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Original research

Learning curve for gasless endoscopic thyroidectomy using the trans-axillary approach: CUSUM analysis of a single surgeon's experience

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ABSTRACT

Background: Endoscopic thyroidectomy and endoscopic parathyroidectomy were first reported in the 1990s. However, there have been few studies reporting on the learning curve of endoscopic thyroidectomy. We used the moving average method and cumulative sum (CUSUM) analysis to assess the learning curve of gasless endoscopic thyroidectomy. **Methods**: Three hundred consecutive patients with thyroid carcinoma underwent gasless endoscopic thyroidectomy between September 2008 and February 2012. Patients were divided into two groups according to the type of operation they underwent; group L included hemithyroidectomy patients, and group T included total thyroidectomy patients. Endoscopic total thyroidectomy was performed mostly after the time endoscopic lobectomy could be done without difficulty. The results of surgical outcome were analyzed for changes over the case sequence in each group by using the moving average method and CUSUM analysis. **Results**: The mean operation time of group T (131 ± 41 min) was longer than that of group L (102 ± 33 min; $p < 0.05$). The moving average method showed that the operation time began to decrease from the 60th case and the 38th case in groups L and T, respectively. However, other factors such as transient hypocalcemia, transient vocal cord palsy and the number of the retrieved lymph nodes had no learning curves based on the moving average method and CUSUM analysis. **Conclusions**: The learning curve duration of gasless endoscopic thyroidectomy is about 60 cases for unilateral lobectomy. Thereafter, the learning curve of endoscopic total thyroidectomy is 38 cases. Careful dissections must be carried out to avoid surgical complications even after the surgeon mastered endoscopic thyroidectomy.

1. Introduction

Thyroid cancer is the most common endocrine cancer. The incidence of thyroid cancer, especially papillary thyroid microcarcinoma (papillary carcinoma with a maximum diameter of 10 mm), is increasing as diagnostic techniques become more sensitive (e.g., ultrasounds and fine-needle aspiration) [1]. In the past three decades, the incidence of thyroid cancer in the United States has more than doubled, from 4.3 cases per 100,000 individuals in 1980 to 12.9 cases per 100,000 individuals in 2008 [2]. The incidence of thyroid disease is markedly higher in women, which creates an additional need for reducing or even eliminating neck scarring, especially in young patients [3].

The conventional open method for thyroidectomy is known to be safe, but cosmetic results are controversial. Therefore, endoscopic thyroid and parathyroid surgery have emerged as viable options for surgical management of thyroid tumors since the first descriptions of endoscopic parathyroidectomy by Gagner [4] and video-assisted thyroid lobectomy by Huscher [5] in the 1990s. A key benefit of endoscopic thyroidectomies is the superior cosmetic result. However, the endoscopic approach is more technically demanding and uses a narrower space than open surgery [6].

Few studies of the learning curve for endoscopic thyroidectomy have been reported. Criteria for indications and contraindications are still being investigated and continuously updated. Therefore, we used cumulative sum (CUSUM) analysis to investigate the learning curve for endoscopic thyroidectomy based on one surgeon's experience.

Abbreviations: CUSUM, cumulative sum; L, hemithyroidectomy (unilateral lobectomy); T, Total thyroidectomy.

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2. Methods

2.1. Patients' cohort

Three hundred consecutive patients with thyroid carcinoma underwent gasless endoscopic thyroidectomy by a single surgeon at the Department of Surgery, Seoul St. Mary's Hospital, The Catholic University of Korea, between September 2008 and February 2012. The surgeon was experienced in conventional open thyroid surgery but not in endoscopic thyroid surgery. Therefore, in the beginning, endoscopic thyroidectomy was mostly unilateral lobectomy. Endoscopic total thyroidectomies were performed mainly after the surgeon underwent duration of learning curve for endoscopic lobectomy. All data for this study were collected from a prospective database approved by the institutional review board. The clinocopathological data for the 300 patients including age, gender, tumor size, pathologic reports, operation time, postoperative calcium level, both preoperative and postoperative stroboscopy reports, and numbers of the retrieved lymph nodes were collected in the database. All protocols were approved by the institutional review committee of Seoul St. Mary's Hospital, Catholic University of Korea (KC12RISI0704) and met the guidelines of the responsible governmental agency.

2.2. Protocols

Patients were divided into two groups according to the type of operation undergone; group L included patients who had undergone hemithyroidectomy, and group T included those who had undergone total thyroidectomy. The following surgical outcome parameters were analyzed for changes over the case sequence: operation time, transient hypocalcemia, transient vocal cord palsy, and number of the retrieved lymph nodes. Changes in operation times and number of retrieved lymph nodes according to case sequence were analyzed using the moving average method.

Transient hypocalcemia, which was counted only in group T, was defined as at least one measurement of postoperative ionized calcium <1.0 (or serum calcium < 8.0). The observed score for successful postoperative calcium level was defined as zero, and the score for transient hypocalcemia was 1. Changes in occurrence of transient hypocalcemia across the case sequence were analyzed with the CUSUM model.

2.3. Statistical analysis

The CUSUM method is a type of sequential analysis test that was initially used in industrial settings for quality control purposes [7]. It can be applied to monitor any process with a binary outcome and allows one to judge whether the initial or continued performance of a task is acceptable or unacceptable. CUSUM has already been used in several different surgical settings, including the assessment of outcomes in transplant surgery [8], laparoscopic colorectal surgery [9], sentinel lymph node biopsy [10], and focused abdominal ultrasounds [11].

The moving average method and the CUSUM model were analyzed using Minitab 16.0 (Minitab, Inc., State College, PA). Statistical significance was accepted at $p < 0.05$. Continuous variables are expressed as mean ± standard deviation.

2.4. Operation procedures

The patient was placed in a supine position under general anesthesia. The neck was slightly extended, and the arm on the side of the lesion was raised to fully expose the axilla. After making a 6-cm vertical skin incision in the axilla, a subcutaneous blunt dissection was carried up to the prethyroidal space using a long dissector along the upper margin of the pectoralis major muscle. After the dissection, adequate working space was created by lifting with the retractor that was inserted through the axillary incision. A rigid 30-degree videoscope and other endoscopic instruments were inserted through the axillary incision. When total thyroidectomy was performed, a second skin incision (0.5 cm in length) was made on the medial side of the anterior chest wall for the insertion of endoscopic instruments on an imaginary horizontal line starting from the lower end of the axillary incision and extending for 5–6 cm. Endoscopic scissors were used for blunt and sharp dissection of the subplatysmal space. The anteriomedial border of the sternocleidomastoid muscle was divided from the sternothyroid muscle to create adequate entry space to the thyroid gland. The thyroid gland was exposed by medial traction of the sternothyroid muscle and lateral traction of the sternocleidomastoid muscle. The lower pole was then retracted upward by grasper and dissected from the adjacent adipose and lymphovascular tissue to identify the inferior parathyroid gland. The thyroid gland was retracted medially, and the perithyroidal fascia was incised using endoscopic scissors. The inferior thyroid vessel and the middle thyroid vein were divided with the harmonic scalpel (Johnson & Johnson Medical, Cincinnati, OH). This scalpel was used for vessel sealing throughout the operation, but clips were used when needed. The recurrent laryngeal nerve was identified in all cases and was gently separated from the posterior surface of the thyroid gland. After fully separating the gland from the nerve, the upper pole was thoroughly explored, grasped, and drawn toward the operator before the resection to avoid injury to the external branch of the superior laryngeal nerve. The harmonic scalpel was used for the division of the superior thyroid vessels and dissection of the gland. We identified the superior parathyroid gland during the dissection of the upper pole of the gland and were able to save it in all cases. The thyroid gland was then dissected from the trachea, and the isthmus was resected using the harmonic scalpel. The resected specimen was extracted through the axillary incision. After meticulous hemostasis, the axillary incision was closed with a closed suction drain left in place. All endoscopic equipment, including dissector, grasper, and scissors, were commercially available laparoscopic instruments [12].

3. Results

The clinicopathological outcomes and characteristics of patient in group L ($n = 200$) and group T ($n = 100$) are shown in Table 1. The mean age of the patients was 38.1 ± 8.4 and 37.4 ± 9.6 years in groups L and T, respectively ($p = 0.543$). The mean operation time in group T (131 ± 41 min) was significantly longer than that in group L

Table 1
Clinicopathological outcomes for 300 patients who underwent endoscopic unilateral lobectomy (hemithyroidectomy) (L) or total thyroidectomy (T).

	L	T	*p*-Value
Patients (number)	200	100	
Age	38.1 ± 8.42	37.4 ± 9.67	0.543
Operation time (min)	102 ± 33	131 ± 41	
Number of retrieved LNs	4.88 ± 4.22	6.04 ± 4.24	0.027
Tumor (number)			
Malignancy (papillary/follicular)	186 (177/9)	99 (99/0)	
Benign	14	1	
Tumor size (cm)	0.60 ± 0.51	0.71 ± 0.37	0.063
Serum calcium (mg/dL)[a]	8.3 ± 1.74	8.54 ± 0.58	0.314
Ionized serum calcium (mmol/L)[a]	1.14 ± 0.61	1.11 ± 0.13	0.564

L: unilateral lobectomy; T: total thyroidectomy; LN: lymph node.
[a] 3-hours postoperative.