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DYNAMIC MANUSCRIPT

Gasless transoral endoscopic thyroidectomy vestibular approach (gasless TOETVA)

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Abstract

Background The transoral endoscopic thyroidectomy vestibular approach (TOETVA) has been the subject of increasing interest from several institutions around the world over the last 2 years. Recently, we successfully performed TOETVA in live human patients without CO_2 gas using our newly designed retractable blade.

Methods We reviewed the medical records of 15 consecutive patients who underwent gasless TOETVA using a self-retaining retractor.

Results We successfully performed 13 thyroid lobectomies and 2 total thyroidectomies in 15 patients. No patient exhibited serious postoperative complications such as recurrent laryngeal nerve palsy and permanent hypocalcemia. One patient developed transient hypocalcemia but recovered within 2 months. No patient developed a wound infection; furthermore, no visible scar or dimpling was evident on the neck of any patient.

Conclusion Gasless TOETVA provides enough working space and good visibility to perform thyroid surgery without any risk of CO_2 gas-related complications.

Keywords Endoscopy · Minimally invasive surgical procedure · Thyroid · Thyroidectomy · Transoral thyroidectomy · Transoral · TOETVA

The transoral endoscopic thyroidectomy vestibular approach (TOETVA) has been the subject of increasing interest from several institutions around the world over the last 2 years, following the publication of a paper by Anuwong in 2016 reporting the first successful 60 cases in live human patients [1]. In South Korea, surgeons in several hospitals nationwide have also been performing or attempting to initiate either TOETVA or transoral robotic thyroidectomy (TORT) [2–7]. There are numerous advantages to TOETVA, which may explain why this procedure has gained in popularity over a relatively short period of time. TOETVA can be performed without the need for a skin incision. It is also less invasive than other endoscopic/robotic approaches. Furthermore, it is most advantageous when performing total thyroidectomy since it provides an equally excellent surgical view in both retrothyroid areas.

However, the use of carbon dioxide (CO_2) in maintaining the working space is one of the shortcomings that requires attention, since it is associated with CO_2-related complications such as CO_2 embolism, pneumothorax, pneumomediastinum, and subcutaneous emphysema. In particular, CO_2 embolism is known to occur very rarely during endoscopic surgery but can become life threatening for the patient. Some surgeons have reported encountering CO_2 embolism during TOETVA or TORT, thus transitioning to another approach to complete the thyroidectomy [8, 9]. We have also experienced a case in which CO_2 embolism was suspected just after laceration of the anterior jugular vein during flap elevation; fortunately, the patient's vital signs were normalized

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within 2 min after ligating the vessel and we were able to continue with TOETVA. Thus, surgeons should exert great effort toward preventing CO_2 embolism during TOETVA, for example by lowering the flow rate and pressure of CO_2, ensuring close communication with the anesthesiologist, and applying continuous end-tidal carbon dioxide ($EtCO_2$) monitoring.

We attempted to develop a new retractable blade that can provide and maintain a sufficiently large working space for TOETVA without the need for CO_2 gas. Recently, we successfully performed TOETVA in live human patients without CO_2 gas using our newly designed retractable blade. In this study, we report our initial experiences, including a videoclip and also discuss the feasibility and safety of gasless TOETVA.

Materials and methods

Patient selection

We reviewed the medical records of 15 consecutive patients who underwent gasless TOETVA using a self-retaining retractor from July 2018 to November 2018 in our hospital. A newly developed retractable blade, which can be fixed to the body of the pre-existing self-retaining retractor system (Sangdosa Inc., Seoul, Korea), was used to maintain the working space during TOETVA (Fig. 1a). All patients were operated on in the same manner by a single surgeon (Park JO). The inclusion criteria were as follows: (1) No previous head and neck surgery, (2) consent for gasless TOETVA, (3) thyroid cancer without an extrathyroidal extension or lymph node metastasis on preoperative work-up, and (4) thyroid cancer of the mid/lower pole < 2 cm in diameter or of the superior pole < 1 cm in diameter, or a benign tumor < 8 cm in diameter. The Institutional Review Board of Haeundae Paik Hospital approved this study.

Surgical technique [videoclip]

The patient was placed in the supine position with the neck extended, and usual painting and draping was performed. We made a 2.5–3-cm-sized midline curvilinear incision in the vestibule and the working space was made and widened along the subplatysmal plane to the sternal notch inferiorly, and to both sternocleidomastoid (SCM) muscles laterally using blunt instruments such as a Kelley clamp and vascular tunneler, as described in our previous report [4]. A newly developed retractable blade was inserted through the midline incision site and fixed to the body of the self-retaining retractor system. Two lateral incisions were made on the buccal mucosa near the second premolar or first molar tooth. A 5-mm-diameter cannula (for the endoscope) was positioned through the midline incision site and inserted, and two

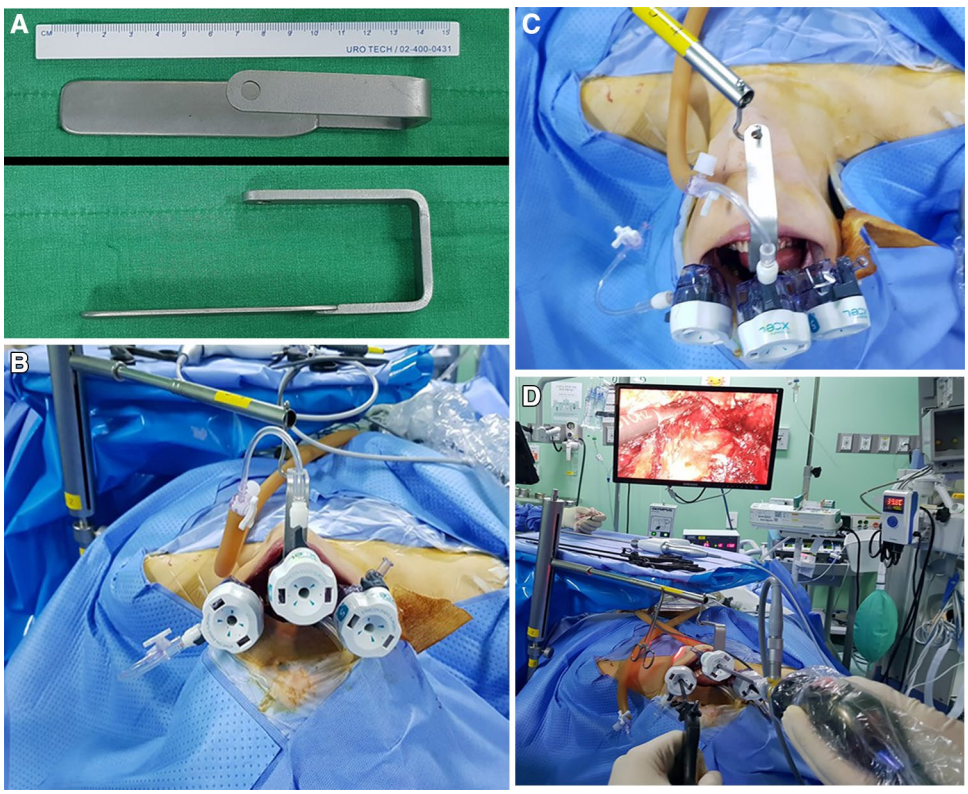

Fig. 1 Application of the self-retaining retractor. **A** A newly designed blade for transoral endoscopic thyroid surgery; **B**, **C** three 5-mm cannulas are positioned after application of the self-retaining retractor; **D** gasless transoral endoscopic thyroidectomy vestibular approach (TOETVA) using the self-retaining retractor

5-mm-diameter cannulas (for the laparoscopic instruments) were positioned through each lateral incision. Under the magnified endoscopic view, the working space was widened using an ultrasonic device and L-hook cautery. The anterior border of the SCM muscles was sufficiently separated on each side to ensure that the height of the working space was adequate for the operation. To prevent the roof of the working space from sagging, a percutaneous suture was placed on the roof skin and hung from a retractor (Fig. 1b–d).

Endoscopic operative procedures were performed routinely, step-by-step, as described in our previous report: separation of the strap muscle in the midline to expose the thyroid gland, division of the isthmus and upper pole, dissection of the retrothyroid area (identifying and preserving the parathyroid gland and recurrent laryngeal nerve), removal of the specimen, and re-approximation of both strap muscles [4]. After the endoscopic procedures were completed, the self-retaining retractor was removed and the three oral incision sites were closed using absorbable sutures. A pressure dressing was placed around the chin and neck using an elastic bandage. Postoperative management followed routine protocol, as in our previous report [4] (Fig. 2).

Results

We performed 13 thyroid lobectomies and 2 total thyroidectomies in 15 patients. The gender/age, and radiological and pathological features of all patients are summarized in Table 1. The operative details, postoperative progress notes, and complications are summarized in Table 2. No sensory change around the lower lip or facial weakness was reported by any patient. No patient exhibited recurrent laryngeal nerve palsy. One patient developed transient hypocalcemia but recovered within 2 months. No patient developed a wound infection; furthermore, no visible scar or dimpling was evident on the neck of any patient.

Discussion

TOETVA is recognized as one of the most advanced techniques currently available for thyroid surgery. It has a number of advantages and has shown a rapid take-up by a number of surgeons around the world over the last 2 years [1–5, 9–11]. Since the implementation of TOETVA in Korea 2 years ago, we have accumulated experience in TOETVA treating patients with early stage papillary thyroid cancer or a benign nodule to date [2, 4]. TOETVA is performed within a working space created by artificially expanding neck spaces that do not actually exist along the fascial plane of the neck; this is unlike endoscopic abdominal surgery, which is performed within the normal abdominal cavity. Several small blood vessels can be damaged in the process of making a working space using blunt instruments, and the probability of CO_2 gas entering the circulatory system is increased. Although the history of TOETVA is very short, there have been reports of CO_2 gas-related complications such as CO_2 embolism during surgery [8, 9]. In light of this, we designed retractors of various shapes in cooperation with other researchers. The retractor used in this study was made (by Koh YW) by modifying the blade of a commercialized retractor for retroauricular robotic/endoscopic head and neck surgeries. The width of the retractable blade used in this study was 2 cm and its length was 13 cm. However, the larger the blade width, the more difficult it is to insert into the working space. We found that the width used in this study was sufficient to pull the anterior neck skin. Blades of various lengths would be useful, given the variation in patients' bodies. During surgery, the curvilinear incision in the midline vestibule was made to be about 2.5–3 cm (about 2 cm

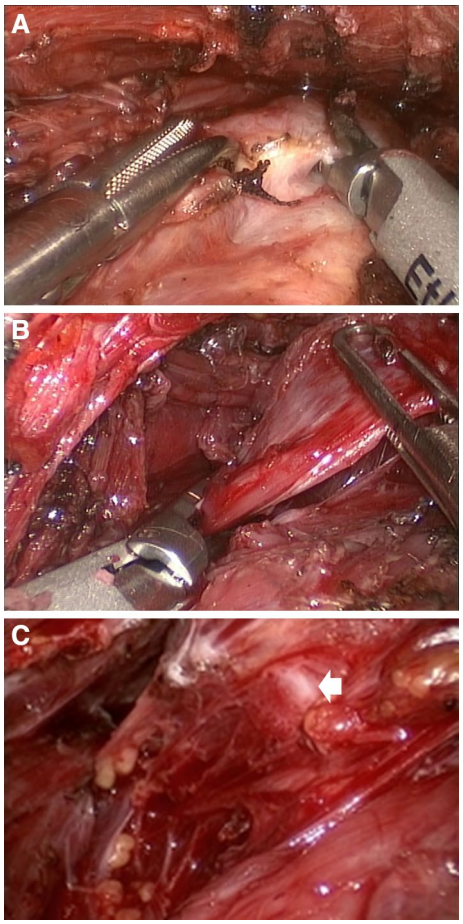

Fig. 2 The surgical field of view during gasless TOETVA. **A** The isthmus of the thyroid gland is divided using an ultrasonic device; **B** the superior pole of the left thyroid gland is divided using the ultrasonic device; **C** the left recurrent laryngeal nerve (arrow)

Table 1 Radiological and pathological features of patients who underwent gasless transoral endoscopic thyroidectomy vestibular approach (gaseless TOETVA) ($n = 15$)

Case	Sex/age (years)	Preoperative cytopathology (Bethesda system)	Preoperative ultrasonography					Postoperative pathology				Other
			L Size (cm)	Number of tumors	Location	ETE	Lymph node metastasis	Diagnosis	Margin	ETE	Number of positive nodes/dissected nodes	
1	F/46	PTC	1.2	1	Right	No	No	PTC	Negative	No	0/3	Left indeterminate nodule
2	F/29	PTC	1.2	2	Left	No	No	PTC	Negative	No	0	
3	F/51	PTC	0.5	5	Right	No	No	PTC	Negative	No	3/5	
4	M/34	PTC	0.5	2	Left	No	No	PTC	Negative	No	0	
5	F/48	PTC	1.2	3	Right	No	No	PTC	Negative	No	0	
6	F/36	PTC	1.2	1	Left	No	No	PTC	Negative	No	0	
7	F/46	PTC	0.5	1	Left	No	No	PTC	Negative	No	0	
8	F/55	PTC	0.4	3	Bilateral	No	No	PTC	Negative	No	0/1	
9	M/37	FN	1.8	1	Right	No	No	FA	Negative	No	0	
10	F/58	PTC	0.6	1	Right	No	No	PTC	Negative	No	0	
11	M/47	PTC	0.4	3	Left	No	No	PTC	Negative	No	0	
12	F/36	PTC	1.3	1	Right	No	No	PTC	Negative	No	0	
13	M/56	PTC	0.6	1	Isthmus	No	No	PTC	Negative	No	0	
14	F/45	PTC	0.8	2	Left	No	No	PTC	Negative	No	0	
15	F/55	PTC	0.4	1	Right	No	No	PTC	Negative	No	0	

L size size of the largest nodule, *ETE* extrathyroid extension, *F* female, *M* male, *PTC* papillary thyroid cancer, *FN* follicular neoplasm, *FA* follicular adenoma

Table 2 Operative details, postoperative progress notes, and complications of gasless transoral endoscopic thyroidectomy vestibular approach (gaseless TOETVA) ($n = 15$)

Case	Operation			Progress notes					Complications	
	Extent of surgery	CND	Operation time (min)	Diet (POD)	Drain removal (POD)	Hospital stay (POD)	Sensory change	Vocal cord palsy	Hypocalcemia	Other
1	Total	Yes	180	1	1	5	No	No	No	
2	Lobectomy	No	110	1	1	4	No	No	No	–
3	Lobectomy	Yes	110	1	1	4	No	No	No	–
4	Lobectomy	No	170	1	2	4	No	No	No	
5	Lobectomy	No	160	1	1	3	No	No	No	
6	Lobectomy	No	150	1	1	4	No	No	No	
7	Lobectomy	No	130	1	1	5	No	No	No	
8	Total	Yes	180	1	1	5	No	No	Transient	
9	Lobectomy	No	180	1	2	4	No	No	No	
10	Lobectomy	No	120	1	1	5	No	No	No	
11	Lobectomy	No	110	1	1	4	No	No	No	
12	Lobectomy	No	140	1	1	2	No	No	No	
13	Isthmectomy	No	70	1	1	4	No	No	No	
14	Lobectomy	No	120	1	1	4	No	No	No	
15	Lobectomy	No	150	1	1	4	No	No	No	

CND central node dissection, *POD* postoperative day

when using CO_2 gas) to allow insertion of the blade, which is a little longer than previously. The medial portion of both mentalis muscles was cut slightly more than before so that the retractor could be lifted up, to ensure sufficient space for the 5-mm cannula to be inserted. When creating the working space, the anterior border of the SCM muscle was sufficiently exposed on each side so that the working space was of sufficient height for the operation to proceed.

The main advantage of gasless TOETVA is the lack of any risk of CO_2 gas-related complications. When CO_2 gas was used previously, we had to continuously monitor $EtCO_2$ and the surgeon checked frequently to see if the level had risen during surgery. If $EtCO_2$ was more than 45–50, surgery was paused until the level dropped to below 40–45, and therefore the flow of surgery was occasionally interrupted. However, we have not had to worry about this issue since we adopted the gasless TOETVA procedure. Eliminating the possible risk of fatal complications such as CO_2 embolism allows the surgeon to operate in a more psychologically relaxed and steady manner. In addition, we previously routinely checked for signs and symptoms of subcutaneous emphysema after TOETVA in all patients. After using our retractor, no obvious sign or symptom of subcutaneous emphysema was observed in any patient. We plan to perform a comparative study to determine whether there is a significant difference in postoperative pain according to objective parameters and the use of CO_2 gas.

In addition, gasless TOETVA had several other minor advantages. To maintain the working space by insufflating CO_2 gas in conventional TOETVA, the working space should be maintained as a closed cavity. Thus, if continuous negative suction was applied, the working space would collapse due to the negative pressure, or repeated shrinkage and expansion would occur. Therefore, continuous negative suction could not be applied, and the smoke created by the use of an energy device frequently interfered with the visibility, causing the assistant surgeon to open the suction valve to remove the smoke, before locking it again to restart surgery after every such occurrence. However, using our novel retractor, continuous negative suction can be applied so that the smoke can be easily removed, and the operation performed continuously (because the working space is connected to the outside via an open cavity). In addition, we previously set the flow rate of the CO_2 gas to a constant 12–15 L/min and the equipment pressure to a constant 4–6 mmHg, but the narrow working space was easily affected by small changes to these conditions during surgery due to the varying external environment. Thus, the roof of the working space and surrounding soft tissues continued to move periodically as if they were pulsating. These movements were problematic and distracting when the surgeon was managing critical structures such as the recurrent laryngeal nerves or blood vessels. However, after gasless TOETVA, no such movement was observed and the operation could be performed in a stable environment.

There remain some minor drawbacks of gasless TOETVA. A 5-mm endoscope was used instead of a 10-mm cannula due to the space occupied by the blade; therefore, the image quality of the surgical view is somewhat reduced, although still acceptable. To insert both the retractor blades and the 5-mm cannula simultaneously, the medial portion of both mentalis muscles was cut more extensively and the size of the midline mucosal incision was longer.

TOETVA appears to be a true minimally invasive surgery that can be performed in the complete absence of any skin incision. It has many merits but some shortcomings that should not be taken lightly and require improvement, such as the risk of CO_2 gas-related complications. Gasless TOETVA seems to be a safe and feasible technique for thyroid surgery.

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Compliance with ethical standards

Conflicts of interest Jun-Ook Park, Yeong Jun Park, Mi Ra Kim, Dong-Il Sun, Min-Sik Kim, and Yoon Woo Koh have no conflicts of interest or financial ties to disclose.

References

1. Anuwong A (2016) Transoral endoscopic thyroidectomy vestibular approach: a series of the first 60 human cases. World J Surg 40:491–497
2. Park JO, Kim MR, Kim DH, Lee DK (2016) Transoral endoscopic thyroidectomy via the trivestibular route. Ann Surg Treat Res 91:269–272
3. Chai YJ, Chung JK, Anuwong A, Dionigi G, Kim HY, Hwang KT, Heo SC, Yi KH, Lee KE (2017) Transoral endoscopic thyroidectomy for papillary thyroid microcarcinoma: initial experience of a single surgeon. Ann Surg Treat Res 93:70–75
4. Park JO, Sun DI (2017) Transoral endoscopic thyroidectomy: our initial experience using a new endoscopic technique. Surg Endosc 31:5436–5443
5. Yi JW, Yoon SG, Kim HS, Kim SJ, Chai YJ, Choi JY, Lee KE (2018) Transoral endoscopic surgery for papillary thyroid carcinoma: initial experiences of a single surgeon in South Korea. Ann Surg Treat Res 95:73–79
6. Dionigi G, Chai YJ, Tulfano RP, Anuwong A, Kim HY (2018) Transoral endoscopic thyroidectomy via a vestibular approach: why and how? Endocrine 59:275–279
7. Kim HY, Chai YJ, Dionigi G, Anuwong A (2018) Richmon JD (2018) Transoral robotic thyroidectomy: lessons learned from an initial consecutive series of 24 patients. Surg Endosc 32:688–694
8. Kim KN, Lee DW, Kim JY, Han KH, Tae K (2017) Carbon dioxide embolism during transoral robotic thyroidectomy: a case report. Head Neck 40:E25–E28
9. Fu J, Luo Y, Chen Q, Lin F, Hong X, Kuang P, Yan W, Wu G, Zhang Y (2018) Transoral endoscopic thyroidectomy: review of 81 cases in a single institute. J Laparoendosc Adv Surg Tech A 28:286–291
10. Dionigi G, Tulfano RP, Russell J, Kim HY, Piantanida E, Anuwong A (2017) Transoral thyroidectomy: advantages and limitations. J Endocrinol Invest 40:1259–1263
11. Anuwong A, Ketwong K, Jitpratoom P, Sasanakietkul T, Duh QY (2018) Safety and outcomes of the transoral endoscopic thyroidectomy vestibular approach. JAMA Surg 153:21–27