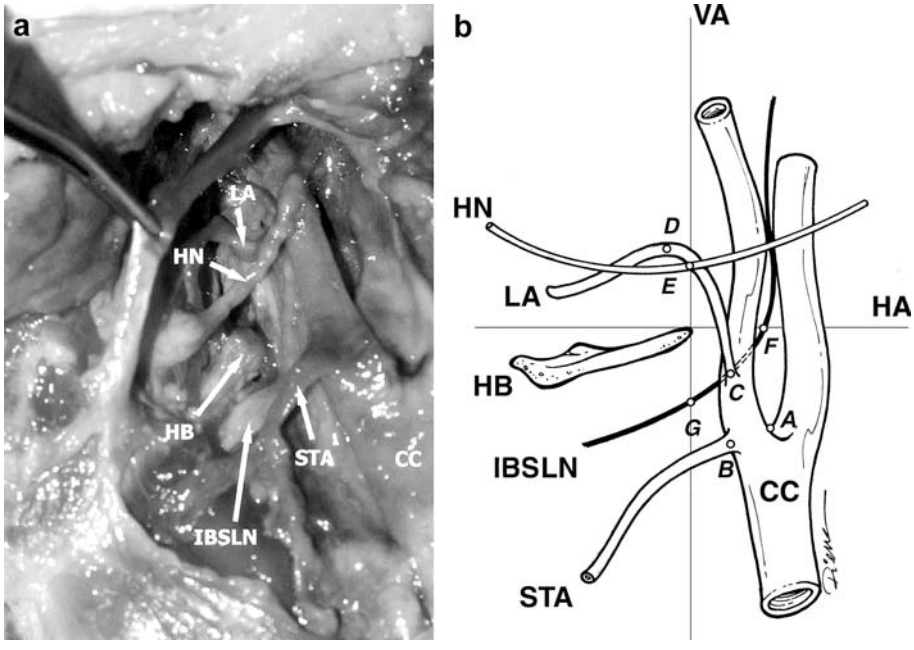

Fig. 1a, b Left anterolateral view of the neck showing the THB and the surrounding structures (**a**) and corresponding line drawing (**b**) illustrating the points of measurement (explained in the text) and the orthogonal axes. *CC* Common carotid artery, *HA* horizontal axis, *HB* hyoid bone, *HN* hypoglossal nerve, *IBSLN* internal branch of the superior laryngeal nerve, *LA* lingual artery, *STA* superior thyroid artery, *VA* vertical axis

Table 1 Position of the common carotid bifurcation, superior thyroid and lingual arteries, and hypoglossal and superior laryngeal nerves with respect to the THB. *HA*, horizontal axis; *SD*, standard deviation; *VA*, vertical axis

Variable	Mean (mm)	SD (mm)	Minimum (mm)	Maximum (mm)
Common carotid bifurcation (point *A*)				
VA	−13.2	5.6	−3	−33.9
HA	−8.8	2.6	0	−13.2
Origin of the superior thyroid artery (point *B*)				
VA	−13	4.5	−5.2	−28
HA	−4.7	2.7	0	−11.9
Origin of the lingual artery (point *C*)				
VA	−0.5	4.4	−13	13
HA	−5.6	2.6	0	−14.2
Culminating point of the lingual artery (point *D*)				
VA	7.9	2.7	1.2	13.1
HA	0	2.1	−6.1	5.3
Hypoglossal nerve (point *E*) VA	6.3	1.8	1.7	11.2
Superior laryngeal nerve (point *F*), HA	−8.4	3.3	−0.2	−24.6
Superior laryngeal nerve (point *G*), VA	−9.6	1.7	−6	−17.8

vary [13]. Therefore, orthogonal localization seems to be a valuable alternative.

Classically, the superior thyroid artery is the first branch of the external carotid artery and arises below the level of the greater horn of the hyoid bone (point *B*) [1]. However, its origin from the common carotid artery is a well-known variation. The results of this study on the relative frequencies of origin of the superior thyroid artery along the carotid axis are consistent with those of Poisel and Golth [18].

Urgent localization of the lingual artery may be necessary to allow its ligation in cases of life-threatening lingual artery hemorrhage causing marked intraoral swelling. Its ligation is also necessary during glossectomy procedures. It is commonly sought within Pirogoff's triangle, but this delineated area has been reported to be present in only 58% of cases [10]. The origin of the lingual artery (point *C*) with respect to the hyoid bone has already been studied, with a mean distance slightly greater than in the present study: 4 ± 4 mm above the level of the greater horn of the hyoid bone [21]. However, the findings relating to the first arch were comparable, with the exception that it was found within the submandibular triangle in only 84% of cases.

The importance of the preservation of both the lingual and the superior thyroid arteries has been highlighted by their contribution to the blood supply of the lower four cranial and cervical nerves [3]. Injuries to these structures as well as to the other main branches of the external carotid artery could in part explain the variable painful impairment observed among different patients after the same nerve losses with similar neck procedures [3]. Another study has demonstrated the importance of the lingual artery in supplying the lingual part of the hypoglossal nerve [7]. Moreover, both vessels are valuable as recipient vessels for free tissue transfer [16, 27].

Lauretano et al. studied the hypoglossal/lingual artery neurovascular bundle with respect to several bony and soft tissue landmarks, including the hyoid bone [11]. They measured it further anteriorly than in the present study (points *D* and *E*) and found it to be located a mean distance of 9 ± 3.7 mm above the hyoid. Homze et al. searched for both structures at about the same level, i.e., the posterior border of the mylohyoid muscle, and found the hypoglossal nerve 9.4 ± 3.4 mm and the lingual artery 6.3 ± 3.9 mm above the hyoid bone [10]. These results confirm those of the present study since the hypoglossal nerve ascends towards the sublingual space as it courses anteriorly, while the lingual artery, which is then covered by the hypoglossus muscle, slopes down to the hyoid bone before becoming the ascending segment of the deep lingual artery [21]. The identification of the nerve using the carotid bifurcation lacks accuracy, due to the variability of relation of the two structures [5, 7]. Maintenance of the integrity of the hypoglossal nerve improves the functional outcome of reconstructive surgery of the oral cavity, whereas, in total glossectomy, the horizontal portion of the nerve is preserved in order to join it to the motor neuron of the flap [27]. Precise knowledge of its localization would also be useful in thyroid surgery since, in markedly enlarged glands, the apex has been seen next to the hypoglossal nerve [26].

The superior laryngeal nerve is constantly divided into its internal and external branches as it passes behind the THB. This disposition has been documented by previous studies [6, 24]. Consequently, the nerve located behind (point *F*) and under (point *G*) the THB was the IBSLN, the external branch lying in a deeper layer. The IBSLN supplies the sensory innervation of the supraglottic mucosa and may contribute to the innervation of the posterior subglottic mucosa [20]. It represents the afferent component of the laryngeal cough reflex, probably via the middle ramus of its intralaryngeal division [22]. Therefore, sparing this nerve in diverse procedures like supraglottic laryngectomy is an essential stage in order to avoid postoperative aspiration pneu-

monia. Hill and Olson first highlighted this fact and proposed looking for the IBSLN in an area bordered by the carotid bifurcation, the greater horn of the hyoid bone, the thyrohyoid muscle, and the superior laryngeal and superior thyroid arteries [9]. The latter has been shown to be a poor landmark for the IBSLN [14].

Knowledge of the anatomy of the area centered on the THB is significant for a number of surgical procedures, including an anterior cervical spine approach [14] and vascular surgery [23]. However, it is especially relevant for lateral pharyngotomy since this approach is anatomically based on the greater horn of the hyoid bone. This technique allows good visualization of the tongue base and pharyngeal wall lesions. In addition, it has functional and esthetic advantages compared to other techniques such as segmental mandibular resection or mandibulotomy so long as important structures are preserved, its disadvantages including potential injury to the hypoglossal and superior laryngeal nerves [4, 19].

Conclusion

The middle part of the neck is an area of significance for many surgical procedures. The vessels and nerves encountered during such procedures have to be spared for functional or reconstructive purposes. The present study emphasizes the importance of the THB as a surgical landmark for the localization of the carotid bifurcation, the superior thyroid and lingual arteries, and the hypoglossal and superior laryngeal nerves. In addition, it gives a range of measurements to give the surgeon greater accuracy during cervical dissection. However, the structures studied can show some variation [10, 12, 13, 25], and one should allow for these potential anomalies in order to prevent complications or to minimize those which cannot be avoided.

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References

1. Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, Fergusson MW (1995) Gray's anatomy, 38th edn. Churchill Livingstone, London, pp 1513–1517
2. Bibby RE, Preston CB (1981) The hyoid triangle. Am J Orthod 80:92–97
3. Brown H, Hidden G, Ledroux M, Poitevan L (2000) Anatomy and blood supply of the lower four cranial and cervical nerves: relevance to surgical neck dissection. Proc Soc Exp Biol Med 223:352–361
4. Byers RM (1994) The lateral pharyngotomy. Head Neck 16:460–462
5. Curto FS, Suarez F, Kornblut AD (1980) The extracranial hypoglossal nerve: 112 cadaver dissections. Ear Nose Throat J 59:94–99
6. Espinoza J, Hamoir M (1988) La préservation de la branche externe du nerf laryngé supérieur en chirurgie thyroïdienne: étude anatomique sur 30 dissections. Acta Otorhinolaryngol Belg 42:623–639
7. Fernando DA, Lord RS, Ozmen J (1999) The blood supply of the hypoglossal nerve and its relevance to carotid endarterectomy. Cardiovasc Surg 7:287–291
8. Guerrier Y (1980) Traité de technique chirurgicale O.R.L. et cervico-faciale, tome 4: cou et cavité buccale. Masson, Paris, pp 14–16
9. Hill JH, Olson NR (1979) The surgical anatomy of the spinal accessory nerve and the internal branch of the superior laryngeal nerve. Laryngoscope 89:1935–1942
10. Homze EJ, Harn SD, Bavitz BJ (1997) Extraoral ligation of the lingual artery: an anatomic study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 83:321–324
11. Lauretano AM, Li KK, Caradonna DS, Khosta RK, Fried MP (1997) Anatomic location of the tongue base neurovascular bundle. Laryngoscope 107:1057–1059
12. Lemaire V, Jacquemin G, Medot M, Fissette J (2001) Thyrolingual trunk arising from the common carotid artery: a case report. Surg Radiol Anat 23:135–137
13. Lie TA (1968) Congenital anomalies of the carotid arteries. Excerpta Medica Foundation, Amsterdam, pp 20–23
14. Liguoro D, Vital JM, Guérin J, Sénégas J (1992) Anatomical basis of the anterior cervical spine approach: topographic study of the nerve structure. Surg Radiol Anat 14:203–208
15. Lingeman RE, Shellhamer RH (1966) Surgical landmarks of the head and neck. Laryngoscope 76:1042–1056
16. Nakatsuka T, Harii K, Ebihara S (1994) An inferior rectus abdominis bridge flap for revascularization of an ischemic tongue. Ann Plast Surg 32:97–100
17. Papadopoulos N, Lykaki-Anastopoulou G., Alvanidou E (1989) The shape and size of the human hyoid bone and a proposal for an alternative classification. J Anat 163:249–260
18. Poisel S, Golth D (1974) Zur Variabilität der großen Arterien im Trigonum caroticum. Wien Med Wochenschr 124:229–232
19. Righi PD, Bade MA, Coleman JJ, Allen M (1996) Arteriovenous malformation of the base of tongue: case report and literature review. Microsurgery 17:706–709
20. Sanders I, Mu L (1998) Anatomy of the human internal superior laryngeal nerve. Anat Rec 252:646–656
21. Shangkuan H, Xinghai W, Zengxing W, Shizhen Z, Shiying J, Yishi C (1998) Anatomic bases of tongue flaps. Surg Radiol Anat 20:83–88
22. Stephens RE, Wendel KH, Addington WR (1999) Anatomy of the internal branch of the superior laryngeal nerve. Clin Anat 12:79–83
23. Verta MJ, Applebaum EL, McClusky DA, Yao JS, Bergan JJ (1977) Cranial nerve injury during carotid endarterectomy. Ann Surg 185:192–195
24. Visset J, Leborgne J, Barbin JY (1975) Le nerf laryngé externe. Bull Assoc Anat (Nancy) 59:1001–1012
25. Weinstein GS, May M (1990) Anomaly of the hypoglossal nerve: embryologic, anatomic, and surgical considerations. Ann Otol Rhinol Laryngol 99:304–306
26. Yerzingatsian KL (1987) Surgical anatomy of structures adjacent to the thyroid apex and post-operative voice change (a review including dissection). J Laryngol Otol Suppl 14:1-13
27. Yousif NJ, Dzwierzynski WW, Sanger JR, Matloub HS, Campbell BH (1999) The innervated gracilis musculocutaneous flap for total tongue reconstruction. Plast Reconstr Surg 104:916–921