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Impact of bedside assistant on outcomes of robotic thyroid surgery

A STROBE-compliant retrospective case-control study

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Abstract

The importance of bedside assistants has been well established in various robotic procedures. However, the effect of assistants on the surgical outcomes of thyroid surgery remains unclear. We investigated the effects of a dedicated robot assistant (DRA) in robotic thyroidectomy. We also evaluated the learning curve of the DRA.

Between January 2016 and December 2019, 191 patients underwent robotic total thyroidectomy, all of which were performed by a single surgeon. The DRA participated in 93 cases, while non-dedicated assistants (NRAs) helped with 98 cases. Demographic data, pathologic data, operative times, and postoperative complications were recorded and analyzed.

Robotic thyroidectomy was successful in all 191 patients, and none required conversion to the conventional open procedure. Mean operative time was shorter in the DRA group than in the NRA group (183.2 ± 33.6 minutes vs 203.1 ± 37.9 minutes; $P < .001$). There were no significant differences in terms of sex distribution, age, preoperative serum thyroid stimulating hormone level, or pathologic characteristics between the groups. Cumulative summation analysis showed that it took 36 cases for the DRA to significantly reduce operative time. Mean operative time decreased significantly in the subgroup including the 37th to the 93rd DRA cases compared with the subgroup including only the first 36 DRA cases (199.7 ± 37.3 minutes vs 172.8 ± 26.4 minutes; $P < .001$). NRA group showed no definite decrease of operation time, which indicated that the NRAs did not significantly deviate from the mean performance.

Increased experience of the bedside assistant reduced operative times in the robotic thyroidectomy. Assistant training should be considered as a component of robotic surgery training programs.

Abbreviations: BABA = bilateral axillo-breast approach, CUSUM = cumulative summation, DRA = dedicated robot assistant, NRA = non-dedicated assistant, PGY = postgraduate year, RLN = recurrent laryngeal nerve.

Keywords: assistant, cumulative summation, learning curve, robotic, thyroid

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The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author on reasonable request.

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1. Introduction

Conventional thyroid surgery has traditionally been performed through a neck incision, although the resulting scar can be a cosmetic concern, particularly for young patients.[1,2] Bilateral axillo-breast-approach (BABA) robotic thyroidectomy was developed as an alternative procedure for removing the thyroid gland without a neck incision.[3] The BABA allows a symmetrical operative view, which resembles that of open thyroid surgery.[4] This midline approach allows excellent visualization and dissection of important structures in both thyroid lobes. Furthermore, BABA provides the largest operative angles for instrument manipulation, which can minimize instruments crowding or fighting. The oncologic safety and cosmetic superiority of BABA robotic thyroidectomy has been recognized in recent studies.[5–7] With the increased application of the surgical robots for thyroidectomy in recent years, proficiency and experience of the surgeon are major concerns.[8]

Many researchers have investigated the relationship between surgeon experience and patient outcomes using various methods.[9] Learning curve analysis is one of the more popular methods for evaluating proficiency of robotic skills, although there is no perfect method to measure surgical proficiency.[10] In the past 5 years, >1000 articles investigating or discussing learning curves for robotic surgery have been published. Previous studies investigating learning curves for robotic thyroidectomy have indicated that operative times decrease gradually and reach a steady state after 35 to 50 cases.[8,11,12] These studies analyzed the relationship between the experience of the surgeon and perioperative variables, including operative times, complication rates, blood loss, and the number of dissected lymph nodes. However, the role of the surgical assistant was not taken into consideration.

In robot-assisted procedures, as the main surgeon manipulates the console away from the patient cart, a bedside assistant often supports the main surgeon by changing robotic instruments or providing pure laparoscopic assistance, including suction and irrigation.[13] Previous studies have demonstrated that higher levels of experience of the surgical assistants are associated with reduced operative times, less blood loss, and lower overall complication rates.[13–16] Moreover, participation of trainees resulted in higher rates of anastomosis leakage, readmissions, re-interventions, and complications.[14] In contrast, Abu-Ghanem et al[17] found that assistant's experience levels had no influence on operative outcomes. The effects of bedside assistants on surgical outcomes for thyroid surgery have remained unclear.[18] Furthermore, most previous studies did not evaluate the learning curve required for the assistant to gain the mastery and proficiency.

In terms of surgical outcomes, this study investigated the effects of bedside assistants and their associated learning curve in the context of BABA robotic thyroidectomy.

2. Methods

2.1. Study population

The institutional review board of Ewha University Medical Center approved this study and waived the requirement for written informed consent (Approval No. 2020–02–039). The BABA technique used in the present study has been described elsewhere.[5] From January 2016 to December 2019, 191 consecutive patients underwent BABA robotic total thyroidectomies, all of which were performed by a single surgeon (HK) who had already performed >75 robotic thyroid operations. Demographic data, pathologic data, operative times, postoperative complications, and name of assistant were recorded and analyzed. Primary outcome of this study was operative time.

2.2. Bedside assistant participation in robotic thyroidectomy

At the study institution, operative assistants were either postgraduate year-3 (PGY III) or postgraduate year-4 (PGY IV) general surgery residents until February 2016. A new dedicated robot assistant (DRA) joined the department in March 2016, with no previous experience as an assistant in robotic thyroid surgery. The DRA started bedside assistance for BABA robotic thyroidectomy from May 2016 and participated in 93 cases. When the DRA was unavailable, a PGY III or IV resident served as the non-dedicated robot-assistant (NRA). The resident NRAs also had little or no previous experience with robotic thyroid surgery. The NRAs participated in a total of 93 cases, while each NRA assisted with, at most, 12 cases.

2.3. Follow-up examinations

The vocal cord motility was examined routinely 1 day before and 2 weeks after surgery using video-assisted laryngoscopy. Serum concentrations of calcium, phosphorus, ionized calcium, and parathyroid hormone were measured 1 day before and 2 days after the thyroidectomy. Follow-up examinations were performed at intervals of 2 weeks, 3 months, and then 6 months.

2.4. Statistical analysis

The cumulative summation (CUSUM) method enables quantitative assessment of individual performance in various surgical procedures.[19] CUSUM analysis demonstrates the cumulative differences between the target data and the observed data. In brief, the 191 cases were arranged in chronological order, from the earliest to the latest operation date. The difference between the operative time of the xth case and the mean operative time was defined as Sx. The Sx values were summed sequentially and then plotted as a graph using the equation: $\text{CUSUM} = \Sigma \text{Sx}$.[14]

SPSS 22.0 (IBM Corp., Armonk, NY) was used for all statistical analyses. Continuous variables were compared using Student t test, and dichotomous variables were compared using the chi-squared test. Correlation coefficients (R) were calculated using bivariate Pearson correlation analysis. A P-value <.05 was considered statistically significant.

3. Results

The baseline characteristics of the included patients are summarized in Table 1. BABA robotic thyroid surgery was successful in all 191 patients, and none required conversion to the conventional open procedure. The overall mean operative time was 193.4 ± 37.1 minutes (range, 120–340). Seventy-six patients (39.8%) experienced postoperative hypoparathyroidism, including 1 (1.0%) patient who developed permanent hypoparathyroidism. Recurrent laryngeal nerve (RLN) palsy occurred in 10 patients (5.2%), but no patients showed RLN palsy on laryngoscopic exam after 3 postoperative months. In Fig. 1, operative times and assistants' participation are plotted in chronological order.

The clinicopathological characteristics of the patients in the DRA and NRA groups are compared in Table 2. There were no

Table 1

Clinicopathological characteristics of the patients.

Patient characteristics	
Sex (male:female)	21 (11.0%): 170 (89.0%)
Age, y	37.9 ± 9.6 (range, 17–66)
Body mass index, kg/m^2	22.7 ± 3.1 (range, 17.4–39.5)
Preoperative serum TSH level, mIU/L	1.93 ± 1.93
Assistant participation	
Dedicated robot assistant	93 (48.7%)
Non-dedicated robot assistants	98 (51.3%)
Pathologic characteristics	
Tumor size, cm	0.8 ± 0.5
Microscopic extrathyroidal extension	98 (57%)
Lymph node metastasis	62 (36.0%)
Number of retrieved lymph nodes	5.4 ± 4.8
Excised thyroid weight, g	21.7 ± 8.3 (range, 8.2–65.8)
Operation time, min	193.4 ± 37.1 (range, 120–340)
Complications	
Transient hypoparathyroidism	76 (39.8%)
Transient RLN palsy	10 (5.2%)
Permanent hypoparathyroidism	2 (1.0%)
Permanent RLN palsy	0 (0.0%)
Postoperative bleeding	0 (0.0%)

RLN = recurrent laryngeal nerve; TSH = thyroid stimulating hormone.

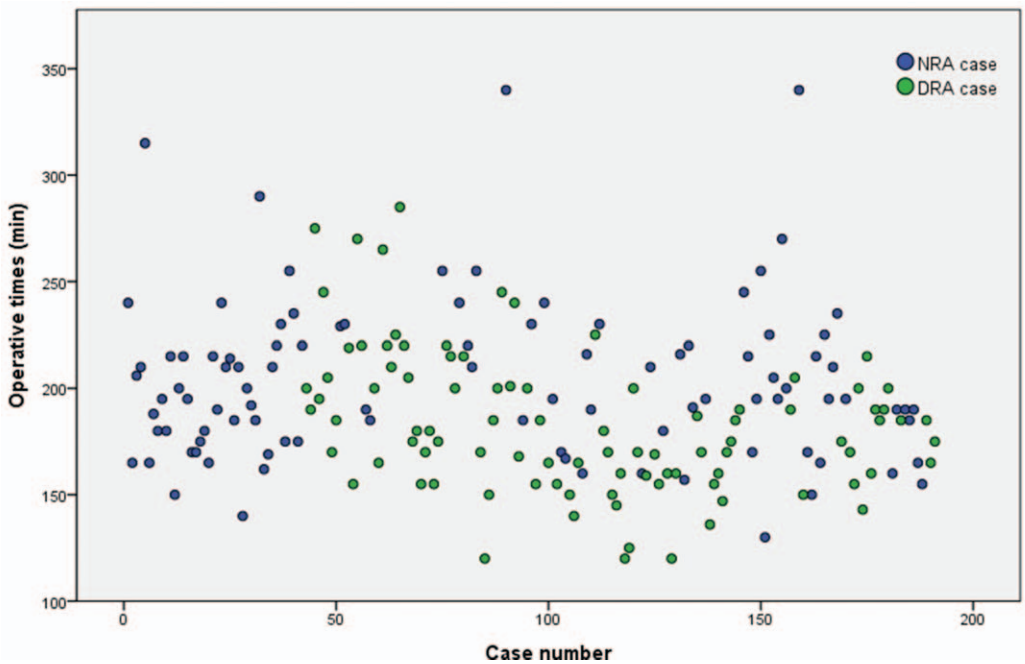

Figure 1. Operative times plotted in chronological order. Green dots represent the DRA cases, while Indigo-blue dots do the NRA cases. DRA=dedicated robot assistant, NRA=non-dedicated assistant.

significant differences in terms of sex distribution, age, preoperative serum thyroid stimulating hormone level, or pathologic characteristics between the groups. The mean operative time was shorter in the DRA group than in the NRA group (183.2±33.6 minutes vs 203.1±37.9 minutes; $P<.001$). Postoperative complications, including transient hypoparathyroidism (34.4% vs 44.9%; $P=.139$), transient RLN palsy (4.3% vs 6.1%; $P=.572$), or permanent hypoparathyroidism (1.1% vs 1.0%; $P=.970$) were comparable between the groups.

Table 2

Comparison of clinicopathological characteristics between the DRA and NRA groups.

Characteristics	DRA group (n=93)	NRA group (n=98)	*P*-value
Sex (male:female)	13:80	8:90	.20
Age, y	39.1±9.5	36.6±9.9	.07
Body mass index, kg/m^2	22.9±2.9	22.5±3.3	.92
Preoperative serum TSH level	1.94±1.22	1.92±2.43	.95
Pathologic characteristics			
Tumor size, cm	0.8±0.4	0.8±0.6	.30
Microscopic ETE	55 (59.1%)	50 (51.0%)	.26
LN metastasis	37 (39.8%)	36 (36.7%)	.67
Number of retrieved LNs	5.3±4.8	5.5±4.8	.79
Excised thyroid weight, g	22.4±7.8	21.1±8.7	.27
Operative time, min	183.2±33.6	203.1±37.9	<.001
Complications			
Transient hypoparathyroidism	32 (34.4%)	44 (44.9%)	.14
Transient RLN palsy	4 (4.3%)	6 (6.1%)	.57
Permanent hypoparathyroidism	1 (1.1%)	1 (1.0%)	.97
Permanent RLN palsy	0 (0.0%)	0 (0.0%)	NA
Postoperative bleeding	0 (0.0%)	0 (0.0%)	NA

ETE=extrathyroidal extension; LN=lymph node; NA=not applicable; RLN=recurrent laryngeal nerve; TSH=thyroid stimulating hormone.

The CUSUM learning curves of the DRA group are plotted in Fig. 2. The mean operative time was 183.2±33.6 minutes in the DRA group. The best fitting curve was a sixth-order polynomial with the equation:

$$\begin{aligned} \text{CUSUMDRA} = {} & -46.7 + 46.5 \times (\text{Case number}) - 1.68 \\ & \times (\text{Case number})^2 + 6.58 \times 10^{-2} \\ & \times (\text{Case number})^3 - 1.62 \times 10^{-3} \\ & \times (\text{Case number})^4 - 1.72 \times 10^{-5} \\ & \times (\text{Case number})^5 - 6.42 \times 10^{-8} \\ & \times (\text{Case number})^6, \end{aligned}$$

which had a high R^2-value of 0.971. The slope of the CUSUM learning curve turned from positive to negative after the 36th case, which means that the DRA required 36 cases to gain proficiency. The mean operative time was significantly shorter in the subgroup including the 37th to the 93rd DRA-assisted cases than in the subgroup including only the first 36 cases (199.7±37.3 minutes vs 172.8±26.4 minutes; $P<.001$). There was no difference between these subgroups in the complication rates (Table 3).

On the other hand, the mean operative time was 203.1±37.9 minutes in the NRA group. The fitting curve for the NRA group was a third-order polynomial with the equation:

$$\begin{aligned} \text{CUSUMNRA} = {} & 155.0 - 25.7 \times (\text{Case number}) - 0.648 \\ & \times (\text{Case number})^2 - 4.06 \times 10^{-3} \\ & \times (\text{Case number})^3, \end{aligned}$$

with a R^2-value of 0.701. The slope of CUSUM learning curve for the NRA group showed no definite changes from positive to

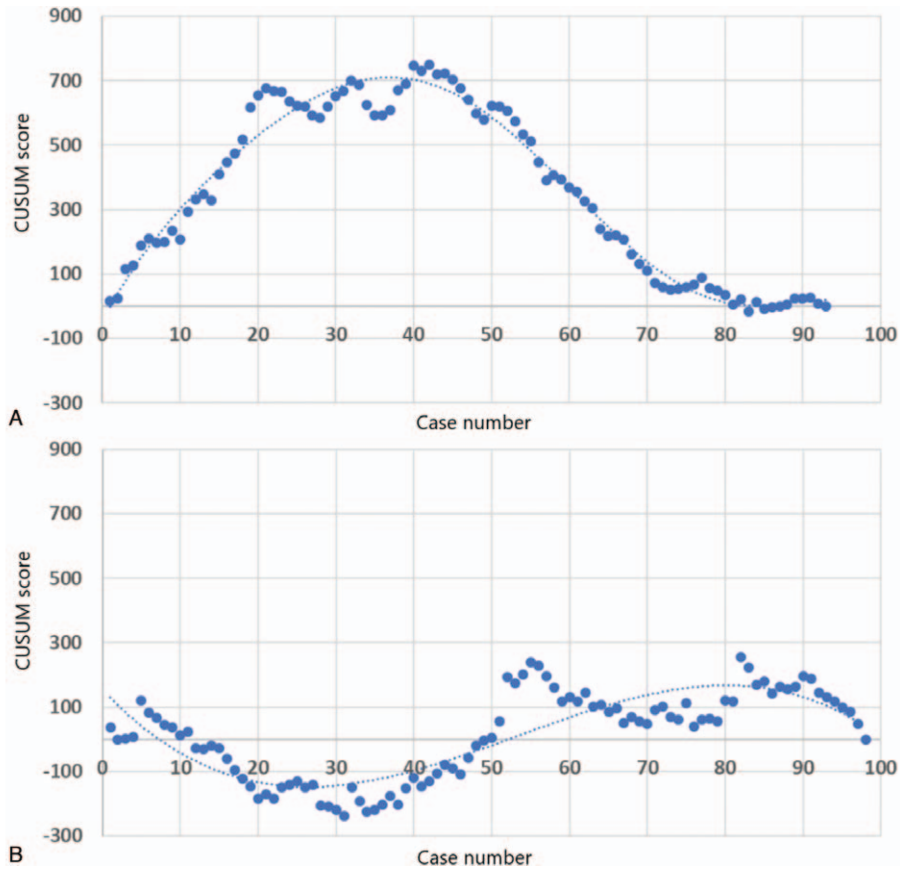

Figure 2. CUSUM analysis of the operative time. (A) CUSUM score and fitting curve of the DRA group. (B) CUSUM score and fitting curve of the NRA group. CUSUM = cumulative summation, DRA = dedicated robot assistant, NRA = non-dedicated assistant.

negative, which indicated that the NRAs did not significantly deviate from the mean performance. Bivariate correlation analysis also showed no correlation between the operative time and case number in the NRA group ($R = -0.013$, $P = .902$), whereas the operative time decreased as the cumulative number of cases increased in the DRA group ($R = 0.401$, $P < .001$).

Table 3

Comparison of clinicopathological characteristics between the first 36 cases and after 37th-case groups.

Characteristics	Early DRA (n = 36)	Late DRA (n = 57)	*P*-value
Sex (male:female)	5:31	8:49	.98
Age, y	39.9 ± 8.3	38.7 ± 10.2	.56
Body mass index, kg/m^2	23.4 ± 2.9	22.6 ± 2.8	.17
Preoperative serum TSH level	1.92 ± 0.94	1.95 ± 1.38	.89
Pathologic characteristics			
Tumor size, cm	0.8 ± 0.3	0.7 ± 0.4	.23
Microscopic ETE	26 (72.2%)	29 (50.9%)	.04
LN metastasis	14 (38.9%)	23 (40.4%)	.89
Number of retrieved LNs	5.8 ± 6.0	4.9 ± 3.8	.43
Excised thyroid weight, g	24.5 ± 8.9	21.2 ± 6.9	.06
Operative time, min	199.7 ± 37.3	172.8 ± 26.4	<.001
Complications			
Transient hypoparathyroidism	13 (36.1%)	19 (33.3%)	.78
Transient RLN palsy	2 (5.6%)	2 (3.5%)	.64
Permanent hypoparathyroidism	0 (0.0%)	1 (1.8%)	.42
Permanent RLN palsy	0 (0.0%)	0 (0.0%)	NA
Postoperative bleeding	0 (0.0%)	0 (0.0%)	NA

ETE = extrathyroidal extension; LN = lymph node; NA = not applicable; RLN = recurrent laryngeal nerve; TSH = thyroid stimulating hormone.

4. Discussion

This study demonstrated that an experienced assistant could further reduce the operative time in BABA robotic thyroidectomy, even after the main surgeon's learning curve had plateaued. In the era of laparoscopic surgery, it has been well established that the experience of the assistant can affect operative times and complication rates.[20–23] The importance of bedside assistants in terms of surgical outcomes has also been shown in various robotic procedures, including complex gastrointestinal surgery, bariatric surgery, and prostatectomy.[13–16] However, little attention has been paid to the role of the assistant in robotic thyroid surgery. During BABA robotic thyroidectomy, the bedside assistant has important roles, including aligning the patient and robot in appropriate positions, which enables better control of the console surgeon, changing and mounting devices efficiently, and providing effective suction and irrigation to make a clear surgical field of view. Therefore, we assumed that a bedside assistant could influence the performance of the console surgeon in BABA robotic thyroidectomy.

To evaluate the impact of the bedside assistant, it is essential to minimize selection biases and potential confounding effects of console surgeon-related factors. Our previous study indicated that 50 to 75 cases of BABA robotic surgery were required to overcome the learning curve of the console surgeon.[8] Thus, the first 100 cases of the console surgeon were not included in the present study. As a result, the mean operative time of the DRA group (183.2 ± 33.6 minutes) was significantly lower than that of the NRA group (203.1 ± 37.9 minutes; $P < .001$). Moreover, the operative times decreased as the number of cases increased in the DRA group ($R = 0.401$, $P < .001$); this phenomenon was not observed in the NRA group ($R = -0.013$, $P = .902$). These results suggested that decreasing operative times with increasing case numbers in the DRA group were related to the learning curve of the assistant and not that of the console surgeon.

Training of the bedside assistant is an essential component of a robotic surgery training program.[24] Most robotic training curricula include bedside assistant experience to allow trainees to learn patients-side demands, such as positioning, trocar placement, and docking.[24,25] However, these curricula required participation of only 4 robotic procedures at minimum for bedside assistants. This limited experience might not be enough for bedside assistants to achieve proficiency. Song et al[26] demonstrated that a bedside assistant required at least 20 cases to consistently perform optimal docking for robotic lung lobectomy. Furthermore, as the experience of bedside assistants increased, the bedside assistants became familiar with the operative setting and learned more from watching cases.[27] Cimen et al[28] indicated that previous bedside assistant experience enhanced troubleshooting skills. Xu et al[29] reported that, in addition to individual surgeon experience, team familiarity contributed to reductions in operative times.

There are a few published reports of studies investigating the experience required for assistants to gain proficiency in laparoscopic or robotic surgery.[20–29] Hwang et al[20] showed that assistants required participation in 30 to 40 cases before gaining competence in laparoscopic colorectal resection. Lower assistant training levels significantly decreased efficiency, as reflected in longer operative times and increased blood loss, as well as in increased intraoperative complication rates and readmission rates.[22] In terms of robotic surgery, Nayyar et al[13] indicated that mean operative time consistently decreased as the experience of the bedside assistant increased in the context of robotic urologic surgery. Conversely, Albo et al[30] demonstrated that the learning curve of the bedside assistant did not influence surgical outcomes in robotic prostatectomy. These conflicting results were at least in part because the role of the assistant varied depending on the type of surgery. CUSUM analysis in the present study revealed that at least 36 cases were needed to overcome the learning curve for the bedside assistant.

The present study had some limitations. First, a single DRA participated in all operations of the DRA group, which may limit the external validity of our findings. Individual assistants can have different learning curves depending on their experience in laparoscopy, familiarity with the procedure, or surgical skills.[31] Second, the robotic procedure was confined to BABA robotic thyroidectomy in this study. Caution should be exercised in generalizing these results to other robotic procedures. Third, this study was retrospective, and a lack of prospective randomization may have introduced selection bias. Further validation studies are warranted to draw more precise conclusions.

5. Conclusion

Increased experience of the bedside assistant reduced operative times in the BABA robotic thyroidectomy. The learning curve of the assistant was approximately 36 cases. Assistant training should be considered as a component of robotic surgery training programs.

Author contributions

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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