Langenbeck's Archives of Surgery (2024) 409:294
https://doi.org/10.1007/s00423-024-03473-y

REVIEW

Key points of surgical anatomy for endoscopic thyroidectomy via a gasless unilateral axillary approach

Kexin Meng[1,2,3] · Ying Xin[1,2,3] · Zhuo Tan[1,2,3] · Jiajie Xu[1,2,3] · Xiaoliang Chen[4] · Jincong Gu[5] · Parikh Nikhilkumar Jagadishbhai[6] · Chuanming Zheng[1,2,3]

Received: 15 March 2024 / Accepted: 6 September 2024

Abstract

Purpose Endoscopic thyroidectomy utilizing the Gasless Unilateral Axillary Approach (GUA) offers distinct advantages including clear visibility, simple manipulation, safe oncological outcomes. This technique eliminates postoperative neck scarring, ensures concealed surgical incisions, and minimizes postoperative swallowing discomfort.
Methods We retrospectively reviewed 150 surgical videos to document key anatomical features and their variations during this procedure.
Results The GUA endoscopic thyroidectomy, which approaches from the contralateral side, presents significant difficulties in identifying anatomical structures, especially anatomical abnormalities in the contralateral neck, while constructing feasible operative fields. This article offers an in-depth discussion of the anatomical challenges, pitfalls, and viable strategies associated with this surgery, particularly for less experienced surgeons.
Conclusions Given the intricate interplay of muscular, vascular, and neural anatomical structures, novices in surgery must be well-acquainted with the underlying anatomy to minimize potential complications.

Keywords Endoscopic thyroidectomy · Gasless unilateral axillary approach · Surgical anatomy

Introduction

The Gasless Unilateral Axillary Approach (GUA) for endoscopic thyroidectomy was first introduced by the Korean surgeon Chung in 2000 [1]. This surgical technique was subsequently introduced in China in 2005. Due to the high costs associated with robotic thyroidectomy, the adoption of robotic surgery remains limited in China. Consequently, the GUA for endoscopic thyroidectomy has emerged as a cost-effective alternative to robotic surgery. Dr. Zheng's advancements, including the introduction of modified retractors [2], and the standardization of surgical space construction [3], have further bolstered the popularity and acceptance of this approach among both surgeons and patients. These sentiments are attributable to its procedural convenience, feasibility, safety, and cosmetic benefits [4].

In addition to thyroid-related surgeries, GUA has been employed in the resection of parathyroid adenomas, lymph node biopsies in regions III/IV, and surgeries involving the brachial plexus. While approaches that enter the central neck provide an operative field comparable to that of open surgery, the GUA endoscopic thyroidectomy, which enters

Kexin Meng and Ying Xin are contributed equally to this work.

✉ Chuanming Zheng
mingdoc@163.com

1 Otolaryngology & Head and Neck Center, Cancer Center, Department of Head and Neck Surgery, Zhejiang Provincial People's Hospital, Affiliated People's Hospital, Hangzhou Medical College, 158 Shangtang Road, Hangzhou 310014, Zhejiang, China

2 Zhejiang Key Laboratory of Precision Medicine Research On Head & Neck Cancer, Hangzhou 310014, China

3 Zhejiang Provincial Clinical Research Center for Malignant Tumor, Hangzhou 310014, Zhejiang, China

4 Department of Thyroid, Breast & Hernia Surgery, Tiantai People's Hospital of Zhejiang Province, Tiantai Branch of Zhejiang Provincial People's Hospital, Hangzhou Medical College, Taizhou 317200, Zhejiang, China

5 Department of Thyroid and Breast Surgery, Zhejiang Southeast Campus of Zhejiang Provincial People's Hospital, Xianju People's Hospital, Affiliated Xianju's Hospital, Hangzhou Medical College, Xianju 317300, Zhejiang, China

6 Zhejiang Chinese Medical University, Hangzhou 310053, Zhejiang, China

Published online: 01 October 2024

from the contralateral side, presents unique challenges for less experienced surgeons. These challenges include difficulties in identifying anatomical structures in the contralateral neck, constructing a feasible operative field within complex anatomical environments, and a higher risk of unintentional tissue trauma. As a result, the learning curve associated with GUA is significantly steeper [5].

To effectively execute the GUA, surgeons must adeptly establish three relative surgical spaces, delineating them within potential tissue gaps. Each of these spatial constructions encounters unique muscles, blood vessels, and nerves. As surgeons navigate the initial stages of learning this approach, a comprehensive grasp of the associated surgical anatomy is imperative. In this article, we will discuss the potential challenges, pitfalls, and viable strategies, addressing the intricacies of each anatomical space in the order they are encountered during surgery.

Materials and methods

We performed 3,214 cases of Gasless Unilateral Axillary (GUA) endoscopic thyroid surgery from December 2019 to January 2024 at Zhejiang Provincial People's Hospital. We retrospectively reviewed 150 surgical videos to document key anatomical features and their variations during this procedure. All videos were recorded by Dr. Zheng, who has significantly contributed to the modification and standardization of gasless endoscopic thyroidectomy via the axillary approach in China [2, 6, 7]. Dr. Zheng's innovations have made this surgical technique more accessible to surgeons in regions with limited medical resources. This study received approval from the Ethics Committee of Zhejiang Provincial People's Hospital (Approval No. QT2023273), and all data were collected with patient authorization.

The patient was positioned supine with shoulders elevated and the upper limb on the surgical side abducted to 90 degrees (Fig. 1). A 4 cm skin incision was made within the natural fold of the left armpit to access the surgical area. Dissection to the anterior neck region was carried out through the anterior surface of the pectoralis major muscle using electric cautery under direct vision. After exposing the clavicular and sternal heads of the sternocleidomastoid (SCM) muscle, the space between these two heads was separated, and a modified retractor was placed between the SCM branches. Following the dissection of the omohyoid muscle, the strap muscles were exposed and dissected laterally. The thyroid cavity was then created by lifting the strap muscles with the retractor, allowing for the dissection of the thyroid gland under endoscopic guidance. Three relatively independent surgical spaces are constructed during this procedure, and we discuss the key surgical anatomy for each space.

Results

Space I. From axillary incision to intermuscular space of sternocleidomastoid muscle

Clavicle

The clavicle while anatomically straightforward, presents challenges in the dissection of the axillary flap. First, its positioning can sometimes be elevated, obstructing the surgeon's view. In cases of a prominent clavicle, the incision can be shifted inward and upward (Fig. 1). This adjustment allows the endoscopic instruments to use the clavicle as a fulcrum, reducing the lever arm and facilitating the operation. While elevating the upper limb on the surgical side can also address this issue, it may risk injury to the brachial plexus. For Asian patients, shifting the incision is a more suitable solution. Additionally, improper placement of surgical instruments may lead to excessive friction with the clavicle, resulting in postoperative discomfort and difficulties in manipulating the instruments.

In thyroidectomy procedures involving the right lobe, central cervical lymph nodes located posterior to the recurrent laryngeal nerve are deeply set, necessitating ample space for their manipulation. Additionally, a low primary

Fig. 1 Position and incision of GUA encoscopic thyroid surgery, red line illustrates the conventional incision and green line shows incision for patients with elevated clavicle. **A** Front view. **B** Lateral view

operational hole for the right hand, and a loosely fixed lifting instrument can complicate surgical manipulation.

While the clavicle's anatomy remains largely consistent, factors like gender, body weight, age, and others can introduce challenges during axillary flap separation. Consequently, preoperative positioning of the upper limb becomes pivotal. Early on, European surgeons recommended positioning the arm raised above the shoulder. However, a suggestion from a Korean surgeon [8] was to elevate the operative side's upper limb at a 90° angle (with shoulder extension and elbow flexion), thereby providing a more expansive space for the surgeon and assistant. Yet, studies showed that extending, elevating, or retracting the upper limb results in the acromioclavicular joint being lifted, potentially obstructing subsequent surgical actions [9].

In theory, a beach chair position (semi-reclining) can lower the clavicle. However, this may elevate the working space required for thyroidectomy. We recommend a natural outward extension of 60° -90° for the upper limb (Fig. 1)[7]. It is important to eliminate the possibility of posterior extension of the upper limb and elevate the elbow if necessary.

Key points: It is essential to assess the height of the patient's clavicle before surgery. During the procedure, proper attention to the patient's upper limb positioning and making precise incisions can significantly streamline subsequent surgical phases.

Supraclavicular nerve

The supraclavicular nerve originates from the C3-C4 nerve roots and forms a common trunk posterior to the sternocleidomastoid muscle (SCM). It traverses the middle of the SCM, subsequently dividing into the medial, intermediate, and lateral bundles. This nerve then descends deep beneath the platysma within the posterior triangle of the neck, progressing through the superficial layer of the cervical fascia and the inferior portion of the platysma. It crosses the clavicle and then terminates in the clavicle, anteromedial shoulder, and the proximal chest skin (Fig. 2A) [10]. The supraclavicular nerve facilitates sensation to the clavicle, the anteromedial shoulder, and the proximal chest wall beneath the clavicle. Damage to this nerve can lead to paresthesia in the shoulder and upper chest, compromising the patient's quality of life [5]. Tae reported a higher incidence of anterior chest pain one month post-operation ($P=0.014$) [11], potentially indicative of supraclavicular nerve paralysis.

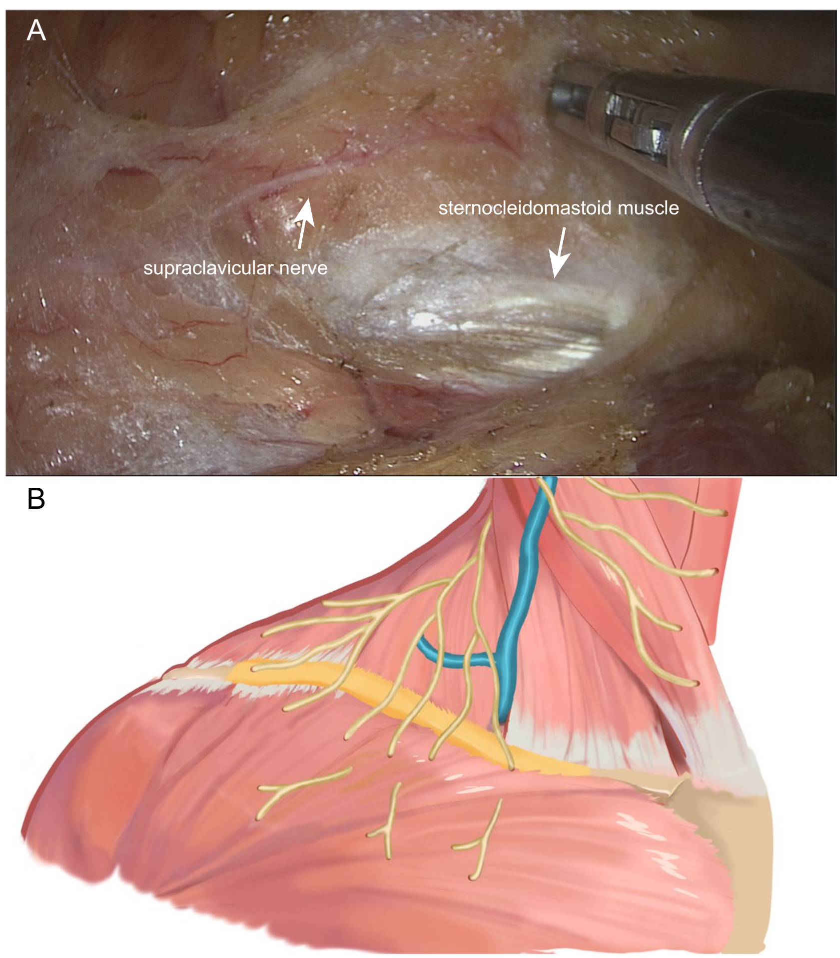


Fig. 2 **A** Supraclavicular nerve passes through the superficial layer of the cervical fascia, and may inadvertently be impacted during an axillary approach surgery. **B** Yellow zone of clavicle shows the region where supraclavicular nerve traverses (within 2.7 cm of the sternoclavicular joint and 1.9 cm of the acromioclavicular joint)

Nathe found that 97% of specimens had two or three nerve bundles that crossed the clavicle [10]. The nerve's surface projection manifests as a triangular area delineated by the midpoint of the SCM's posterior margin, the manubrium sterni, the midpoint of the clavicle, and the acromion. Notably, the precise branch locations at the clavicle vary. The medial branches typically exist within 2.7 cm of the sternoclavicular joint, while the lateral branches lie within 1.9 cm of the acromioclavicular joint (Fig. 2B) [10]. Surgeons should aim to separate the flap above this designated area. Given the nerve's superficial positioning in the subcutaneous fascia, it's susceptible to injury from clamping tissue bundles during coagulation, thermal damage from the harmonic scalpel, and excessive retractor traction. Surgeons must be cautious within the area where the supraclavicular nerve is present. Minimizing traction of the flap during surgery and reducing unnecessary tissue separation can significantly reduce the occurrence of iatrogenic injury.

Key points: To uphold minimally invasive principles and ensure postoperative quality of life, it is essential to prevent injury to the supraclavicular nerve. During the surgery, the following principles should be observed: avoiding thermal injury, avoiding excessive traction, and avoiding clamping large bulks of tissue.

External jugular vein

The external jugular vein (EJV), is the largest superficial vein in the neck, originating from the union of the posterior branch of the retromandibular vein and the posterior auricular vein [12, 13]. The external jugular vein progresses obliquely posteriorly from the mandibular angle, traversing the SCM, and penetrates the layer of deep cervical fascia [14]. The path of the external jugular vein after draining from the posterior border of the SCM, exhibits significant variations.

The terminations of EJV can be classified into three types [15] (Fig. 3), Type I (venous angle type), Type II (subclavian vein type), and Type III (internal jugular vein type). It was observed that Type III was significantly higher in the Chinese population, while Type I was lower (Table 1). Deslaugiers [15] also indicated that the angle between the external jugular vein and the subclavian vein ranged from 20° to 70°, with Type II showcasing the smallest angle and Type I the largest angle.

Table 1 Incidence of three types of external jugular vein terminations

authors	cases	Type I	Type II	Type III
Deslaugiers 15	50 (100 sides)	60%	36%	4%
Kopuz 36	50 (100 sides)	72%	26%	2%
Zhang 37	30 (60 sides)	46.7%	23.3%	30%

During axillary endoscopic surgery, suspended skin flap might compress the EJV. Therefore, it is essential to be cautious with the compressed EJV when displacing the flap outward to expose the SCM. Indiscriminate clamping of tissues without inspecting the vein can incur damage. Type II typically passes through the posterior triangle of the neck, and its trace is close to the dissection region. Before surgery, demarcating the vein's course on the skin is recommended. Given the superficial positioning of the Type II EJV and the direction of dissection aligning with the vein's tangent, managing potential ruptures can be intricate. To achieve satisfactory hemostasis, techniques such as suction devices, endoscopic automatic suturing devices, or titanium clips can be employed.

Key points: The EJV is not a structure mandatorily exposed during the surgical procedure. However, the anatomical variation of Type II may lead to challenges, especially during coagulation. Surgeons are advised to execute judicious tissue separation and to eschew unwarranted expansion of the surgical field.

Space II. Intermuscular space of sternocleidomastoid muscle to thyroid

Sternocleidomastoid muscle

The sternocleidomastoid muscle (SCM) attaches to the manubrium sterni and the clavicle, with its two ends merging into one muscle belly, extending obliquely upward and outward to attach to the mastoid process. Serving as a pivotal anatomical landmark in the neck, the SCM muscle plays a significant role in neck flexion and rotation. It also serves as a common route for axillary approach surgeries. Accurate identification of the gap between the sternal and clavicular heads is a critical step to reach the anterior region of the neck. There are considerable variation types for SCM [16]. Notably, variations related to GUA pertain to the origins of

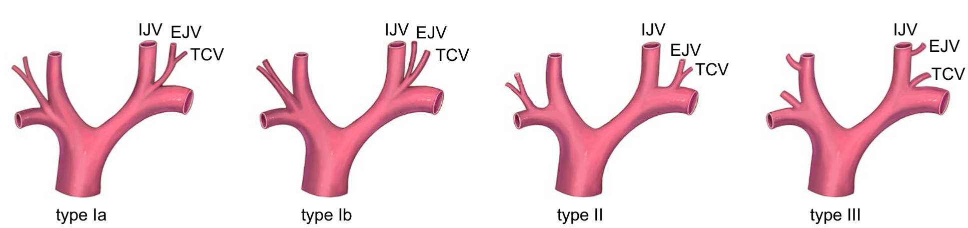


Fig. 3 Three types of terminations of external jugular vein. IJV, internal jugular vein. EJV, external jugular vein. TCV, transverse cervical vein

the SCM's clavicular head [17]. Supernumerary proximal heads [18–20] and morphologic variations [16] are critical, especially in the context of the dimensions of the lesser supraclavicular fossa [21].

Supernumerary proximal heads variation is not uncommon and has a profound effect on surgical pathway establishment. According to the report, supernumerary proximal heads variations in Chinese individuals are mainly 2–4 heads, with 3 heads being the most common, accounting for approximately 47% [22]. The occurrences of 2 heads and 4 heads are approximately 22% and 24%, respectively, and it is not common to have multiple heads variations simultaneously on two sides. This observation also revealed that 27% of cadavers had fusion of the proximal heads on at least one side. This type of variation has also been reported in different ethnic groups [18–21]. We also encountered multiple heads variations in surgery occasionally. These additional heads might interfere identifying lesser supraclavicular fossa (intermuscular space of SCM) (Fig. 4A), posing challenges for surgeons.

Morphologic variation is relatively rare, which can be described as separate sternomastoid and cleidomastoid bellies, or as fusion of these two entities. In a study conducted on 50 cadavers (100 sides) within the Chinese cohort, Li [23] discerned that a dominant 80% exhibited the prototypical bi-headed configuration. The fusion type, where the sternal head and clavicular head were merged, accounted for 11%. A smaller fraction, 5%, had separated sternal head and clavicular head. The remaining 4% showed multiple heads. The fusion type can occur in multiple heads variation, causing overlapping or stenosis of the lesser supraclavicular fossa.

Furthermore, due to individual variations in body size, the base length (clavicle side) of lesser supraclavicular fossa can vary. This also holds true for the line connecting its apex to its base. In a study conducted by Yin [24], measurements were taken on the right lesser supraclavicular fossa in 200 healthy adults, and it was found that 15% of individuals had a base length $\leq$ 1 cm. An excessively narrow base can also introduce uncertainty in locating the intermuscular space.

Additionally, if the origin of the clavicular head involves the sternoclavicular joint capsule, it may extend the clavicular head backward towards the sternum. This extension could lead to the disappearance of the lesser supraclavicular fossa due to overlapping muscles. Anatomical variations original part of SCM will result in stenosis of the less supraclavicular fossa, posing challenges in the surgical route establishment for this surgery.

The correct identification of lesser supraclavicular fossa is crucial during surgery. If the separation is too shallow, it may lead to the penetration of the flap above SCM. Conversely, if the separation is too deep, it may go beneath the SCM and directly face the internal jugular vein (IJV). If the separation position is too low, it might miss the intermuscular space and directly reach the contralateral thyroid gland through loose connective tissue above the suprasternal fossa.

For those new to this surgical procedure, it is essential to be aware of anatomical structure in this area, and continuously adjust the surgical route with surface markings. Preoperative CT scans can assist in evaluating the dimensions of the lesser supraclavicular fossa (Fig. 4B). Another essential consideration is the use of retractor, excessive force caused by the retractor will tear myofiber of SCM. With sufficient upward traction and proper insertion, the intermuscular space can be naturally exposed. However, when encountering anatomical variations of the SCM, subtle dissection may be required, and the intermuscular space can often be recognized by a thin layer of fatty connective tissue.

Key points: The identification of the intermuscular space of SCM is the first technical challenge for beginners. Common errors include separating too superficially, too deeply, or too low. Proper insertion of retractor is crucial for exposing this structure.

Superior root of the ansa cervicalis

The ansa cervicalis, situated deep to the SCM, is an ideal choice for nerve replantation in patients with recurrent laryngeal nerve paralysis garnering significant attention. It is comprised of both superior and inferior roots, forming a nerve loop [25]. The superior root of ansa cervicalis, also referred to as the descendens hypoglossi [25, 26], integrates fibers from branches of the first and second cervical spinal nerve (C1–2) [27]. The superior root travels with the hypoglossal nerve and descends along the anterior wall of

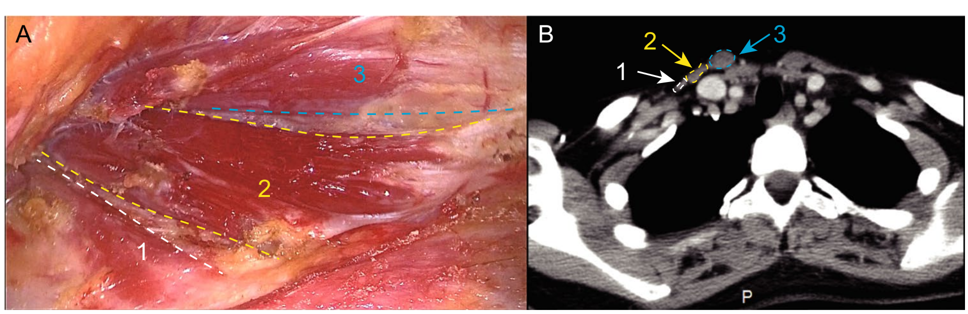


Fig. 4 Three heads of sternocleidomastoid muscle, from axillary approach surgical view (**A**) and CT scan (**B**)

the carotid sheath, then gives rise to branches to innervate the omohyoid, sternothyroid and sternohyoid muscles. Currently, it is recommended to use the term "superior root of the ansa cervicalis" for this section, given that it lacks components of the hypoglossal nerve fibers.

The superior root of the ansa cervicalis travels along the carotid sheath. However, its relationship with the internal carotid artery and IJV is not fixed. According to Lv [28], based on the autopsy results of 65 cases, the positions of the superior root in relation to the neck vasculature were as follows: 54% were located in front and lateral to the carotid artery, 34% were between the internal carotid artery and IJV, and 8% were in front of the carotid artery. Therefore, there is a high possibility of coming across the superior root of the ansa cervicalis while detaching strap muscles above the thyroid (Fig. 5).

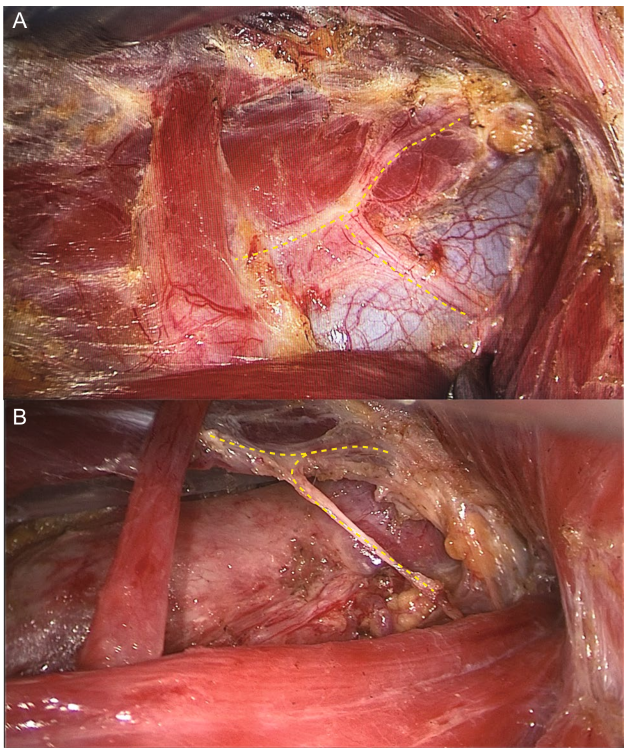


Fig. 5 Yellow dotted line delineates the superior root of the ansa cervicalis and the loop. **A** The superior root was detected in the surgical route establishment. **B** The loop preserved intactly after surgery

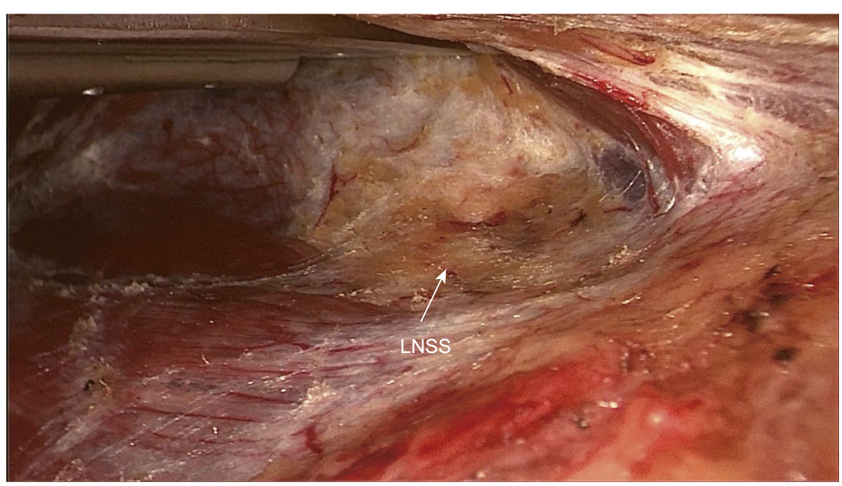
Key points: Beginners may mistakenly identify the ansa cervicalis as the recurrent laryngeal nerve. Damage to the ansa cervicalis can lead to muscle atrophy but does not result in serious consequences. However, neglecting or irresponsibly damaging the ansa cervicalis during surgery contradicts the minimally invasive concept of endoscopic thyroid surgery, leading to muscle denervation.

Lymph nodes between sternocleidomastoid and sternohyoid

The lymph nodes between the sternocleidomastoid and the sternohyoid muscle (LNSS), are categorized within the Level IV cervical lymph nodes. These are also known as the muscular nodes (Fig. 6). Studies have indicated that the incidence of LNSS metastasis in patients ranged from approximately 9.1%-22.6% [29, 30]. Among those with LNSS metastasis, most were classified as pN1b (especially level III and level IV nodal metastasis) [29] and have T3/4 stage tumors [30]. LNSS has a relatively higher rate of metastasis for lesions in the inferior lobe of the thyroid compared to other regions [29, 31]. The preoperative evaluation of LNSS using ultrasound can be challenging due to the obstruction of the clavicle. However, enlargement of LNSS can be detected through neck CT or MRI.

Key points: For cases of thyroid tumors located in the inferior lobe, it is essential to carefully assess the lymph nodes of the sternocleidomastoid-sternohyoid muscle space (LNSS) in the surgery. Moreover, lymphatic adipose tissue

Fig. 6 The lymph nodes between the sternocleidomastoid and the sternohyoid muscle from axillary approach surgical view. LNSS, lymph nodes between the sternocleidomastoid and the sternohyoid muscle



excision of this area will improve the surgical field for central lymphadenectomy.

Omohyoid muscle, internal jugular vein

The omohyoid muscle is easily identifiable and serves as an anatomical landmark for locating the sternothyroid muscle and the internal jugular vein (IJV). In this region, the muscle is situated at the convergence of various fascias, including the inner border of the SCM's clavicular head, the outer border of the strap muscle, and the inner border of the carotid sheath. Laterally, surgeons may come across the IJV and its branching vessels, whereas medially, structures like the ansa cervicalis and thyroid gland are present. Many of these fascias are dense, making certain structures challenging to discern from a lateral perspective in GUA.

In axillary endoscopic surgery, the lateral border of omohyoid muscle and the lateral side of the strap muscle form a triangular region, where small vessels drain into IJV (Fig. 7). The isolation of this region is beneficial for the exposure of the inferior lobe of the thyroid.

For an optimal surgical viewpoint, the omohyoid muscle should be positioned by the retractor in the middle and upper 1/4 to 1/3 of the thyroid after the surgical cavity is created. However, due to factors such as the position of incision, the size of the thyroid, and patient anatomical variations, this muscle may sometimes obstruct the central surgical field. In such cases, fully isolating the omohyoid muscle and suspending it from the bottom completely by retractor can facilitate the field of view expansion. Beginners may also consider cutting off this muscle, since the postoperative appearance and neck movement will not be affected. However, from a minimally invasive perspective, it is not recommended to cut off the omohyoid muscle.

There are slight anatomical differences between the left and right IJV [32]. The right IJV is generally thicker and almost aligns in a straight line with the brachiocephalic vein and superior vena cava. The relationship between the thyroid surrounding vessels and the internal jugular vein is also close. Turning the head to the right accentuates the overlap between the left IJV and the common carotid artery. Given these considerations, during IJV detachment, surgeons should pay attention to the pathways of small vessels such as the middle thyroid vein, to avoid forceful tearing and subsequent bleeding. Due to the increased overlap between the IJV and common carotid artery, acquiring the signal of vagus nerve stimulation on the right side may be relatively easier during recurrent laryngeal nerve monitoring.

Key points: Omohyoid muscle is an anatomical landmark for GUA. The connective tissue on the inner border of the internal jugular vein and the outer border of the strap muscle is relatively dense, which is relatively hard for beginners to manipulate. Finding a safe entrance to access thyroid bed is of vital importance.

Sternohyoid

The strap muscle is composed of sternothyroid, sternohyoid, thyrohyoid and omohyoid [33]. The sternohyoid is located above sternothyroid and thyrohyoid. Typically, the sternothyroid is more laterally positioned compared to sternohyoid. During axillary endoscopic surgery, surgeons must detach the lateral border of sternothyroid and sternohyoid from the dense fascia.

The sternohyoid originates from the medial edge of the clavicle bone, sternoclavicular ligament, and posterior side of the manubrium [34]. Reports on the origin variation of sternohyoid are rare. From GUA, we have encountered cases with the sternohyoid arising entirely from the clavicle (Fig. 8), which makes it challenging to separate the lateral border. When facing such variations, our experience is to perform a medial-to-lateral separation of this muscle from midline, and then expose the sternothyroid. Subsequently,

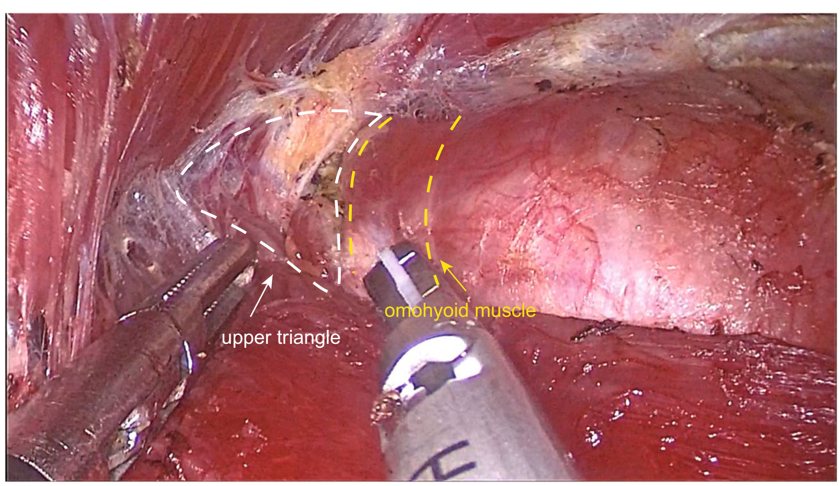


Fig. 7 The triangular region formed by the lateral border of omohyoid muscle and the lateral side of the strap muscle, where small vessels drain into internal jugular vein

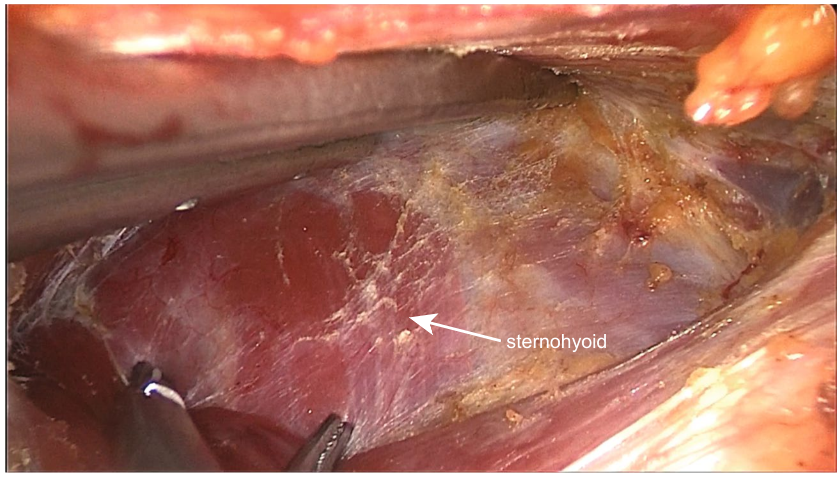


Fig. 8 Sternohyoid arises entirely from the clavicle

we proceed with the routine separation of the lateral border of the sternothyroid to expose the thyroid.

Key points: Accurate identification of the IJV and the boundaries of the strap muscle is essential for effective access to the thyroid bed.

Space III. Thyroid bed

Distinct from the open procedure, axillary approach like GUA provides a lateral view. Due to the change from a downward to a horizontal view, recurrent laryngeal nerve is more superficial for the former, especially in cases with small thyroid or slim body. For patients with Hashimoto's thyroiditis or enlarged thyroid, the recurrent laryngeal nerve may be situated more deeply. In these instances, surgeons need to expand the surgical field for a better exposure through lowering the structures like the internal jugular vein.

The identification of parathyroid glands and external branch of the superior laryngeal nerve (EBSLN) is relatively easy due to the magnified endoscope view and lateral vision. The recurrent laryngeal nerve monitoring facilitates the recognition of recurrent laryngeal nerve and EBSLN. When safeguarding the EBSLN, it is notably easier to access via GUA than through the transoral vestibular approach (TVA) or conventional open surgery (Fig. 9). With TVA, transection of the strap muscles is inevitable to expose the superior lobe and EBSLN. However, during the exposure of the thyroid lobe, surgeons need to be aware of the possibility of the lobe shifting to the opposite side due to the retractor usage [35].

The anatomical variations of recurrent laryngeal nerve, parathyroid glands, and superior laryngeal nerve are well interpreted in many literatures and will not be discussed here.

Key points: How to effectively utilize the retractor in thyroid surgery to provide a safe and surgeons-friendly space is a question worth considering.

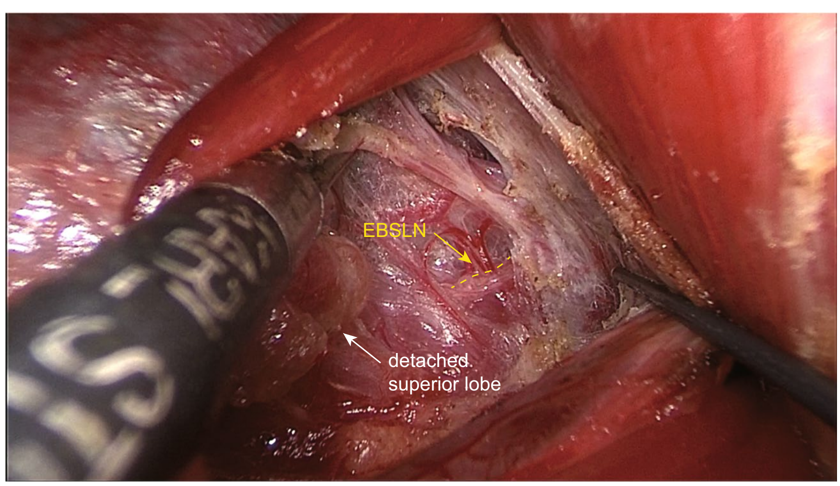


Fig. 9 The external branch of the superior laryngeal nerve (yellow dotted line) can be detected while detaching the superior thyroid lobe from gasless unilateral axillary approach. EBSLN, external branch of the superior laryngeal nerve

Conclusion

GUA is a type of endoscopic thyroid surgery performed through a lateral neck incision, which has advantages in terms of better cosmetic satisfaction, no CO_2 insufflation, and a low level of swallowing impairment. As one of the minimally invasive cosmetic endoscopic thyroid surgeries, reducing related complications during the long-distance route establishment is a crucial concern for surgeons. Throughout the procedure, surgeons may encounter anatomical variations in neck muscles, blood vessels, and nerves. A comprehensive understanding of the challenges and strategies associated with each anatomical region can lead to decreased surgical complications and more favorable outcomes.

Author contribution KX Meng: manuscript writing Y Xin: manuscript editing Z Tan: concept JJ Xu: definition of intellectual content XL Chen: data collection JC Gu: literature search PN Jagadishbhai: manuscript review CM Zheng: protocol development.

Funding National Natural Science Foundation of China (82372618), Traditional Chinese Medicine Science and Technology Project of Zhejiang Province (2021ZA013), and General Scientific Research Project of Education Department of Zhejiang Province (Y202146111, Y202352347).

Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval This study was approved by the Ethics Committee of Zhejiang Provincial People's Hospital (Approval No. QT2023273).

Patient consent statement Written informed consent was obtained from patient for publication.

Conflict of interest The authors declare no competing interests.

References

1. Yoon JH, Park CH, Chung WY (2006) Gasless endoscopic thyroidectomy via an axillary approach: experience of 30 cases. Surg Laparosc Endosc Percutan Tech 16:226–231
2. Zheng C, Mao X, Wang J, Tan Z, GE M (2018) Preliminary evaluation of effect of endoscopic thyroidectomy using the gasless unilat-eral axillary approach. Chin J Clin Oncol, pp 27–32
3. Zhou Y, Cai Y, Sun R, Shui C, Ning Y, Jiang J, Wang W, Sheng J, Jiang Z, Tang Z et al (2021) Gasless transaxillary endoscopic thyroidectomy for unilateral low-risk thyroid cancer: Li's six-step method. Gland Surg 10:1756–1766
4. Xu S, Yang Z, Guo Q, Zou W, Liu S, Gao Q, Wu M, An X, Han Y (2022) Surgical steps of gasless transaxillary endoscopic thyroidectomy: from A to Z. J Oncol 2022:2037400
5. Xu JJ, Zhang LZ, Zhang QH, Guo HW, Tan Z, Wang JF, Jiang LH, Zheng CM, Ge MH, Lan XB (2020) Clinical application of the gasless unilateral axillary approach in endoscopic thyroid surgery. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi 55:913–920
6. Zheng G, Xu J, Wu G, Ma C, Sun H, Ge M, Zheng H, Zheng C (2022) Transoral versus gasless transaxillary endoscopic thyroidectomy: a comparative study. Updates Surg 74:295–302
7. Ge M, Zheng C, Gao M, Cheng R, Tian W, Zheng X, Lei S, Li C, Wei T, Shi L (2021) Expert consensus on endoscopic thyroidectomy by a gasless unilateral axillary approach (version 2022). Chin J Endocr Surg 15:557–563
8. Kang SW, Jeong JJ, Yun JS, Sung TY, Lee SC, Lee YS, Nam KH, Chang HS, Chung WY, Park CS (2009) Gasless endoscopic thyroidectomy using trans-axillary approach; surgical outcome of 581 patients. Endocr J 56:361–369
9. Ludewig PM, Phadke V, Braman JP, Hassett DR, Cieminski CJ, LaPrade RF (2009) Motion of the shoulder complex during multiplanar humeral elevation. J Bone Joint Surg Am 91:378–389
10. Nathe T, Tseng S, Yoo B (2011) The anatomy of the supraclavicular nerve during surgical approach to the clavicular shaft. Clin Orthop Relat Res 469:890–894
11. Tae K, Ji YB, Cho SH, Kim KR, Kim DW, Kim DS (2011) Initial experience with a gasless unilateral axillo-breast or axillary approach endoscopic thyroidectomy for papillary thyroid microcarcinoma: comparison with conventional open thyroidectomy. Surg Laparosc Endosc Percutan Tech 21:162–169
12. Dalip D, Iwanaga J, Loukas M, Oskouian RJ, Tubbs RS (2018) Review of the variations of the superficial veins of the neck. Cureus 10:e2826
13. Shenoy V, Saraswathi P, Raghunath G, Karthik JS (2012) Double external jugular vein and other rare venous variations of the head and neck. Singapore Med J 53:e251-253
14. Park SO, Ahn KC, Hong KY, Chang H, Imanishi N (2017) External jugular veno-accompanying artery adipofascial flap: A novel and convenient flap for head and neck reconstruction. Head Neck 39:2249–2255
15. Deslaugiers B, Vaysse P, Combes JM, Guitard J, Moscovici J, Visentin M, Vardon D, Bécue J (1994) Contribution to the study of the tributaries and the termination of the external jugular vein. Surg Radiol Anat 16:173–177
16. Hasan T (2011) Variations of the sternocleidomastoid muscle: a literature review. Internet J Hum Anat 1:3425–3428
17 Silawal S, Schulze-Tanzil G (2022) The sternocleidomastoid muscle variations: a mini literature review. Folia Morphol (Warsz) 82(3):507–512
18. Heo YR, Kim JW, Lee JH (2020) Variation of the sternocleidomastoid muscle: a case report of three heads and an accessory head. Surg Radiol Anat 42:711–713
19. Kim SY, Jang HB, Kim J, Yoon SP (2015) Bilateral four heads of the sternocleidomastoid muscle. Surg Radiol Anat 37:871–873

20. Oh JS, Kim CE, Kim J, Yoon SP (2019) Bilateral supernumerary clavicular heads of sternocleidomastoid muscle in a Korean female cadaver. Surg Radiol Anat 41:699–702
21. Natsis K, Asouchidou I, Vasileiou M, Papathanasiou E, Noussios G, Paraskevas G (2009) A rare case of bilateral supernumerary heads of sternocleidomastoid muscle and its clinical impact. Folia Morphol (Warsz) 68:52–54
22. Li M (1956) Research on the anatomical and anthropological characteristics of the sternocleidomastoid muscle in chinese population - Part V. J Haerbin Med Univ 3:35-40
23. Li Y, Dai B (1988) Observation report on the types of the sternocleidomastoid muscle's starting heads. J Ningxia Med Coll 4:119–120
24. Yin G, Chen K (1991) Measurement of the right-sided sternocleidomastoid muscle triangle in normal neck. Chin J Anesthesiol, pp 117–118
25. Kikuta S, Jenkins S, Kusukawa J, Iwanaga J, Loukas M, Tubbs RS (2019) Ansa cervicalis: a comprehensive review of its anatomy, variations, pathology, and surgical applications. Anat Cell Biol 52:221–225
26. Chhetri DK, Berke GS (1997) Ansa cervicalis nerve: review of the topographic anatomy and morphology. Laryngoscope 107:1366–1372
27. Loukas M, Thorsell A, Tubbs RS, Kapos T, Louis RG Jr, Vulis M, Hage R, Jordan R (2007) The ansa cervicalis revisited. Folia Morphol (Warsz) 66:120–125
28. Lv D, Liu C, Chen R (1984) Survey of the Ansae Cervicales in chinese individuals. Anatomy Research 6:24–28
29. Sun G, Wang Y, Zhu Y, Wang Y, Xu K, Wei W, Li H, Lu Z, Ji Q (2013) Lymph node metastasis between sternocleidomastoid and sternohyoid muscle in clinically node-positive papillary thyroid carcinoma. Head Neck 35:1168–1170
30. Zhai Y, Ruan L (2022) The necessity of lymph node dissection between sternocleidomastoid and sternohyoid muscles in pn1b papillary thyroid carcinoma. Front Endocrinol (Lausanne) 13:865621
31. Song L, Zhou J, Chen W, Li G, Wang Z, Xue G, Wu J, Yan H, Lei J, Zhu J (2021) Lymph node metastasis between the sternocleidomastoid and sternohyoid muscle in papillary thyroid carcinoma patients: a prospective study at multiple centers. Asian J Surg 44:1043–1049
32. Shoja MM, Ardalan MR, Tubbs RS, Loukas M, Vahedinia S, Jabbary R, Jalilvand M, Shakeri A (2008) The relationship between the internal jugular vein and common carotid artery in the carotid sheath: the effects of age, gender and side. Ann Anat 190:339–343
33. Janus JR, Moore EJ, Price DL, Kasperbauer J (2012) Robotic thyroid surgery: clinical and anatomic considerations. Clin Anat 25:40–53
34. Nguyen JD, Duong H (2023) Anatomy, head and neck, sternohyoid muscle. StatPearls, Treasure Island. Available from: https://www.ncbi.nlm.nih.gov/books/NBK547693/
35. Meng K, Chen X, Shen W, Xin Y (2023) Gasless transaxillary endoscopic surgery for papillary thyroid carcinoma in a patient with thyroid hemiagenesis: an appropriate choice or not? Asian J Surg 46:4545–4546
36. Kopuz C, Akan H (1996) The importance of the angulation and termination of external jugular vein in central venous catheterization in newborn. Okajimas Folia Anat Jpn 73:155-159
37. Zhang YZ, Zhang L, Zhang W, Wang Y, Li SY (2009) Anatomy of external jugular vein and its clinical applied study. Chinese Clinical Nursing, pp 95-97