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The Intraoperative Use of a Drain Line for Gas-Insufflation One-Step Single-Port Transaxillary (GOSTA) Robotic Thyroidectomy

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Abstract

Objective. This study aimed to evaluate the intraoperative use of a drain line for smoke suction during robotic thyroidectomy using a gas insufflation one-step single-port transaxillary (GOSTA) approach and its impact on surgical outcomes.

Study Design. Retrospective cohort study.

Setting. University tertiary care facility.

Methods. A comprehensive retrospective analysis was conducted in patients divided into 2 groups: the Drain group, where a drain line was directly inserted into the surgical space during surgery (n = 53), and the Control group (n = 83). The 2 groups were compared in terms of perioperative surgical outcomes, including operative time, number of endoscope cleaning, and the number of patients with endoscopes that did not require cleaning.

Results. The operative time was significantly shorter in the Drain group than in the Control group ($P = .003$). The number of endoscope cleaning procedures was considerably lower in the Drain group ($P < .001$), indicating a decreased need for endoscope cleaning during surgery. Moreover, a higher number of patients with endoscopes that did not require cleaning were observed in the Drain group ($P = .001$), suggesting a potential benefit in maintaining endoscope clarity.

Conclusion. These results suggest that using smoke suction with a drain line directly inserted into the surgical space in robotic thyroidectomy using the GOSTA approach may offer advantages such as reduced operative time and improved endoscope clarity.

Keywords

follicular thyroid carcinoma, papillary thyroid cancer, robotic surgical procedure, thyroid neoplasm, thyroidectomy

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Robotic thyroid surgery has gained significant traction globally, drawing the interest of surgeons and patients seeking novel and advanced approaches for thyroidectomy that offer enhanced cosmetic outcomes compared to traditional open procedures.[1] Robotic thyroidectomy has been developed and utilized in the transaxillary approach,[2-4] retroauricular approach,[5-7] bilateral axillo-breast approach,[8-11] and transoral approach.[12-17] Various centers in Korea have performed robotic thyroidectomies using different approaches.[18]

Our hospital recently introduced a new approach known as the gas-insufflation one-step single-port transaxillary (GOSTA) approach for robotic thyroidectomy using a single port. This method reduces the workload of surgeons and assistants compared to the conventional transaxillary method and is considered equally safe.[19]

The GOSTA approach involves gas insufflation surgery, and similar to other gas insufflation procedures, has its own challenges and issues. One issue with gas insufflation surgery is obscured visibility due to surgical smoke.[20] In particular, in the GOSTA approach, surgery in confined spaces significantly disrupts visibility, even with a small amount of surgical smoke.

Using the GOSTA approach, we encountered issues of obscured visibility due to surgical smoke, prompting us to seek solutions. To address this, we introduced a method of placing a drain line directly near the area where surgical smoke is produced. We explored its efficacy through an experimental and control group study.

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Methods

Patients

Between January 2022 and June 2023, 136 patients underwent robotic thyroid lobectomy using the GOSTA approach performed by a single surgeon (Y.W.C.) at a single tertiary institution, Korea University Ansan Hospital. The study group comprised 53 patients who underwent robotic thyroidectomy with a drain line directly inserted into the surgical space (Drain group) (**Figure 1**). In contrast, the control group included 83 patients who underwent robotic thyroidectomy with a suction drain connected to a single port (Control group).

This retrospective study was approved by the Institutional Review Board of Korea University Medical Center, Ansan (approval number: 2024AS0011). The requirement for informed consent was waived.

Procedures of Robotic Thyroidectomy Using the GOSTA Approach

In the GOSTA approach, the patients were in the supine position with both arms down (**Figure 2A**). A 2-cm incision was made along the skin crease at the axillary fold. The SP access port (Intuitive) or the Glove port (Nelis), designed for single-port surgery, was inserted, followed by CO_2 gas insufflation to 8 mm Hg. The remote center of the da Vinci SP trocar was placed externally; only the endoscope and device were inserted through the axillary incision. After docking, the skin flap was created using the robot. The dissection proceeded along the anterior surface of the pectoralis major muscle and continued between the sternal and clavicular heads of the sternocleidomastoid muscles. The anterior wall of the thyroid gland was dissected from the strap muscles. During the dissection of the superior pole, the external branch of the superior recurrent laryngeal nerve was identified and preserved. The superior thyroidal artery and vein were meticulously coagulated using a monopolar cautery or bipolar forceps. On the lateral side of the thyroid gland, the recurrent laryngeal nerve and parathyroid glands were preserved.[19] In cases of malignancy, central lymph node dissection was performed along the carotid artery sheath, extending from the lateral side to the sternal notch.[21,22]

Surgical Smoke Drain Procedure

In the Drain group, a cut-end Jackson-Pratt drain line with a diameter of 4.8 mm was used as the intraoperative drain line. This line was cut to a length that left approximately 3 to 4 holes in the portion with holes for effective absorption. The drain line was inserted directly into the surgical space through the SP access or Glove port. This cut-end drain line was used with continuous suction to prevent visual disturbances due to the smoke produced during the surgery. In the Control group, an intravenous extension

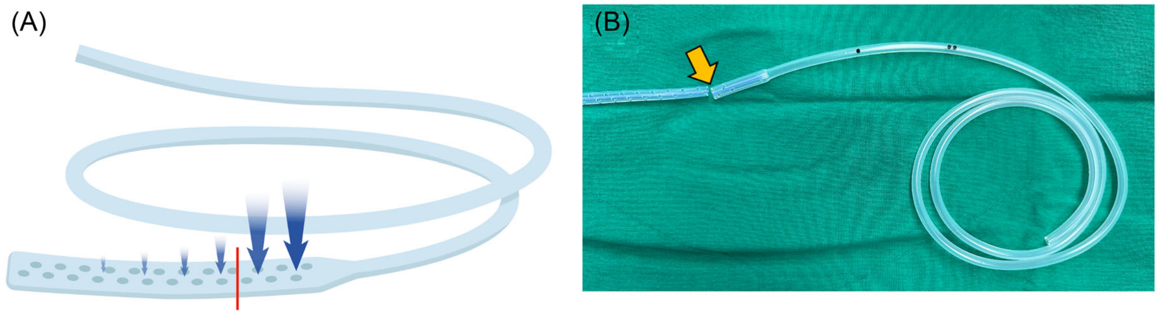

Figure 1. Illustration and photograph of the cut-end drain line. (A) Effective absorption at the proximal site of the drain (red bar, appropriate cutting line). (B) Cut-end Jackson-Pratt drain line with a diameter of 4.8 mm (arrow, appropriate cutting line).

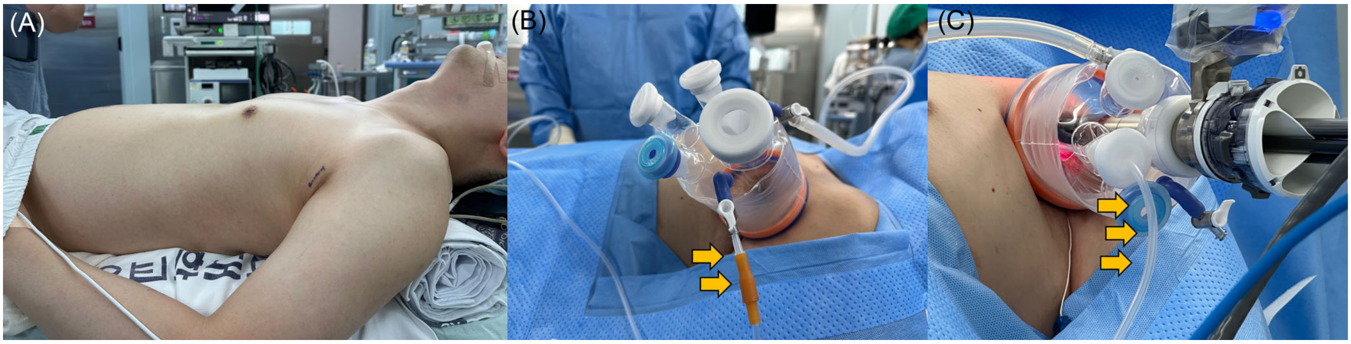

Figure 2. Photographs depicting the placement of a suction drain in the Control and Drain groups for air circulation. (A) Patient positioning and a single-incision line for GOSTA thyroid lobectomy. (B) The suction drain connected directly to the Glove port (arrows) in the Control group. (C) The cut-end drain inserted through the Glove port (arrows) in the Drain group. GOSTA, gas-insufflation one-step single-port transaxillary.

line was connected to the suction line and installed at the SP access or Glove port (**Figure 2**).

Comparison Study

Data were analyzed using SPSS Statistics (version 25.0.0.0; IBM Corp). Continuous variables were presented as means with standard deviations, while categorical variables were presented as percentages. Student's *t* test was used to compare continuous variables. χ^2 or Fisher's exact tests were used to compare categorical variables. Statistical significance was considered at $P < .05$.

Results

Clinicopathologic Characteristics

A total of 83 patients underwent robotic thyroid lobectomy without the use of an intraoperative drain line (Control group), and 53 patients underwent robotic thyroid lobectomy with a drain line (Drain group). The mean age at the time of surgery in the Control and Drain group were 49.1 and 46.9 years old, respectively, with no significant difference. The proportion of female patients and body mass index were also comparable. The Drain group consisted of 29 patients who underwent left lobectomy and 24 patients who underwent right lobectomy. The Control group included 31 left lobectomies and 52 right lobectomies. Diagnoses after thyroidectomy included thyroid carcinoma and benign nodules. Although the proportion of left lobe tumors and N0 classification were slightly higher in the Control group, there was no distinctive difference in the T classification distribution between the 2 groups. The detailed distribution of patient diagnoses is presented in **Table 1**.

Table 1. Clinicopathological Characteristics of the Patients Who Underwent Thyroid Lobectomy

Characteristic	Control (n = 83)	Drain (n = 53)	*P*
Age at operation, y (range)	49.1 (27–72)	46.9 (20–61)	.235
Sex (%)			.724
Female	62 (74.7)	41 (77.4)	
Male	21 (25.3)	12 (22.6)	
Body mass index	25.32 (16.2–38.0)	25.26 (17.8–35.3)	.938
Tumor size, cm (range)	1.34 (0.3–3.8)	1.38 (0.3–4.4)	.745
Tumor position			.047
Left	31 (37.3)	29 (54.7)	
Right	52 (62.7)	24 (45.3)	
Pathology (%)			.357
Benign nodule	16 (19.3)	7 (13.2)	
Differentiated thyroid carcinoma	67 (80.7)	46 (86.8)	
T classification (%)			.293
T1a	37 (55.2)	21 (45.7)	
T1b	24 (35.8)	22 (47.8)	
T2	6 (9.0)	2 (4.3)	
T3a	0 (0.0)	1 (2.2)	
N classification (%)			.045
N0	56 (83.6)	31 (67.4)	
N1a	11 (16.4)	15 (32.6)	

Analysis of Perioperative Details

There was a significant difference in the total operation time between the Control and Drain groups at 108.4 and 96.6 minutes, respectively ($P = .003$). The number of endoscope cleaning procedures was significantly lower in the Drain group (3.3 vs 1.7; $P < .001$), and the number of patients with endoscopes that did not require cleaning was significantly higher in the Drain group (6 vs 15; $P = .001$). The number of sacrificed parathyroid glands, postoperative hospital days, and postoperative complications did not differ significantly between the groups (**Table 2**).

Discussion

In procedures like robotic thyroidectomy, which involves a smaller surgical space, surgical smoke obscures the view more significantly compared to laparoscopic surgery, where the space is larger. In gasless transaxillary robotic thyroidectomy, surgical smoke can be effectively removed by continuously circulating air within the surgical space using a suction-equipped Chung's retractor. However, in the GOSTA robotic thyroidectomy, which utilizes a single port, the air circulation was not smooth, making it challenging to remove surgical smoke efficiently. In the early days of the GOSTA approach, we connected a suction line directly to the single port to enhance air circulation. Still, it was ineffective in expelling surgical smoke (**Figure 2B**). To address this challenge, we inserted a drain line directly into the surgical space to improve air circulation, similar to the conventional transaxillary approach (**Figure 2C**).

Inserting a drain line into the surgical space significantly improved the absorption of surgical smoke during GOSTA robotic thyroidectomy compared to the previous method. This enhanced the visual clarity of the endoscope by absorbing the smoke near the surgical site, thus improving ventilation in the confined surgical field. In the previous method of directly connecting the suction line to the single port, clean CO_2 gas could not reach the actual surgical site and was immediately absorbed by the suction line; the surgical smoke was not removed effectively. However, inserting the suction line into the surgical space created an environment in which CO_2 gas was continuously circulating, and the drain could be placed dynamically near the areas where surgical smoke is generated, thereby directly absorbing the smoke (**Figure 3**).

This method reduced the fogging of the endoscopic lens as well. Fogging of the endoscopic camera lens occurs because of condensation, which is more frequent when

Table 2. Analysis of Perioperative Details of the Control and Drain Groups

	Control (n = 83)	Drain (n = 53)	*P*
Total operative time	108.4 (59–195)	96.6 (65–156)	.003
Number of endoscope cleaning procedures	3.3 (0–8)	1.7 (0–7)	<.001
Number of patients with endoscope that did not require cleaning, n (%)	6 (7.2)	15 (28.3)	.001
Number of sacrificed PTG, n ± SD	0.23 ± 0.42	0.26 ± 0.49	.656
Postoperative hospital stays, d (range)	3.8 (3–7)	4.0 (3–6)	.531
Postoperative complications, n (%)	2 (2.4)	0 (0.0)	.523
Flap necrosis	0 (0.0)	0 (0.0)	
Transient RLN palsy	1 (0.0)	0 (0.0)	
Permanent RLN palsy	0 (0.0)	0 (0.0)	
Hematoma	1 (0.0)	0 (0.0)	

Abbreviations: PTG, parathyroid gland; RLN, recurrent laryngeal nerve; SD, standard deviation.

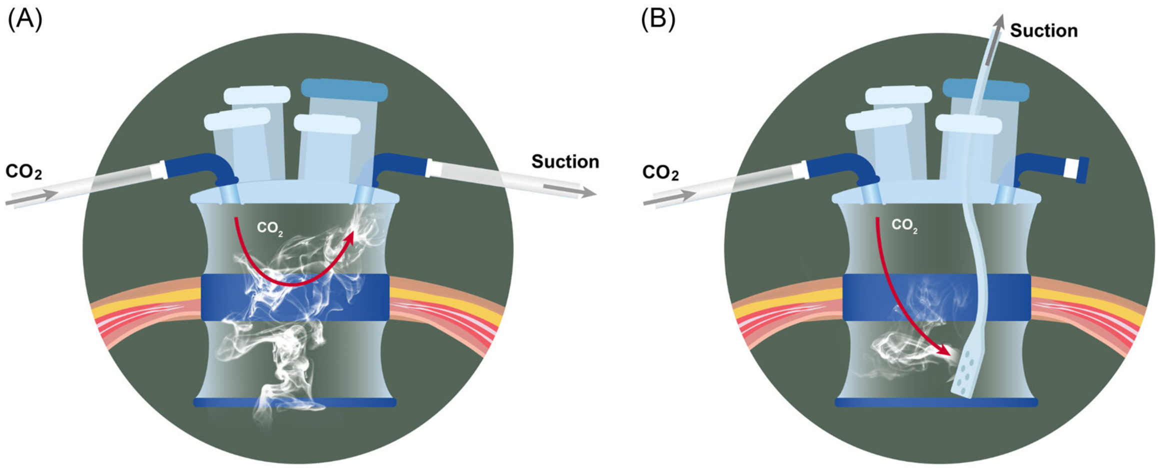

Figure 3. Illustrations of air circulation during surgery in both groups. (A) Smoke generated during surgery is not adequately absorbed in the Control group. (B) Smoke generated during surgery is adequately absorbed in the Drain group.

there is a larger temperature difference between the camera lens and surgical space, along with higher relative humidity in the surgical space.[23-25] Typically, after cleaning the camera, a warming bath is used to reheat it to reduce the temperature difference,[26-29] but this can delay the surgical process. In robotic surgical systems, the endoscope removal and insertion take longer than endoscopic or laparoscopic surgeries, potentially affecting the surgeon's focus. Inserting the suction line into the surgical space increases the distance between where CO_2 is supplied and suction occurs, allowing for adequate air circulation. This setup helped reduce the temperature and humidity in the surgical space, resulting in a clearer lens and allowing for reinsertion without the need for reheating.[30-32]

The effective absorption of surgical smoke and reduced fogging led to consistently clear visibility during surgery, which decreased the frequency of lens cleaning. **Figure 4** shows that the intraoperative use of a drain line enhanced the visual clarity of the endoscope by absorbing the smoke near the surgical site. As shown in the tables above, the number of endoscope cleanings was fewer in the Drain group, and the proportion of patients whose endoscopes did not require cleaning was higher in the Drain group. Additionally, the Drain group exhibited a shorter overall operative time. While a 12-minute difference may not be clinically significant, we presume that the reduction in endoscope cleaning and reheating frequency, achieved by maintaining clear vision throughout the surgery, contributed to the shortened operative time.

A Jackson-Pratt drain line with a diameter of 4.8 mm was sufficient for suctioning surgical smoke while maintaining pressure in the surgical space. In most cases, the flow rate of CO_2 gas was higher than the suction rate; therefore, the surgical space was steadily maintained. However, in robotic thyroidectomy using the GOSTA approach, as the surgical space is smaller compared to laparoscopic surgeries, even a slight air leak when installing a single port causes the surgical space to shrink and fluctuate due to suction during the operation. To address this, a 3-way port was installed between the drain and wall suction for pressure control.

The Jackson-Pratt drain line was cut approximately 2 cm above the start of the suction hole for effective absorption. In the early days of inserting a drain line into the surgical space, we inserted the drain without cutting it,

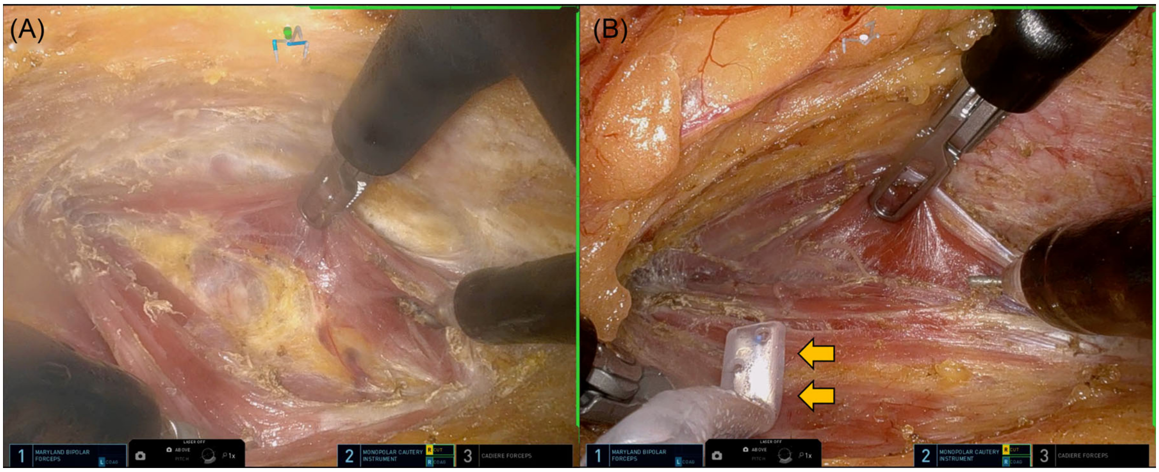

Figure 4. Intraoperative photographs of GOSTA thyroid lobectomy. (A) Smoke generated during surgery is not adequately absorbed in the Control group. (B) Smoke generated during surgery is adequately absorbed using the intraoperative drain line (arrows) in the Drain group. GOSTA, gas-insufflation one-step single-port transaxillary.

expecting all the holes to remove smoke effectively, but it did not work as expected. The effect of suction of the Jackson-Pratt drain line starts from the proximal hole. Generally, this drain is used after surgery, and suction power extends to the distal hole because the surgical space is compressed postoperatively. However, during the surgery, the suction effect is limited to the proximal hole only, with the distal hole not possessing any suction power. Because the surgical space is always inflated with CO_2 in gas-insufflation surgeries (**Figure 1**). Therefore, we cut the distal hole of the drain, which was unnecessary, leaving about 2 cm from where the holes started. From then on, smoke was cleared entirely from the surgical field, and fogging did not occur, allowing us to maintain a clean field. Moreover, the shortened drain was more accessible to manipulate with robotic devices and more convenient for locating the bleeding points.

This technique has also been used in other surgeries. In a robotic lateral transperitoneal adrenalectomy using a single port, surgical smoke was directly suctioned near the smoke-producing sites using the cut-end Jackson-Pratt drain line, resulting in clearer vision.[33] However, in abdominal surgery, owing to the large volume of the abdominal space, the smoke density is low, which results in decreased smoke disturbance. Therefore, this method may be beneficial in surgeries that require creating space, such as retroperitoneal adrenalectomy or total extraperitoneal inguinal hernia repair using a single-port approach.

In several situations, the drain line has been used as a blood suction line in robotic thyroidectomies. Suctioning blood using conventional endoscopic suction devices in robotic thyroidectomy is challenging. These instruments are straight and inflexible, making it difficult to navigate around anatomical obstacles such as the clavicle or trachea to reach the bleeding sites. The cut-end Jackson-Pratt drain line offers wider applicability due its softness and ability to effectively control bleeding around any curvature. This study involved only thyroid lobectomy cases; however, even in cases with more complex procedures and many anatomical curvatures, such as total thyroidectomy or modified radical neck dissection, the cut-end Jackson-Pratt drain line can serve as an effective suction line to control bleeding.

The present study has several limitations. First, as a retrospective cohort study, it is susceptible to selection bias, confounding factors, and measurement errors, which can compromise internal validity. Additionally, the cut-end Jackson-Pratt drain line method was introduced later in the study, potentially introducing bias related to time differences and affecting the total operative time. However, considering our experience with over 250 cases of transaxillary robotic thyroidectomy before introducing the GOSTA approach, the impact of surgical experience on operative time between the early and late GOSTA cases is minimal. The statistically significant reduction in operative time is more likely attributed to fewer endoscope cleaning and reheating instances and maintaining a consistently clear view throughout the procedure. Although there were differences in tumor position and N classification among the clinicopathological characteristics between the 2 groups, these did not lead to differences in surgical methods and thus did not significantly impact the results. This is because we routinely performed thyroid lobectomy with prophylactic central lymph node dissection in all patients with negative lymph node metastasis based on preoperative radiologic findings. Finally, reliance on a single surgeon's experience limits our findings' generalizability. Prospective studies are needed to address these limitations, and a multicenter trial would be beneficial to confirm the external validity of our results.

In conclusion, the intraoperative use of a drain line significantly reduced the operative time and improved endoscope clarity during robotic thyroidectomy using the GOSTA approach.

Author Contributions

Dohoe Ku, collected the data, analyzed and interpreted the data, and wrote the manuscript; **Young Woo Chang**, designed the research, collected the data, analyzed and interpreted the data, wrote the manuscript, and provided critical revisions; **Da Young Yu**, analyzed and interpreted the data; **Seung Yeon Ko**, analyzed and interpreted the data; **Hye Yoon Lee**, analyzed and interpreted the data; **Gil Soo Son**, analyzed and interpreted the data.

Disclosures

Competing interests: The authors declare that there is no conflict of interest.

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