The Impact of Body Mass Index on Safety and Efficacy of Endoscopic Radical Thyroidectomy via Gasless Unilateral Axillary Approach for Thyroid Cancer Patients

Ann. Ital. Chir., 2025 96, 8: 1103–1109
https://doi.org/10.62713/aic.4134

Haiwei Guo[1,2,3], Jiajie Xu[1,2,3], Chuanming Zheng[1,2,3], Wenjie Xia[4], Tianwei Zhan[1,2,3]

[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, 310014 Hangzhou, Zhejiang, China
[2]Zhejiang Provincial Clinical Research Center for Head & Neck Cancer, 310014 Hangzhou, Zhejiang, China
[3]Zhejiang Key Laboratory of Precision Medicine Research on Head & Neck Cancer, 310014 Hangzhou, Zhejiang, China
[4]General Surgery, Cancer Center, Department of Breast Surgery, Zhejiang Provincial People's Hospital (Affiliated People's Hospital), Hangzhou Medical College, 310014 Hangzhou, Zhejiang, China

AIM: To evaluate the safety and efficacy of endoscopic radical thyroidectomy via the gasless unilateral axillary approach (GUAA) for thyroid cancer patients across different body mass index (BMI) categories.

METHODS: A total of 333 patients with papillary thyroid carcinoma who underwent GUAA unilateral thyroidectomy and central lymph node dissection between June 2021 and February 2023 were retrospectively analyzed. The patients had been followed up for at least longer than 1 year. Patients were stratified into four groups based on their BMI: Group 1 (control group, $18.5 \leq \text{BMI} < 24$), Group 2 (BMI <18.5), Group 3 ($24 \leq \text{BMI} < 28$), and Group 4 (BMI ≥ 28). The Group 3 and 4 defined as high BMI group while Group 1 defined as low BMI. The surgical-related indicators, operative time, numbness in the supraclavicular area, and rates of complication incidence between the four groups were compared.

RESULTS: There were no significant differences among the groups in terms of age, sex, tumor location (left or right), number of central lymph node dissections, central lymph node metastasis rates, total drainage volume, or postoperative hospital stay ($p > 0.05$). However, patients with higher BMI experienced significantly longer operative time compared to the control group (128.14 ± 38.69 min [Group 3], 142.17 ± 37.92 min [Group 4] vs. 114.33 ± 38.79 min [Group 1], $p < 0.05$). The incidence of complications—including recurrent laryngeal nerve (RLN) palsy, incision infection, and postoperative bleeding—did not differ significantly among groups. However, patients with low BMI (Group 1) had a significantly higher incidence of supraclavicular numbness compared to the Group 2 (56.25% vs. 8.04%, $p < 0.05$).

CONCLUSIONS: Endoscopic thyroidectomy via gasless unilateral axillary approach is a safe surgical option for patients with thyroid cancer. High BMI is associated with longer operative time but does not increase complication rates. The average surgical duration for obese patients is approximately 28 minutes longer than that for patients with normal weight. Patients with low BMI require particular attention to the protection of the supraclavicular nerve to reduce the risk of postoperative numbness.

Keywords: papillary thyroid carcinoma; gasless unilateral axillary approach; thyroidectomy; supraclavicular nerve; body mass index

Introduction

With the rising incidence of thyroid cancer, the demand for thyroid surgery has increased. Patients are increasingly concerned with the aesthetic outcomes following thyroid surgery. Since the advent of endoscopic thyroid surgery in 1997, scarless procedures have gained widespread adoption [1]. Currently, the most common surgical approaches include the gasless unilateral axillary approach (GUAA) [2], bilateral axillo-breast approach [3], axillo-bilateral breast approach, unilateral axillo-breast approach, chest-breast approach, and the transoral approach [4,5]. Among these approaches, GUAA has become increasingly popular due to its favorable aesthetic and functional outcomes [6,7]. However, the rising prevalence of overweight and obesity—mostly associated with lifestyle changes—poses new challenges. Statistics have shown that between 1975 and 2016, the proportion of obese individuals had markedly increased [8]. Higher body mass index (BMI) is associated not only with an increased risk of thyroid cancer [9], but also with more aggressive pathological features [10]. Consequently, an increasing number of patients with high BMI require thyroid surgery. While some prior studies suggested that

Submitted: 26 April 2025 Revised: 28 May 2025 Accepted: 11 June 2025 Published: 10 August 2025
Correspondence to: Tianwei Zhan, 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, 310014 Hangzhou, Zhejiang, China; Zhejiang Provincial Clinical Research Center for Head & Neck Cancer, 310014 Hangzhou, Zhejiang, China; Zhejiang Key Laboratory of Precision Medicine Research on Head & Neck Cancer, 310014 Hangzhou, Zhejiang, China (e-mail: zhantianwei2009@126.com).

BMI does not significantly affect the incidence of postoperative complications following thyroid surgery, others showed that obesity is associated with increased risks of postoperative complications [11,12]. Therefore, most overweight and obese patients tend to choose open surgery. This preference is largely driven by the perception among both patients and physicians that patients with high BMI have greater difficulty with endoscopic surgery, leading to longer surgical times and more complications. The cosmetic needs of these patients are often overlooked, which is unfair.

The GUAA is gaining traction as a preferred technique for patients seeking both oncological efficacy and aesthetic satisfaction. Nevertheless, research on the impact of BMI, specifically on GUAA outcomes, remains limited. In this study, we retrospectively analyzed the outcomes of patients undergoing GUAA performed by the same surgical team, focusing on operative time and the unique complication associated with GUAA, namely the supraclavicular skin numbness. We aim to compare the operative time and complication rate among patients with different BMIs undergoing GUAA surgery.

Materials and Methods

Clinical Information

This study retrospectively analyzed 333 patients who underwent endoscopic radical thyroidectomy via the GUAA in the Department of Head and Neck Surgery, Zhejiang Provincial People's Hospital between June 2021 and February 2023. All surgeries were performed by the same surgical team. Each patient underwent unilateral thyroidectomy with isthmus resection and ipsilateral central lymph node dissection for papillary thyroid carcinoma. All primary tumors measured less than 1 cm to minimize differences in surgical difficulty. Patients aged 18–60 years who underwent radical surgery for thyroid cancer with GUAA were included. Patients with a history of neck surgery, neck radiation therapy, or Hashimoto's thyroiditis were excluded from the study. The included patients were categorized according to official Chinese guidelines on BMI classification [13], as follows: Group 1 (control group with normal weight; $18.5 \leq \text{BMI} < 24$), Group 2 (underweight; BMI <18.5), Group 3 (overweight; $24 \leq \text{BMI} < 28$), and Group 4 (obese; BMI ≥ 28). This study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Institutional Review Board of Zhejiang Provincial People's Hospital (NO: QT2025102).

Operative Method

Following general anesthesia, patients were placed in the supine position with the ipsilateral upper limb abducted to expose and stabilize the axilla. A 4–5 cm incision was made along the natural axillary crease, extending posteriorly and inferiorly between the anterior and middle axillary lines. A subcutaneous flap was elevated on the surface of the pectoralis major fascia, crossing the clavicle and continuing deep to the platysma muscle to expose the lower third of the sternocleidomastoid muscle. The sternal and clavicular heads of the sternocleidomastoid were identified, and the natural intermuscular space between them was accessed. A retractor (draw hook) was used to elevate the sternal head, and dissection proceeded medially. The strap muscles were separated laterally, and the sternothyroid muscle was retracted to expose the affected thyroid lobe. The upper pole vessels were bluntly dissected with vascular clamps, separated from the cricothyroid muscle, and subsequently ligated. The middle and inferior thyroid vessels were ligated. The recurrent laryngeal nerve (RLN) was identified and protected using a nerve monitor, and the thyroid isthmus was divided. Central lymph node dissection was then performed [14]. All patients had been followed up for at least more than 1 year, and were administered long-term treatment with levothyroxine sodium after surgery.

Observation Indicators

The observation indicators evaluated in this study included operative time (minutes), total drainage volume (mL), length of postoperative hospital stay (days), and postoperative complications, including supraclavicular area numbness, RLN palsy, incision infection, and postoperative bleeding. During the follow-up period, we inquired whether patients experienced numbness of the skin in the supraclavicular region [15]. Persistent loss of function or dysfunction of the RLN for more than 1 year was considered permanent palsy, while less than 1 year was considered temporary palsy [16].

Statistical Analysis

Statistical analysis was performed using SPSS software, version 19.0 (IBM Corp., Armonk, NY, USA). Normality of data was assessed using the Kolmogorov–Smirnov test. Quantitative data are expressed as mean $\pm$ standard deviation (SD) or median and interquartile range (IQR), depending on their normality of data distribution. Normally distributed data were analyzed using one-way analysis of variance (ANOVA) for inter-group comparisons. The Mann–Whitney U test was utilized for analyzing non-normally distributed data. Categorical variables are expressed as number and percentage (%), and comparisons were conducted using the chi-square test (2×2 or $R\times C$ contingency tables) or Fisher's exact test, where appropriate. A two-sided p-value < 0.05 was considered statistically significant.

Results

The present study included a total of 333 patients who had successfully undergone endoscopic thyroidectomy via GUAA without converting to open surgery. Among these patients, there were 50 males and 283 females, with a mean age of 37.48 $\pm$ 9.01 years and a mean BMI of 22.76 $\pm$ 3.15 kg/m^2. All tumors were papillary thyroid carcinomas

Table 1. General characteristics of all patients.

Characteristic	Statistic
Age (years)	37.48 ± 9.01
Sex	
Male, *n* (%)	50 (15.02%)
Female, *n* (%)	283 (84.98%)
Height (m)	1.62 ± 0.07
Weight (kg)	60.22 ± 10.31
BMI (kg/m^2)	22.76 ± 3.15
Position of tumor	
Left, *n* (%)	157 (47.15)
Right, *n* (%)	176 (52.85)
Primary tumor size (mm)	4.94 ± 1.96
Operating time (min)	111.81 ± 39.43
Total drainage volume (mL)	151.90 ± 57.44
Lymph node metastasis, *n* (%)	88 (26.43%)
Number of lymph node dissections in the central area, median (IQR)	3 (3)
Number of lymph node metastases in the central area, median (IQR)	0 (1)
Length of postoperative hospital stay (days)	4.07 ± 1.00
RLN palsy, *n* (%)	2 (0.60%)
Incision infection, *n* (%)	2 (0.60%)
Bleeding, *n* (%)	1 (0.30%)
Numbness in the supraclavicular area, *n* (%)	33 (9.91%)
Achieved restoration ≤1 year	22 (6.61%)
Experienced persistent numbness >1 year	11 (3.30%)

Abbreviations: BMI, body mass index; IQR, interquartile range; RLN, recurrent laryngeal nerve.

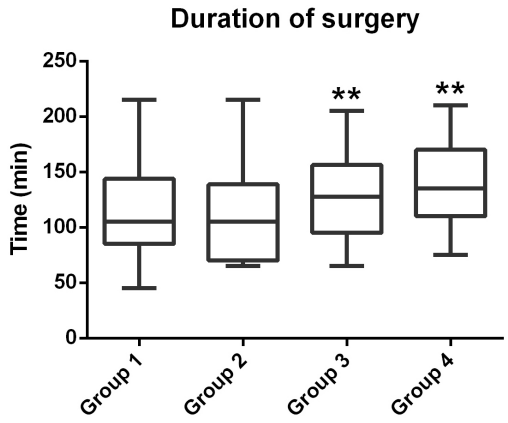

Fig. 1. Duration of surgery conducted in patients of every group. Notes: $^{**}p < 0.01$ compared with Group 1 (control group with normal weight; 18.5 ≤ BMI < 24). Definitions of other experimental groups are as follows: Group 2 (underweight; BMI <18.5), Group 3 (overweight; 24 ≤ BMI < 28), and Group 4 (obese; BMI ≥28).

measuring less than 1 cm, with 157 tumors located on the left side and 176 tumors on the right side. Central lymph node metastasis was detected in 88 patients, accounting for 26.43% of the cohort (Table 1). According to the National Comprehensive Cancer Network (NCCN) guidelines for tumor staging, all patients were classified as stage I, while one patient was stage II (aged >55 years and with lymph node metastasis).

Regarding postoperative complications, there were two cases of temporary RLN palsy, two cases of postoperative infection, and one case of postoperative bleeding. Sensory numbness in the supraclavicular area occurred in 33 patients (9.91%), with two-thirds (22 cases) recovering within 1 year, while 11 cases experienced persistent numbness for more than 1 year.

Patients were stratified into four groups based on BMI: Group 1 (n = 224), Group 2 (n = 16), Group 3 (n = 70), and Group 4 (n = 23). Groups 2, 3, and 4 were treated as experimental groups, whereas Group 1 was control group for comparison purposes.

There were no significant differences between the experimental groups and the control group in terms of age, sex, tumor location (left or right), postoperative hospital stay, total postoperative drainage volume, number of central lymph node dissections, and central lymph node metastasis rate ($p > 0.05$) (Table 2). However, operative time was significantly longer in Groups 3 and 4 (overweight and obese, respectively) compared to Group 1 (control group). Specifically, the operative time in Groups 3 and 4 was 128.14 ± 38.69 ($p = 0.009$) and 142.17 ± 37.92 minutes ($p = 0.001$), respectively, as compared to 114.33 ± 38.79 minutes in Group 1 (Fig. 1).

Table 2. Clinical features and postoperative complications of the four groups.

Items	Group 1 (18.5 ≤ BMI < 24)	Group 2 (BMI <18.5)	Group 3 (24 ≤ BMI < 28)	Group 4 (BMI ≥28)
Age (years)	37.22 ± 8.75	32.69 ± 6.51	39.40 ± 10.26	37.57 ± 7.79
F-value	2.673			
p-value		0.097	0.508	1.000
Sex				
Male, *n* (%)	28 (12.5%)	1 (6.25%)	15 (21.43%)	6 (26.09%)
Female, *n* (%)	196 (87.5%)	15 (93.75%)	55 (78.57%)	17 (73.81%)
χ^2		0.118	3.405	2.200
p-value		0.731	0.067	0.138
Primary tumor size (mm)	4.79 ± 2.01	5.00 ± 1.75	5.39 ± 1.85	5.00 ± 1.78
F-value	1.694			
p-value		0.672	0.025	0.617
Operative time (min)	114.33 ± 38.79	107.19 ± 36.92	128.14 ± 38.69	142.17 ± 37.92
F-value	5.655			
p-value		0.475	0.009	0.001
Total drainage volume (mL)	147.54 ± 54.19	165.44 ± 68.50	156.30 ± 62.94	171.48 ± 60.00
F-value	1.765			
p-value		0.228	0.265	0.057
Length of postoperative hospital stay (days)	4.02 ± 1.56	3.81 ± 1.05	4.29 ± 0.80	4.00 ± 0.91
F-value	1.652			
p-value		0.417	0.055	0.919
Position of tumor				
Left, *n* (%)	109 (48.66%)	8 (50.00%)	27 (38.57%)	13 (56.52%)
Right, *n* (%)	115 (51.34%)	8 (50.00%)	43 (61.43%)	10 (43.48%)
χ^2		0.011	2.184	0.516
p-value		0.918	0.139	0.473
Number of lymph node dissections in the central area, median (IQR)	3 (3)	2 (2)	3 (3)	2 (2)
Z-value		–0.860	–1.628	–1.916
p-value		0.390	0.104	0.055
Number of lymph node metastases in the central area, median (IQR)	0 (1)	0 (0)	0 (0)	0 (1)
Z-value		–0.739	–1.511	–0.304
p-value		0.460	0.131	0.761
RLN palsy, *n*	2	0	0	0
p-value		1.000	1.000	1.000
Incision infection, *n*	2	0	0	0
p-value		1.000	1.000	1.000
Bleeding, *n*	0	0	0	1
p-value		1.000	1.000	0.093
Numbness in the supraclavicular area, *n* (%)	18 (8.04%)	9 (56.25%)	4 (5.71%)	2 (8.7%)
χ^2		30.107	0.415	0.000
p-value		0.000	0.519	1.000

Notes: The number of lymph node dissections and lymph node metastases in the central area does not conform to a normal distribution and were analyzed using the Mann–Whitney *U* test. Age was analyzed using the Tamhane's T2 test.

In terms of complications such as RLN palsy, bleeding, and incision infection, no significant differences were observed between the experimental groups and the control group ($p > 0.05$). However, regarding supraclavicular sensory numbness, Group 2 demonstrated a significantly higher incidence (56.25%) compared to the Group 1 (8.04%) ($p < 0.05$). On the contrary, the rate of supraclavicular sensory numbness was comparable between Group 1 and the overweight and obese groups.

Discussion

Endoscopic thyroid surgery is recognized as a safe and effective treatment option for thyroid cancer [17]. Among the various techniques available, the GUAA has emerged as one of the most widely adopted methods for endoscopic thyroidectomy [18,19]. The safety and reliability of this approach have been extensively validated [20]. Owing to the dual advantages of high surgical safety and excellent aesthetic satisfaction [14], this approach is particularly suitable

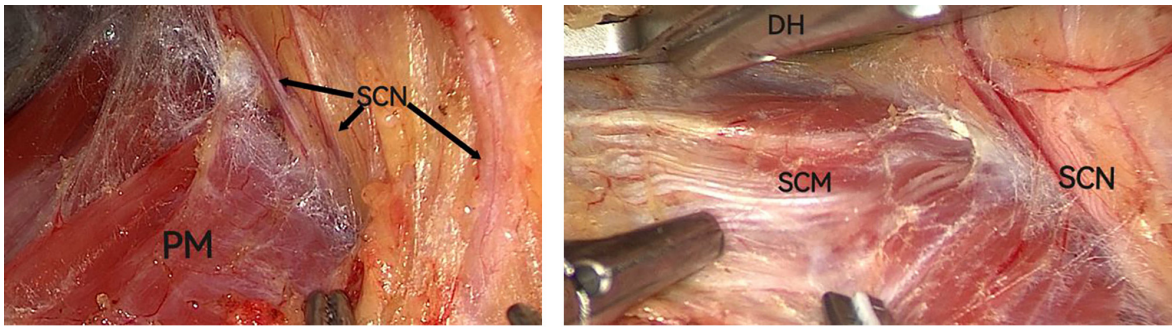

Fig. 2. Exposure of the supraclavicular nerve during the endoscopic radical thyroidectomy via gasless unilateral axillary approach. (a) The dissection of the superficial fascia over the pectoralis major muscle, with preservation of the supraclavicular nerve. The black arrows point to the supraclavicular nerve. (b) The dissection of the sternocleidomastoid muscle at the clavicular head, with preservation of the supraclavicular nerve. Abbreviations: DH, draw hook; PM, pectoralis major; SCM, sternocleidomastoid muscle; SCN, supraclavicular nerve.

for patients undergoing unilateral thyroid procedures. In a comparative analysis of open surgery and transaxillary endoscopic surgery for thyroid cancer patients, Li *et al*. [21] found that the GUAA produces better aesthetic and health-related quality of life (HRQoL) outcomes. The incidence of transient RLN palsy following thyroidectomy, ranging from 1.4% to 38.4%, has been reported in the literature, with permanent palsy rates varying between 0% and 18.6% [22]. In the present study, the incidence of transient RLN palsy was notably low at 0.6%, and no cases of permanent palsy were observed. Moreover, both postoperative bleeding and infection rates were below 1%. These findings further support that GUAA thyroidectomy is a highly safe surgical method for the management of thyroid cancer.

High BMI and obesity are frequently associated with anatomical features such as a short, thick neck and reduced cervical space, which pose technical challenges during thyroid surgery [12]. Excess adiposity in the neck region can obscure critical anatomical landmarks, particularly during the dissection of the sternocleidomastoid muscle space, thereby complicating endoscopic procedures. Previous study has demonstrated that while high BMI is associated with prolonged operative time, it does not significantly increase the rates of complications such as incision infection, bleeding, or RLN injury following open thyroidectomy [23]. For instance, Rossi *et al*. [24] categorized 1228 patients undergoing open thyroid surgery into obese (BMI $\geq$30 kg/m^2) and non-obese (BMI $<$30 kg/m^2) groups and found no significant differences in complication rates between the two groups, although obese patients had to experience longer hospital stay. Other study has suggested a potential association between obesity and increased postoperative complications [12]. However, few investigations have specifically evaluated the influence of BMI on surgical outcomes in the context of thyroidectomy via GUAA. In the present study, a retrospective analysis of 333 patients undergoing GUAA thyroidectomy revealed that high BMI was associated with significantly prolonged operative times. The average operative time for the overweight group was approximately 128 minutes, which was about 14 minutes longer than that of the normal-weight group (approximately 114 minutes). In the obese group, the average operative time extended to approximately 142 minutes, representing a 28-minute increase compared to the normal-weight group. Despite these longer operative durations, surgical outcomes—including complication rates—remained comparable across all BMI categories. These findings indicate that GUAA is a safe and effective surgical option for overweight and obese patients, offering significant aesthetic advantages without increasing surgical risks, although patients receiving this treatment method need to face longer operative time. The extended surgical time is mainly attributed to excessive fat in the neck, which can obscure anatomical landmarks—especially the sternocleidomastoid muscle space, a critical area subjected to dissection in GUAA. Therefore, it is essential to dissect as closely as possible along the surface of the pectoralis major muscle to reach the surface of the sternocleidomastoid muscle during surgery. This avoids disorientation within the excessive subcutaneous fat layer, which would otherwise lead to prolonged surgical time.

However, compared with other endoscopic thyroidectomy approaches, such as the transoral approach and chest-breast approach, GUAA carries a unique postoperative complication: numbness in the supraclavicular region, in addition to the standard risks of bleeding and RLN palsy. This unique complication is closely linked to injury of the supraclavicular nerve during flap dissection [25], as illustrated in Fig. 2. The supraclavicular nerve, which originates from the C3 and C4 nerve roots of the superficial cervical plexus, is a superficial sensory nerve [26]. It typically divides near the clavicle into medial and lateral branches, providing cutaneous sensation to the clavicle, anteromedial shoulder, and proximal chest. Study has shown that in 97% of individuals,

the nerve bifurcates into medial and lateral branches, with approximately 49% of cases presenting an additional intermediate branch [26]. Medial branches are generally located within 2.7 cm of the sternoclavicular joint, while lateral branches are typically found within 1.9 cm of the acromioclavicular joint. In this study, 9.91% (33 cases) of patients experienced postoperative numbness in the supraclavicular region following GUAA surgery. Of these, two-thirds of the patients recovered within one year, while the remaining patients endured the numbness persisting for over one year. Notably, the incidence of supraclavicular numbness was significantly higher among underweight patients (BMI $<$18.5), reaching 56.25% in this subgroup, whereas patients with BMI $\geq$18.5 exhibited markedly lower rates of numbness. This difference can be attributed to anatomical variations related to body habitus. In underweight patients, the supraclavicular nerve, which lies deep to the platysma muscle, is less protected due to a thinner subcutaneous fat layer, making it more vulnerable to injury during flap dissection. In contrast, in overweight and obese patients, a thicker adipose layer provides a natural cushion that reduces the risk of nerve injury.

Therefore, particular attention must be given to the protection of the supraclavicular nerve when elevating subcutaneous flaps over the pectoralis major fascia during GUAA surgery, especially in patients with low body weight. To avoid injury to the supraclavicular nerve, the surgeon can dissect as close to the fascia of the pectoralis major muscle as possible. This approach can help minimize the risk of injury to the supraclavicular nerve beneath the platysma muscle, which is more likely to occur when the deep fat layer is thin. In summary, recognizing these anatomical nuances can help minimize nerve injury and improve postoperative outcomes for this subset of patients.

Several limitations of the present study should be acknowledged. A total of 333 patients were included in this study. But the number of patients with low body weight (Group 2) and obesity (Group 4) was relatively small, resulting in an imbalance in the sample size. This study is retrospective in nature, which inevitably introduces selection bias. Additionally, supraclavicular numbness was assessed using subjective measures, lacking objective evaluation criteria. To minimize the impact of tumor size on surgical duration, we included only patients with thyroid tumors measuring less than 1 cm in diameter. Given that this is a single-center study with a narrowly defined patient population, further research is warranted to evaluate the applicability of GUAA in patients with larger tumors. Nevertheless, this study had excluded patients carrying factors that could affect surgical difficulty and duration, such as patients with a history of neck surgery, neck radiation therapy, or Hashimoto's thyroiditis and tumor invasion. In addition, there were no significant differences between groups in general terms of sex, age and position of tumor. We attempted to exclude potential confounding factors as much as possible to ensure comparability of surgical time and complications across different BMI groups. In future studies, we will further increase the number of patients for the underweight and obese patient categories and introduce objective evaluation indicators to conduct more in-depth research. Findings derived from such rigorously controlled studies will further explore the impact of different BMIs on GUAA surgery.

Conclusions

This study demonstrates that endoscopic thyroidectomy via GUAA is a safe and effective surgical method for the radical treatment of thyroid cancer. Despite the longer operative time required, GUAA surgery is equally safe for overweight and obese patients without raising the risk of postoperative complications. For underweight patients receiving the GUAA treatment, special attention must be given to protecting the supraclavicular nerve to minimize the risk of postoperative sensory disturbances for supraclavicular skin.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

HWG and TWZ conceived and designed the study, and participated in drafting the manuscript. JJX analyzed the data. WJX contributed to data visualization and interpretation. CMZ contributed to formal analysis. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

All patients were administered long-term treatment with levothyroxine sodium after surgery. This study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Institutional Review Board of Zhejiang Provincial People's Hospital (NO: QT2025102). The informed consent is exempted.

Acknowledgment

Thanks for Dr. Jui-Ming Lin's contribution in language editing.

Funding

This study was supported in part by grants from Zhejiang Health Science and Technology Project (2022KY512, to Haiwei Guo).

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Hüscher CS, Chiodini S, Napolitano C, Recher A. Endoscopic right thyroid lobectomy. Surgical Endoscopy. 1997; 11: 877. https://doi.org/10.1007/s004649900476.

[2] Cong R, Li X, Ouyang H, Xue W, Zhang Z, Xia F. Gasless, endoscopic trans-axillary thyroid surgery: our series of the first 51 human cases. World Journal of Surgical Oncology. 2022; 20: 9. https://doi.org/10.1186/s12957-021-02484-z.

[3] Kang YJ, Stybayeva G, Hwang SH. Surgical safety and effectiveness of bilateral axillo-breast approach robotic thyroidectomy: a systematic review and meta-analysis. Brazilian Journal of Otorhinolaryngology. 2024; 90: 101376. https://doi.org/10.1016/j.bjorl.2023.101376.

[4] He Q, Zhu J, Li X, Wang M, Wang G, Zhou P, *et al*. A comparative study of two robotic thyroidectomy procedures: transoral vestibular versus bilateral axillary-breast approach. BMC Surgery. 2022; 22: 173. https://doi.org/10.1186/s12893-022-01609-9.

[5] Ludwig B, Ludwig M, Dziekiewicz A, Mikuła A, Cisek J, Biernat S, *et al*. Modern Surgical Techniques of Thyroidectomy and Advances in the Prevention and Treatment of Perioperative Complications. Cancers. 2023; 15: 2931. https://doi.org/10.3390/cancers15112931.

[6] Zhou Y, Cai Y, Sun R, Shui C, Ning Y, Jiang J, *et al*. Gasless transaxillary endoscopic thyroidectomy for unilateral low-risk thyroid cancer: Li's six-step method. Gland Surgery. 2021; 10: 1756–1766. https://doi.org/10.21037/gs-21-257.

[7] Zheng G, Xu J, Wu G, Ma C, Sun H, Ge M, *et al*. Transoral versus gasless transaxillary endoscopic thyroidectomy: a comparative study. Updates in Surgery. 2022; 74: 295–302. https://doi.org/10.1007/s13304-021-01062-y.

[8] Global BMI Mortality Collaboration, Di Angelantonio E, Bhupathiraju S, Wormser D, Gao P, Kaptoge S, *et al*. Body-mass index and all-cause mortality: individual-participant-data meta-analysis of 239 prospective studies in four continents. Lancet. 2016; 388: 776–786. https://doi.org/10.1016/S0140-6736(16)30175-1.

[9] Zubčić Ž, Mihalj H, Šestak A, Včeva A, Abičić I, Mendeš T. Relationship between body mass index and patohistological features of thyroid cancer. Acta Clinica Croatica. 2022; 61: 469–475. https://doi.org/10.20471/acc.2022.61.03.11.

[10] Di Filippo G, Canu GL, Lazzari G, Serbusca D, Morelli E, Brazzarola P, *et al*. Exploring the Link between BMI and Aggressive Histopathological Subtypes in Differentiated Thyroid Carcinoma-Insights from a Multicentre Retrospective Study. Cancers. 2024; 16: 1429. https://doi.org/10.3390/cancers16071429.

[11] Üstün M, Karaca AC, Birol I, Uslu G, Atici SD, Aydin C. The relationship between thyroidectomy complications and body mass index. Revista Da Associacao Medica Brasileira (1992). 2020; 66: 1573–1576. https://doi.org/10.1590/1806-9282.66.11.1573.

[12] Jin QF, Fang QG, Qi JX, Li P. Impact of BMI on Complications and Satisfaction in Patients With Papillary Thyroid Cancer and Lateral Neck Metastasis. Cancer Control: Journal of the Moffitt Cancer Center. 2019; 26: 1073274819853831. https://doi.org/10.1177/1073274819853831.

[13] National Health and Family Planning Commission of the People's Republic of China. Criteria of Weight for Adults. Standards Press of China: Beijing, China. 2013. (In Chinese)

[14] Xu JJ, Zhang LZ, Zhang QH, Guo HW, Tan Z, Wang JF, *et al*. Clinical application of the gasless unilateral axillary approach in endoscopic thyroid surgery. Chinese Journal of Otorhinolaryngology Head and Neck Surgery. 2020; 55: 913–920. https://doi.org/10.3760/cma.j.cn115330-20200225-00126. (In Chinese)

[15] Liu LT, Chen JC, Yang TC, Tseng HJ, Yen SH, Lu CC, *et al*. Minimally Invasive Plate Osteosynthesis with Mini-Open Technique and Supraclavicular Nerve Preservation Reduces Postoperative Numbness in Acute Displaced Midshaft Clavicle Fracture. Medicina. 2024; 60: 1669. https://doi.org/10.3390/medicina60101669.

[16] Stager SV. Vocal fold paresis: etiology, clinical diagnosis and clinical management. Current Opinion in Otolaryngology & Head and Neck Surgery. 2014; 22: 444–449. https://doi.org/10.1097/MOO.0000000000000112.

[17] Kasouli A, Spartalis E, Giannakodimos A, Tsourouflis G, Dimitroulis D, Nikiteas NI. Comparison of cosmetic outcomes between remote-access and conventional thyroidectomy: A review of the current literature. World Journal of Otorhinolaryngology - Head and Neck Surgery. 2022; 9: 1–8. https://doi.org/10.1002/wjo2.65.

[18] Ding Y, Qiu C, Zhu C, Li Y, Geng X, Lv G, *et al*. Comparison of gasless transaxillary endoscopic thyroidectomy, endoscopic thyroidectomy via areola approach and conventional open thyroidectomy in patients with unilateral papillary thyroid carcinoma. World Journal of Surgical Oncology. 2024; 22: 148. https://doi.org/10.1186/s12957-024-03433-2.

[19] Wang S, Zhang F, Wang J, Ao Y. A study on the safety and efficacy of endoscopic thyroidectomy via axillary approach for the treatment of thyroid cancer. Medicine. 2024; 103: e38507. https://doi.org/10.1097/MD.0000000000038507.

[20] Sun B, Li P, Cong R, Zhou D, Zhang Z, Xia F, *et al*. Gasless endoscopic transaxillary thyroid surgery: CUSUM analysis of a single surgeon's experience from 105 preliminary procedures. Surgical Endoscopy. 2022; 36: 8270–8279. https://doi.org/10.1007/s00464-022-09273-z.

[21] Li T, Zhang Z, Chen W, Yu S, Sun B, Deng X, *et al*. Comparison of quality of life and cosmetic result between open and transaxillary endoscopic thyroid lobectomy for papillary thyroid microcarcinoma survivors: A single-center prospective cohort study. Cancer Medicine. 2022; 11: 4146–4156. https://doi.org/10.1002/cam4.4766.

[22] Jeannon JP, Orabi AA, Bruch GA, Abdalsalam HA, Simo R. Diagnosis of recurrent laryngeal nerve palsy after thyroidectomy: a systematic review. International Journal of Clinical Practice. 2009; 63: 624–629. https://doi.org/10.1111/j.1742-1241.2008.01875.x.

[23] Konishi T, Fujiogi M, Michihata N, Niwa T, Morita K, Matsui H, *et al*. Impact of body mass index on short-term outcomes after differentiated thyroid cancer surgery: a nationwide inpatient database study in Japan. European Thyroid Journal. 2022; 11: e210081. https://doi.org/10.1530/ETJ-21-0081.

[24] Rossi L, Becucci C, Iachini M, Ambrosini CE, Renieri F, Morganti R, *et al*. The impact of obesity on thyroidectomy outcomes: a case-matched study. Updates in Surgery. 2024; 76: 219–225. https://doi.org/10.1007/s13304-023-01687-1.

[25] Meng K, Xin Y, Tan Z, Xu J, Chen X, Gu J, *et al*. Key points of surgical anatomy for endoscopic thyroidectomy via a gasless unilateral axillary approach. Langenbeck's Archives of Surgery. 2024; 409: 294. https://doi.org/10.1007/s00423-024-03473-y.

[26] Nathe T, Tseng S, Yoo B. The anatomy of the supraclavicular nerve during surgical approach to the clavicular shaft. Clinical Orthopaedics and Related Research. 2011; 469: 890–894. https://doi.org/10.1007/s11999-010-1608-x.