—Original—

Learning Curve for Endoscopic Thyroidectomy Using Video-Assisted Neck Surgery: Retrospective Analysis of a Surgeon's Experience with 100 Patients

Ryuta Nagaoka, Iwao Sugitani, Hiroko Kazusaka, Mami Matsui,
Masaomi Sen, Marie Saitou, Tomoo Jikuzono, Ritsuko Okamura,
Takehito Igarashi and Kazuo Shimizu

Department of Endocrine Surgery, Graduate School of Medicine, Nippon Medical School, Tokyo, Japan

Background: Endoscopic thyroidectomy offers excellent cosmetic outcomes but requires some time for surgeons to become proficient. We examined the learning curve for the first 100 patients treated by a single surgeon using a subclavian approach for video-assisted neck surgery (VANS).

Methods: We retrospectively studied the records of 100 patients (99 women, 1 man; mean age, 36.2 years) with either benign or malignant thyroid disease treated between 2016 and 2020.

Results: Preoperative diagnosis was papillary thyroid carcinoma (PTC) in 36 cases and other (non-PTC) in 64 cases. All patients underwent lobectomy, with additional unilateral central node dissection for patients with PTC. Mean operative time was 125 min for non-PTC cases and 129 min for PTC cases (p = 0.43); blood loss was 33.8 mL and 7.6 mL, respectively (p = 0.01). Recurrent laryngeal nerve paralysis (RNP) was observed in 12 patients (12%) and hemorrhage in 2 patients (2%). In a comparison of the first 30 cases and subsequent 70 cases, no significant differences in operative time or blood loss were evident, although tumor size was significantly greater among later non-PTC cases (32.4 mm vs. 39.5 mm, p = 0.039). RNP was significantly lower in later cases (26.7% vs. 5.7%, p = 0.003). Multivariate analysis revealed that tumor size was a significant risk factor for increased blood loss, and increased experience significantly correlated with a decrease in RNP.

Conclusions: In VANS, satisfactory surgical proficiency was reached after treating 30 patients.
(J Nippon Med Sch 2022; 89: 277–286)

Key words: endoscopic thyroidectomy, gasless lifting method, learning curve, video-assisted neck surgery, papillary thyroid carcinoma

Introduction

Thyroid tumors are common among young women. Conventional thyroid surgery requires a collar-like incision in the neck, which poses a problem for cosmetic appearance. In 1997, Huscher et al. reported the first endoscopic thyroid surgery[1], and Shimizu et al. reported video-assisted neck surgery (VANS) using a subclavian approach in 1998[2]. Various approaches were later reported, including axillary[3], breast[4], anterior chest[5], and transoral approaches[6]. The indications for surgery are currently being expanded to include not only benign conditions, but also malignant diseases.

We have been performing VANS using a subclavian approach since 1998 because this approach: 1) is closer to the neck than other approaches and relatively easy to perform; 2) is less invasive than other approaches in terms of the extent of skin flap creation; and 3) does not need air insufflation and does not result in complications such as CO_2 embolism and subcutaneous emphysema. In addition, as mentioned in our previous report[7], satisfaction with the scar among younger patients, especially those in their 20s and 30s, is greater than for the conventional approach.

However, this new surgical technique requires time for

Correspondence to Ryuta Nagaoka, MD, Department of Endocrine Surgery, Graduate School of Medicine, Nippon Medical School, 1–1–5 Sendagi, Bunkyo-ku, Tokyo 113–8603, Japan
E-mail: ryuta-n@nms.ac.jp
https://doi.org/10.1272/jnms.JNMS.2022_89-302
Journal Website (https://www.nms.ac.jp/sh/jnms/)

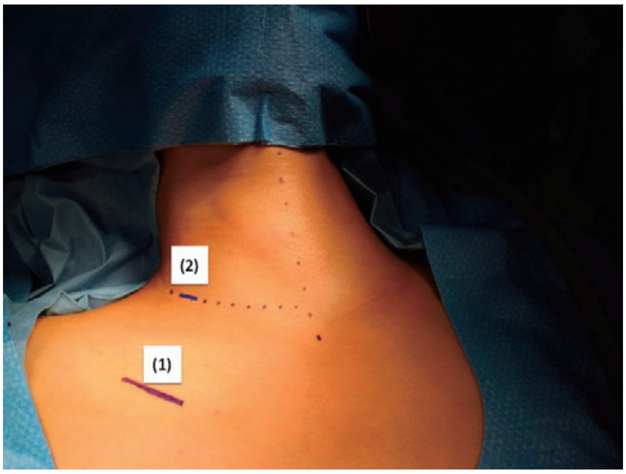


Fig. 1 Skin incision design
(1) 30-mm skin incision, (2) 5-mm camera port

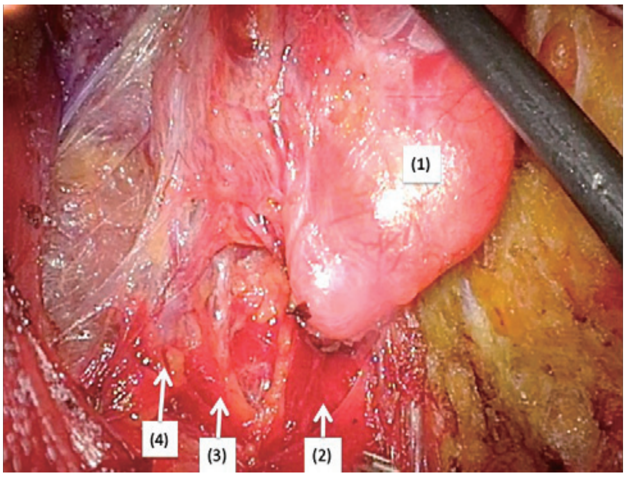


Fig. 2 Intraoperative findings (1)
The recurrent laryngeal nerve is identified after dissecting the superior thyroid artery. The surrounding tissue is carefully dissected, and intraoperative neuromonitoring is used to identify the recurrent laryngeal nerve.
(1) thyroid gland, (2) trachea, (3) recurrent laryngeal nerve, (4) inferior thyroid artery

surgeons to become proficient. Several reports have described the learning curve for endoscopic thyroid surgery and have suggested a need for surgical experience with about 30 cases to attain proficiency[8–12]. However, those studies only examined operative time and blood loss and enrolled patients with only benign or only malignant diseases. This study examined the learning curve for the first 100 cases, as experienced by a single surgeon using the VANS subclavian approach, and included patients with benign and malignant diseases. We compared the rate of postoperative complications, operative time, and blood loss between the first 30 cases and subsequent 70 cases.

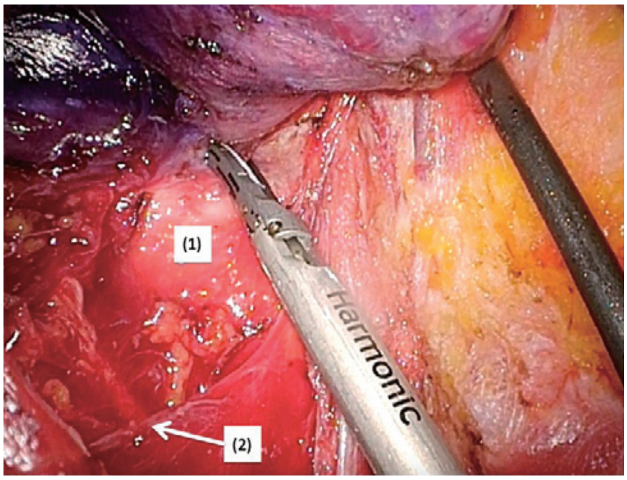


Fig. 3 Intraoperative findings (2)
The tissue surrounding the recurrent laryngeal nerve should be dissected away from the nerve, to the extent possible, and cooled as necessary to prevent thermal damage.
(1) trachea, (2) recurrent laryngeal nerve

Materials and Methods

1) Patients

We examined the records of 107 patients with benign and/or malignant thyroid diseases who underwent surgery by a single surgeon between May 2016 and July 2020. A total of 100 cases were retrospectively reviewed, after excluding 6 patients who underwent procedures other than lobectomy (total thyroidectomy, n=3; isthmectomy, n=3) and 1 patient with malignant recurrent laryngeal nerve invasion. The relevant institutional review board approved this retrospective study (approval number R1-05-1126), and informed consent for participation was obtained using an opt-out method for the study. Indications for surgery were as follows: benign tumors with a longitudinal diameter of ≤6 cm; malignant tumors preoperatively diagnosed as papillary thyroid carcinoma (PTC) only, with a tumor diameter of ≤4 cm, no extrathyroidal invasion or invasion limited to the sternothyroid muscle, and no lymph node metastasis or with central node metastasis (N1a).

2) Study Protocol

Tumors were evaluated by palpation, ultrasound, and computed tomography. Fine-needle aspiration cytology was performed in all cases to obtain a preoperative diagnosis. On the day after surgery, otolaryngologists checked vocal cord movement by using a laryngeal fiber. Prolonged recurrent laryngeal nerve paralysis (RNP) for >6 months was defined as permanent, and otherwise as transient. Preoperative vocal cord movement confirmation was performed only by ultrasound.

Table 1 Relationship between preoperative and pathological diagnosis

Preoperative diagnosis			Pathological diagnosis		
non-PTC					
	AG	27	AG		26
			FA		1
	FT	37	AG		20
			FA		8
			PTC		2
			FTC	minimally invasive	3
				encapsulated angioinvasive	2
				widely invasive	1
			PDTC		1
PTC					
	PTC	36	PTC		35
			FTC	minimally invasive	1
Total		100			100

AG, adenomatous goiter; FT, follicular tumor; FA, follicular adenoma; PTC, papillary thyroid carcinoma; FTC, follicular thyroid carcinoma; PDTC, poorly differentiated thyroid carcinoma

Table 2 Preoperative diagnosis and clinical characteristics of patients

		Total (n = 100)	non-PTC (n = 64)	PTC (n = 36)	p
Age (years)	mean ± SD	36.2 ± 12.7	35.4 ± 13.9	37.7 ± 10.2	0.34
	range	(12-71)	(12-71)	(23-59)	
	median	36.5	34	38.5	
Sex (female)		99	63 (98%)	36 (100%)	0.45
Chronic thyroiditis		25	10 (16%)	15 (42%)	0.004
Use of IONM		25	2 (3%)	23 (64%)	<0.001
Operative time (min)	mean ± SD	126 ± 23.1	125 ± 24.8	129 ± 19.8	0.43
	range	(83-179)	(83-179)	(91-166)	
	median	125	122.5	126.5	
Blood loss (mL)	mean ± SD	24.4 ± 64.4	33.8 ± 78.6	7.6 ± 11.6	0.01
	range	(0-470)	(0-470)	(0-53)	
	median	5	9	4.5	
Tumor size (mm)	mean ± SD	28.8 ± 15.6	37.6 ± 12.2	13.1 ± 4.8	<0.001
	range	(4-60)	(13-60)	(4-27)	
	median	26.5	39	12	
Excised weight (g)	mean ± SD	17.1 ± 10.4	21.5 ± 10.2	9.4 ± 5.1	<0.001
	range	(4-49)	(9-49)	(4-29)	
	median	15.2	18.2	8.0	
Complications					
RNP		12 (12.0%)	6 (9%)	6 (17%)	0.28
Postoperative bleeding		2 (2%)	1 (2%)	1 (3%)	0.68

PTC, papillary thyroid carcinoma; SD, standard deviation; IONM, intraoperative neuro-monitoring; RNP, recurrent laryngeal nerve paralysis

3) Operative Techniques

Intraoperative neuro-monitoring (IONM) was used for the 14th and later cases (April 2018) of malignant disease and for the 63rd and later cases (July 2020) of benign disease. An ultrasonic coagulation incision device was used in all cases. Lobectomy was performed in all cases, with additional central node dissection (CND) on the affected side in cases of malignant disease.

The operative method was based on a previously described procedure[7]. In summary, a 30- to 35-mm skin incision (depending on tumor size) was made in the subclavian area on the affected side, and a lifting technique

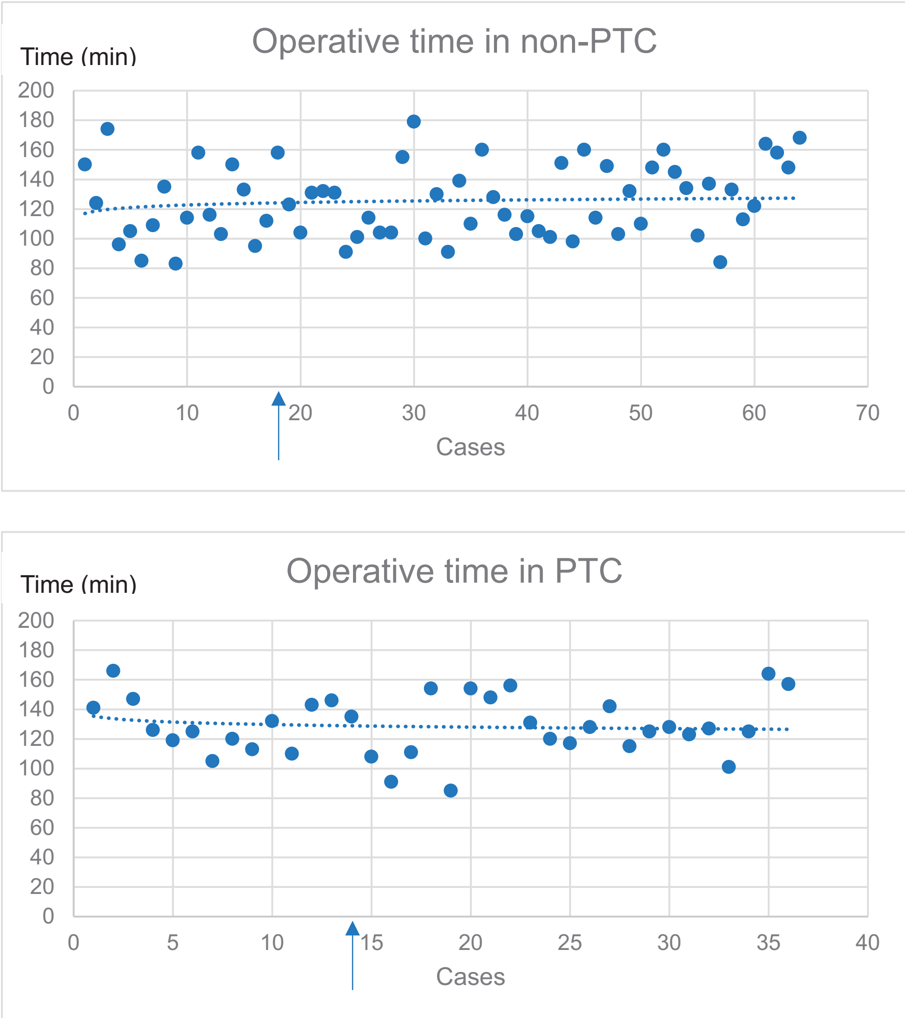


Fig. 4 Operative time in non-PTC and PTC cases
*dotted line, logarithmic approximation curve
**arrow, the 30th case the surgeon experienced overall

using a lifting retractor with an aspirator was applied. A 5-mm camera port was created in the lateral neck (**Fig. 1**). After the thyroid gland was exposed, the superior thyroid artery and inferior thyroid artery were dissected, in that order, and the parathyroid glands were confirmed and preserved (**Fig. 2**). All vessels were dissected with an energy device. The recurrent laryngeal nerve was identified and preserved by careful dissection with the use of IONM. When dissecting around the recurrent laryngeal nerve, the energy device was operated at a distance of least 2 mm from the nerve, to prevent thermal injury (**Fig. 3**). In addition, perineural tissues were periodically cooled by an infusion of saline solution.

4) Statistical Analysis and Evaluation

Data are expressed as mean ± standard deviation. Clinical characteristics were compared between groups by using the chi-square test for categorical variables and the Mann-Whitney U-test for continuous variables. Multivariate analysis was carried out by multiple and logistic regression analyses. All analyses were performed using JMP for Windows version 10.0.2 software (SAS Institute, Cary, NC, USA). A P value of <0.05 was considered statistically significant.

Results

Ninety-nine patients were female, and the mean age was 36.2 years (range, 12-71 years; median, 36.5 years). The preoperative diagnosis was PTC in 36 cases and non-PTC in 64 cases. All patients underwent lobectomy, and unilateral CND was added for patients with PTC. The postoperative pathological diagnosis was malignant in 45 cases (37 PTCs; 7 follicular thyroid carcinomas, including 4 minimally invasive tumors, 2 encapsulated angioinvasive tumors, and 1 widely invasive tumor; and 1 poorly differentiated thyroid carcinoma) and benign in 55 cases (46 adenomatous goiters and 9 follicular adenomas). The

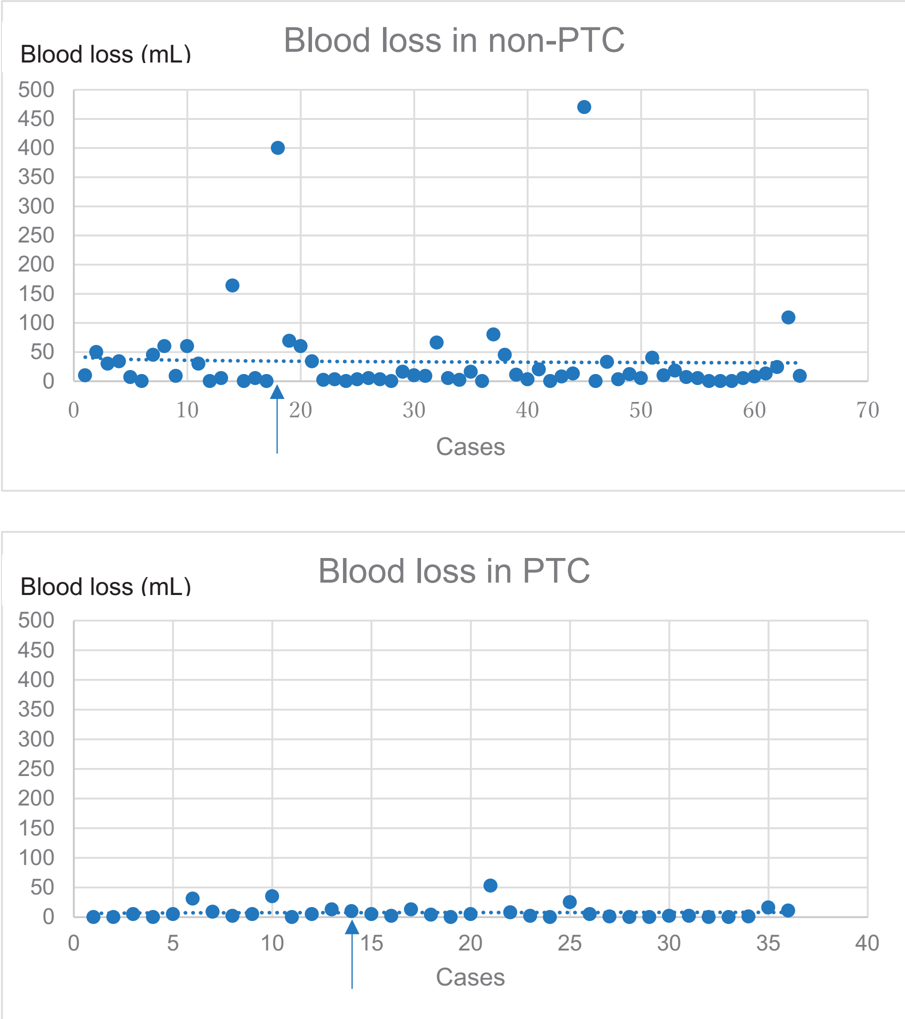
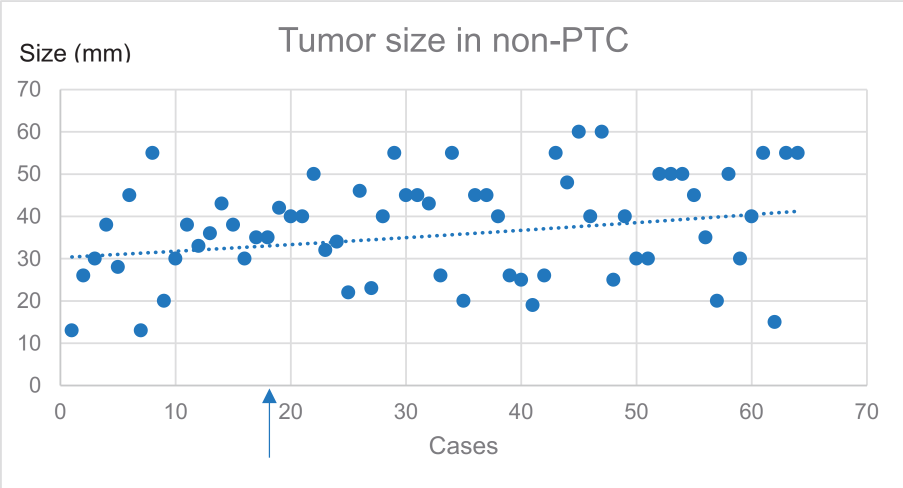


Fig. 5 Blood loss in non-PTC and PTC cases
*dotted line, logarithmic approximation curve
**arrow, the 30th case the surgeon experienced overall

association between preoperative diagnosis and pathological diagnosis is shown in **Table 1**. Associations of clinical characteristics with the preoperative diagnosis of the 100 patients are shown in **Table 2**.

No significant difference in age was evident between non-PTC cases (35.4 years) and PTC cases (37.7 years, $p = 0.34$). Chronic thyroiditis was significantly more frequent in PTC cases (42%) than in non-PTC cases (16%, $p = 0.004$). IONM was used in 25 cases, including 2 non-PTC cases (3%) and 23 PTC cases (64%, $p < 0.001$). Mean operative time was 126 min (range, 83-179 min) and did not differ significantly between non-PTC cases (125 min; range, 83-179 min) and PTC cases (129 min; range, 91-166 min; $p = 0.43$). The approximation curve of operative time showed a slight upward trend in non-PTC cases and a flat trend in PTC cases (**Fig. 4**). Blood loss was 33.8 mL (range, 0-400 mL) in non-PTC cases and 7.6 mL (range, 0-53 mL) in PTC cases (**Fig. 5**), a significant difference ($p = 0.01$). Mean tumor size was 37.6 mm (range, 13-60 mm) in non-PTC cases, with the approximation curve showing a rightward increase, and 13.1 mm (range, 5-27 mm) in PTC cases, with the approximation curve remaining almost unchanged (**Fig. 6**). Excised thyroid weight showed results similar to tumor size (**Fig. 7**). The mean number of dissected lymph nodes in PTC cases was 1.2 (range, 0-5; median, 1).

Regarding postoperative complications, RNP developed in 12 patients (12%) and hemorrhage in 2 patients (2%). RNP occurred in the 6th, 9th, 12nd, 18th, 22nd, 25 th, 28th, 30th, 38th, 57th, 72nd, and 80th cases, and hemorrhage occurred in the 20th and 52nd cases. One case of RNP was permanent, and the remaining 11 cases were transient. No patient suffered nerve transection. Physical damage from traction or forceps manipulation and thermal damage from energy devices were possible causes of RNP. No significant difference in RNP incidence was



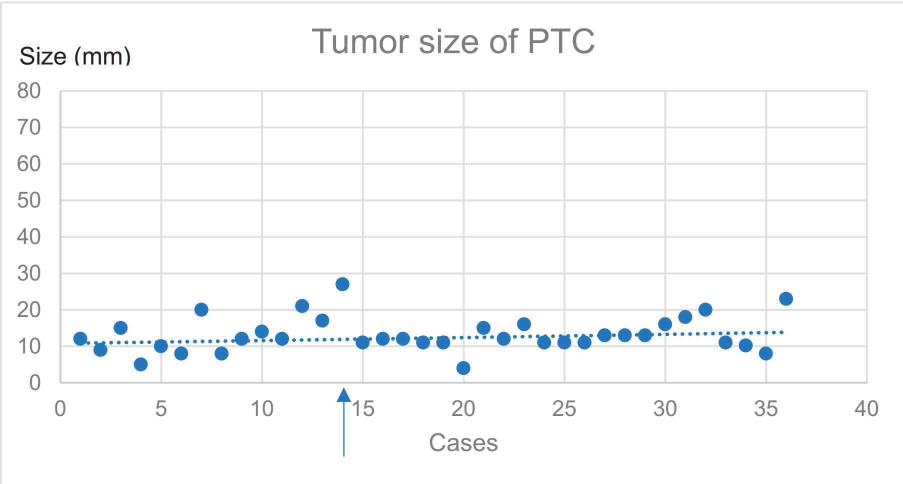


Fig. 6 Tumor size in non-PTC and PTC cases
*dotted line, exponential approximation curve
**arrow, the 30th case the surgeon experienced overall

seen between non-PTC cases (9%) and PTC cases (17%, p = 0.28). The source of postoperative bleeding in all cases was a vein in the skin flap, and hemostasis was obtained endoscopically.

We then classified patients as first 30 cases and subsequent 70 cases, for comparison. The distribution of non-PTC and PTC cases is shown in **Table 3**. While no significant difference was apparent between the first 30 and last 70 cases in operative time (125 min vs. 127 min, p = 0.60) or blood loss (20.6 mL vs. 26.0 mL, p = 0.62), tumor size of non-PTC cases (32.4 mm vs. 39.5 mm, p = 0.039) and excised weight of non-PTC cases (16.0 g vs. 23.4 g, p = 0.009) were significantly higher for the last 70 cases. Numbers of dissected lymph nodes in PTC cases were 0.7 and 1.5 (p = 0.099) for the first 30 and last 70 cases, respectively. RNP incidence was significantly lower for the last 70 cases (26.7% vs. 5.7%, p = 0.003). Among the 25 patients for whom IONM was used, one developed RNP (4%).

Multivariate analysis using multiple regression analysis was performed for 5 factors (age, sex, chronic thyroiditis, tumor size, and total number of cases experienced) to predict operative time and blood loss (**Table 4A, B**). Variance inflation factors for each factor in multiple regression analyses were all less than 1.2. No significant predictors were seen for operative time, although tumor size was a significant risk factor for increased blood loss. We then performed multivariable analysis using logistic regression analysis for RNP incidence with 2 factors: tumor size and total number of cases treated (**Table 4C**). Number of cases treated was significantly inversely correlated with RNP incidence.

Discussion

In VANS surgery, larger tumors are generally more difficult to operate on because they limit forceps manipula-

Fig. 7 Excised weight in non-PTC and PTC cases
*dotted line, exponential approximation curve
**arrow, the 30th case the surgeon experienced overall

tion and development of field-of-view and are more prone to bleeding because of the abundant blood flow. Shimizu et al. reported that for benign tumors operative time (120.7 min vs. 98.1 min, p = 0.0028) and blood loss (82.9 mL vs. 36.3 mL, p = 0.0084) were significantly greater for tumors with a diameter of ≥5 cm than for those with a diameter of <5 cm[13]. In this series, non-PTC tumors were significantly larger than PTC tumors. The amount of blood loss was significantly greater in non-PTC cases, while no significant difference in operative time was evident between groups. This is likely attributable to the addition of CND in PTC cases. Moreover, the tendency for a higher RNP incidence in PTC cases is attributable to perineural manipulation during CND.

In non-PTC cases, tumor size and excised weight tended to increase with the number of cases, indicating that the number of difficult cases gradually increased. The fact that operative time did not exhibit a general downward learning curve was thought to be attributable to changes in surgical difficulty. Operative time and blood loss alone therefore should not be used to evaluate the learning curve.

Regarding the learning curve for endoscopic thyroid surgery, Shimizu et al. reported that operating time and amount of bleeding decreased as surgeons gained experience with more than 30 cases[8]. Although differing in approach, several recent papers used cumulative summation analysis to examine endoscopic thyroidectomy. Previous studies of the learning curve for endoscopic thyroidectomy and the number of cases required for surgeons to attain proficiency are summarized in **Table 5**. Findings from these reports suggest that mastery in VANS can be attained within about 30 cases; we therefore divided the study into the first 30 and last 70 cases.

For non-PTC in the last 70 cases, operative time and blood loss did not increase, despite the increase in tumor

Table 3 Clinical characteristics of first 30 and last 70 patients treated

			First 30 cases (n = 30)	Last 70 cases (n = 70)	p
Preoperative diagnosis	non-PTC		17 (57%)	47 (67%)	0.37
	PTC		13 (43%)	23 (33%)	-
Age (years)		mean ± SD	40 ± 12.9	34.6 ± 12.3	0.053
		range	(13-71)	(12-65)	
		median	41	33	
Sex (female)			29 (97%)	70 (100%)	0.30
Chronic thyroiditis			11 (37%)	14 (20%)	0.09
Use of IONM			0 (0%)	25 (36%)	<0.001
Operative time (min)	Total	mean ± SD	125 ± 23.2	127 ± 23.2	0.6
		range	(83-174)	(84-179)	
		median	122	127.5	
	non-PTC	mean ± SD	120 ± 26.4	127 ± 24.2	0.35
		range	(83-174)	(84-179)	
		median	114	128	
	PTC	mean ± SD	127 ± 18.0	129 ± 20.9	0.81
		range	(105-166)	(85-164)	
		median	125	128	
Blood loss (mL)	Total	mean ± SD	20.6 ± 33.0	26.0 ± 74.0	0.62
		range	(0-164)	(0-400)	
		median	6	5	
	non-PTC	mean ± SD	29.9 ± 40.8	35.2 ± 88.8	0.75
		range	(0-164)	(0-400)	
		median	10	9	
	PTC	mean ± SD	8.4 ± 12.6	7.3 ± 11.4	0.81
		range	(0-35)	(0-53)	
		median	5	4	
Tumor size (mm)	Total	mean ± SD	23.8 ± 13.2	30.9 ± 16.1	0.035
		range	(8-55)	(4-60)	
		median	20.5	30.0	
	non-PTC	mean ± SD	32.4 ± 10.8	39.5 ± 12.2	0.039
		range	(13-55)	(14-60)	
		median	33	40	
	PTC	mean ± SD	11.4 ± 4.1	13.8 ± 5.0	0.15
		range	(8-21)	(4-27)	
		median	12	12	
Excised weight (g)	Total	mean ± SD	13.2 ± 7.2	18.8 ± 11.2	0.004
		range	(4-36)	(4-29)	
		median	11.1	16.5	
	non-PTC	mean ± SD	16.0 ± 7.2	23.4 ± 10.4	0.009
		range	(9-36)	(4-29)	
		median	14.3	19.5	
	PTC	mean ± SD	9.4 ± 5.9	9.4 ± 4.9	0.99
		range	(4-23)	(5-29)	
		median	6.6	8.3	
Complications					
	RNP		8 (26.7%)	4 (5.7%)	0.006
	Postoperative bleeding		1 (3.3%)	1 (1.4%)	0.51

PTC, papillary thyroid carcinoma; SD, standard deviation; IONM, intraoperative neuro-monitoring; RNP, recurrent laryngeal nerve paralysis

size. Among PTC cases, although no significant differences were identified in operative time, blood loss, tumor size, or excised weight, the number of dissected lymph nodes was higher for the last 70 cases of the study, perhaps because of improvements in surgical technique.

The causes of recurrent nerve palsy include transec-

Table 4A Multivariate analysis of predictors of operative time

Independent variables	Estimated regression coefficient	Standardized partial regression coefficient	Standard error	t value	p
(Intercept)	120.17	0	15.00	8.01	<0.001
Age	–0.23	–0.13	0.19	–1.23	0.22
Sex	5.15	0.04	11.62	0.44	0.66
Chronic thyroiditis	0.67	0.03	2.81	0.24	0.81
Tumor size (mm)	0.22	0.15	0.16	1.42	0.16
No. of cases experienced	0.06	0.07	0.08	0.68	0.50

The adjusted R2 was 0.01.

Table 4B Multivariate analysis of predictors of blood loss

Independent variables	Estimated regression coefficient	Standardized partial regression coefficient	Standard error	t value	p
(Intercept)	29.84	0	41.17	0.72	0.47
Age	–0.38	–0.07	0.52	–0.73	0.46
Sex	–14.34	–0.04	31.90	–0.45	0.65
Chronic thyroiditis	0.96	0.01	7.70	0.13	0.90
Tumor size (mm)	1.19	0.29	0.43	2.77	0.007
No. of cases experienced	–0.24	–0.11	0.23	–1.05	0.29

The adjusted R2 was 0.04.

Table 4C Multivariate analysis of predictors of recurrent laryngeal nerve paralysis

Risk factors for RNP	Odds ratio	95%CI	p
Tumor size (mm)	1.01	0.97-1.06	0.55
No. of cases experienced	0.97	0.94-1.00	0.018

RNP, recurrent laryngeal nerve paralysis; CI, confidence interval

Table 5 Learning curve analysis in endoscopic thyroidectomy

Year	Author	Approach	Disease	CO_2 insufflation	CUSUM analysis	Main evaluation items	No. of cases to reach satisfactory proficiency
2001	Shimizu[8]	Subclavian	Benign	–	–	OT, bleeding	30
2014	Liao[9]	Breast	Mainly benign	+	+	OT	27
2014	Kwak[10]	Axillary	Mainly malignant	–	+	OT, complications, no. of LN removed	60
2017	Yu[11]	Axillary	Benign	+	+	OT, complications, no. of LN removed, removal of PTG	31
2019	Cho[12]	Breast	Malignant	+	+	OT, tumor size	35

CUSUM, cumulative summation; OT, operative time; LN, lymph node; PTG, parathyroid gland

tion, ligation, constricting, clamping, traction, and thermal injury[14]. The incidence of RNP decreased significantly to 5.7% in the last 70 cases, which is comparable to previous reports from Japan (conventional surgery, 4.4%; VANS, 8.9%)[15]. We have been using IONM since 2018. Among the 25 cases treated with IONM, RNP was seen in only 4% of cases. Thus, IONM may increase surgical safety.

Multiple regression analysis revealed that increased tumor size is a significant risk factor for increased blood loss. However, tumor size was not a significant risk factor for prolonged operative time, as previously reported[13]. This finding is attributable to the additional time required for CND in PTC cases. Excised weight is believed to be more accurate than tumor diameter in reflecting tumor volume. However, in our judgement, tumor diameter, which is easily measured preoperatively by ultrasound, is the clinically preferable variable, and we thus used tumor diameter rather than excised weight in multiple regression analysis. In patients with chronic thyroiditis, thyroid tissue becomes diffusely hard and is generally difficult to grasp during endoscopic surgery. However, no significant effect on operative time or blood loss was seen. Multivariate analysis showed that total number of cases treated was significantly associated with reduced incidence of RNP. In other words, the more cases treated, the lower the risk of RNP.

A limitation of this study was that analyzing the learning curve for the first 100 cases from the start of VANS required mixing patients with benign and malignant diseases. In clinical practice, the number of difficult cases naturally increases with experience. Thus, surgical difficulty was not consistent during the study period. In addition, although cumulative summation (CUSUM) analysis would usually be used to evaluate learning curves, it was not applicable in this study because of the mixture of benign and malignant cases and the skewed distribution of surgical difficulty and IONM use.

In conclusion, surgical proficiency was attained after performing about 30 procedures using VANS. The incidence of RNP fell significantly as the number of patients treated increased.

Acknowledgements: We wish to acknowledge and thank Dr. Toshiaki Otsuka, Department of Hygiene and Public Health, Nippon Medical School, Tokyo, Japan for assistance with statistical analysis.

Conflict of Interest: None declared.

References

1. Hüscher CS, Chiodini S, Napolitano C, Recher A. Endoscopic right thyroid lobectomy. Surg Endosc. 1997 Aug;11(8):877.
2. Shimizu K, Akira S, Tanaka S. Video-assisted neck surgery: endoscopic resection of benign thyroid tumor aiming at scarless surgery on the neck. J Surg Oncol. 1998 Nov;69(3):178–80.
3. Ikeda Y, Takami H, Sasaki Y, Kan S, Niimi M. Endoscopic resection of thyroid tumors by the axillary approach. J Cardiovasc Surg (Torino). 2000 Oct;41(5):791–2.
4. Ohgami M, Ishii S, Arisawa Y, et al. Scarless endoscopic thyroidectomy: breast approach for better cosmesis. Surg Laparosc Endosc Percutan Tech. 2000 Feb;10(1):1–4.
5. Kitano H, Fujimura M, Kinoshita T, Kataoka H, Hirano M, Kitajima K. Endoscopic thyroid resection using cutaneous elevation in lieu of insufflation. Surg Endosc. 2002 Jan;16(1):88–91.
6. Anuwong A. Transoral endoscopic thyroidectomy vestibular approach: A series of the first 60 human cases. World J Surg. 2016 Mar;40(3):491–7.
7. Shimizu K, Okamura R, Igarashi T, et al. Video-assisted neck surgery (VANS) using a gasless lifting procedure for thyroid and parathyroid diseases: "The VANS method from A to Z". Surg Today. 2020 Oct;50(10):1126–37.
8. Shimizu K. Minimally invasive thyroid surgery. Best Pract Res Clin Endocrinol Metab. 2001 Jun;15(2):123–37.
9. Liao HJ, Dong C, Kong FJ, Zhang ZP, Huang P, Chang S. The CUSUM analysis of the learning curve for endoscopic thyroidectomy by the breast approach. Surg Innov. 2014 Apr;21(2):221–8.
10. Kwak HY, Kim SH, Chae BJ, Song BJ, Jung SS, Bae JS. Learning curve for gasless endoscopic thyroidectomy using the trans-axillary approach: CUSUM analysis of a single surgeon's experience. Int J Surg. 2014 Dec;12(12):1273–7.
11. Yu J, Rao S, Lin Z, Pan Z, Zheng X, Wang Z. The learning curve of endoscopic thyroid surgery for papillary thyroid microcarcinoma: CUSUM analysis of a single surgeon's experience. Surg Endosc. 2019 Apr;33(4):1284–9.
12. Cho J, Lee D, Baek J, Lee J, Park Y, Sung K. Single-incision endoscopic thyroidectomy by the axillary approach with gas inflation for the benign thyroid tumor: retrospective analysis for a single surgeon's experience. Surg Endosc. 2017 Jan;31(1):437–44.
13. Shimizu K, Kitagawa W, Akasu H, Hirai K, Tanaka S. Video-assisted minimally invasive endoscopic thyroid surgery using a gasless neck skin lifting method--153 cases of benign thyroid tumors and applicability for large tumors. Biomed Pharmacother. 2002;56(Suppl 1):88s–91s.
14. Chiang FY, Lu IC, Kuo WR, Lee KW, Chang NC, Wu CW. The mechanism of recurrent laryngeal nerve injury during thyroid surgery--the application of intraoperative neuromonitoring. Surgery. 2008 Jun;143(6):743–9.
15. Igarashi T, Shimizu K, Okamura R, et al. Naishikyoka koujousen shujutsu waaking guruupu no seiseki to kongo no kadai [Surgical outcome and future direction of Japanese endoscopic thyroid surgery working group study]. Official Journal of the Japan Association of Endocrine Surgeons and the Japanese Society of Thyroid Surgery. 2016;33(4):200–4. Japanese.

(Received, May 24, 2021)
(Accepted, August 4, 2021)
(J-STAGE Advance Publication, September 14, 2021)