Oncoplastic Thyroid Surgery Using A Bilateral Axillo-Breast Approach

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Since the first use of the robot da Vinci system for thyroid surgery in 2007, robotic thyroidectomy (RT) via a bilateral axillo-breast approach (BABA) has become a popular surgical alternative for patients who wish to avoid scars on the neck. BABA RT provides excellent cosmetic satisfaction with surgical safety and oncologic completeness. Recently, the use of BABA RT has expanded beyond benign thyroid nodules and small-sized papillary thyroid carcinoma (PTC) to Graves' disease, relatively large PTCs, and PTC with lateral neck metastasis. Unfortunately, there are concerns about the use of this procedure for these additional indications. This review article summarizes postoperative outcomes of BABA RT for thyroid carcinoma, including quality of life, as well as expanding indications for BABA RT.

Keywords: Robotic surgical procedure, Thyroidectomy, Minimal invasive surgery, Laryngeal nerves

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INTRODUCTION

Thyroid carcinoma is the most common endocrine malignancy.¹ Although conventional open thyroidectomy (OT) is safe and effective for patients with thyroid disease, it may result in undesired scars, including hyperemic, hypertrophic, crooked, and keloid scars. For many patients, especially women, surgical scarring after thyroid surgery is a major concern, as important as oncologic completeness. Various remote access surgical methods have been developed to avoid cosmetically undesirable scars, with bilateral axillo-breast approach (BABA) thyroid surgery being one of the most popular.^{2,3}

In BABA as in OT, the patient is placed in the supine position with neck extension, followed by two circumareolar incisions (1.2 and 0.8 cm in size) and two 0.8 cm-sized axillary incisions. The 1.2 cm-sized incision is used for the camera

port, and the three 0.8 cm-sized ports are used for the passage of surgical instruments.³ BABA provides the same view of both thyroid lobes as OT.

Originally, BABA techniques were developed for endoscopic thyroidectomy (ET). However, the learning curve of BABA for ET is steeper because the camera provides a 2-dimensional view and because this technique utilizes inflexible instruments that are difficult to manipulate. Beginning in 2007, with the development of the da Vinci robotic surgical system (Intuitive, Sunnyvale, CA, USA), ET began to be replaced by robotic surgery. The surgical robotic system was found to overcome the limitations of endoscopy by supplying a 3-dimensional magnified view, filtering out hand tremors, and providing fine motion scaling and multi-articulated hand-like motions. However, the role of the robot in thyroid surgery remains unclear, because conventional OT provides excellent outcomes

and robotic thyroidectomy (RT) has disadvantages, including a longer operation time, higher costs, a higher degree of technical skill, and more advanced training than OT.⁴

BABA RT is now called “oncoplastic thyroid surgery” because it can eliminate the thyroid lesion safely, both surgically and oncologically, as well as providing excellent cosmetic results. This review summarizes current knowledge on the comparative surgical outcomes of BABA RT and OT, as well as evaluating their effects on patient quality of life.

SURGICAL SAFETY OF ONCOPLASTIC THYROID SURGERY

Recurrent laryngeal nerve injury

The currently reported rates of transient and permanent recurrent laryngeal nerve (RLN) injury in patients undergoing BABA RT are shown in Table 1. Although transient and permanent RLN injury have not been clearly defined, they are based on persistent hoarseness or vocal cord palsy lasting less than (transient) or more than (permanent) 6 months. The reported rates of transient RLN injury following BABA RT vary from 0~12.1%. Permanent RLN injury was observed in 0.2% of patients in one study, but not in other studies.⁵⁻¹⁰ In

addition, rates of transient and permanent RLN injury did not differ significantly in patients undergoing BABA RT and OT.^{6-9,11}

In BABA RT, intraoperative neuromonitoring (IONM) has been used to identify the RLN and to assess vocal cord function. Postoperative transient and permanent vocal cord palsy were not observed by indirect laryngoscopy, with rates of transient RLN palsy being less than 2%. The Voice Handicap Index-10 questionnaire found that scores 1 and 3 months after surgery were significantly higher than the preoperative score (0.20 ± 0.66 , 3.47 ± 5.04 , and 1.53 ± 2.47 ; $p < 0.001$), but that these scores decreased over time. The cause of these alterations may be not only injury of external branch of superior laryngeal nerve but also arytenoid trauma.¹²

Hypoparathyroidism

The definition of hypoparathyroidism also varies among published studies (Table 2). In most studies, this condition was defined based on serum concentrations of parathyroid hormone (PTH) and calcium (Ca), and on hypocalcemic symptoms. In some studies, transient and permanent hypoparathyroidism were classified as abnormalities lasting less than and more than 6 months, respectively.^{5-7,11} In other institution,

Table 1. Summary of published studies reporting recurrent laryngeal nerve (RLN) injury in patients undergoing BABA robotic thyroidectomy (BABA RT)

First author /year	Affiliate	Sample size (BABA RT vs. OT)	Definition of transient RLN injury	Rates of transient RLN injury (%) (BABA RT vs. OT)	Definition of permanent RLN injury	Rates of permanent RLN injury (%) (BABA RT vs. OT)
Kim, 2011 (6)	Sungkyunkwan University	69 : 138	Vocal cord palsy on laryngoscopy with recovery within 6 months	1.4 : 0.7 ($p = 0.62$)	Failure of voice change to normalize after 6 months	0 : 0 ($p = \text{NS}$)
Kim, 2012 (10)	Korea University	93	Not stated	3.2	Not stated	0
Lee, 2013 (5)	Seoul National University	1,026	Vocal cord palsy on laryngoscopy	12.1	Not stated	0.2
Kim, 2014 (7)	Chung-Ang University	123 : 392	Vocal cord palsy persisted <6 months	4.9 : 6.1 ($p = 0.60$)	Vocal cord palsy persisted >6 months	0 : 0.3 ($p = 1.0$)
Kwak, 2015 (8)	Korea University	206 : 634	Vocal cord palsy on stroboscopy from 2 weeks to 6 months	0.9 : 0.5 ($p = 0.36$)		NR
Cho, 2016 (11)	Kyung Hee University	105 : 105	Vocal cord palsy on laryngoscopy	6.7 : 5.7	Vocal cord palsy persisted >6 months	0.9 : 0.9
*Kim, 2015 (9)	Chung-Ang University	13 : 65	Vocal cord palsy on laryngoscopy lasting for <6 months	0 : 4.6 ($p = \text{NS}$)	Vocal cord palsy on laryngoscopy lasting for >6 months	0 : 3.1 ($p = \text{NS}$)

RLN = recurrent laryngeal nerve; BABA = bilateral axillo-breast approach; RT = robotic thyroidectomy; OT = open thyroidectomy; NR = not reported; NS = not significant. *Total thyroidectomy with modified radical neck dissection (MRND).

Table 2. Summary of published studies reporting rates of hypoparathyroidism in patients undergoing BABA robotic thyroidectomy (BABA RT)

First author /year	Affiliate	Sample size (BABA RT vs. OT)	Definition of transient hypoparathyroidism	Rates of transient hypoparathyroidism (%) (BABA RT vs. OT)	Definition of permanent hypoparathyroidism	Rates of permanent hypoparathyroidism (%) (BABA RT vs. OT)
Kim, 2011 (6)	Sungkyunkwan University	69 : 138	Normalization of PTH within 6 months	33.3 : 27.5 ($p=0.58$)	Failure of normalization of PTH within 6 months	1.4 : 2.9 ($p=NS$)
Kim, 2012 (10)	Korea University	93	Not stated	18.2	Not stated	0
Lee, 2013 (5)	Seoul National University	1,026	Normalization of PTH within 6 months	33.2	Not stated	1.2
Kim, 2014 (7)	Chung-Ang University	123 : 392	Low PTH within 6 months	23.4 : 22.0 ($p=0.16$)	Low PTH persisted for >6 months	0 : 0 ($p=NS$)
Kwak, 2015 (8)	Korea University	206 : 634	Serum ionized Ca <4.4 mEq/L or PTH <8 pg/ml within 1 year	15 : 14.6 ($p=0.29$)	Serum ionized Ca <4.4 mEq/L or PTH <8 pg/ml persisted after 1 year and need of Ca supplement	0.3 : 0.5 ($p=0.08$)
Cho, 2016 (11)	Kyung Hee University	105 : 105	Serum PTH <13 pg/ml and symptoms requiring Ca replacement	34.3 : 55.2	Serum PTH <13 pg/ml and requiring Ca replacement lasted over 6 months	1.9 : 1.9
*Kim, 2015 (9)	Chung-Ang University	13 : 65	Serum ionized Ca <4.0 mEq/L or symptoms requiring Ca replacement	0 : 15.4 ($p=NS$)	Not stated	0 : 1.5 ($p=NS$)

BABA = bilateral axillo-breast approach; RT = robotic thyroidectomy; OT = open thyroidectomy; PTH = parathyroid hormone; Ca = calcium; NS = not significant. *Total thyroidectomy with modified radical neck dissection (MRND).

transient and permanent hypoparathyroidism were based on low serum Ca and PTH levels and the need for Ca supplementation 1 year after BABA RT.⁸ The rate of permanent hypoparathyroidism in patients who underwent BABA RT was less than 2%.⁵⁻¹¹ Moreover, in five studies that compared BABA RT and OT, the incidence of permanent hypoparathyroidism was comparable in the two groups.^{6-9,11}

Other complications

The incidences of complications associated with BABA RT were generally low (Table 3). No patient in any study experienced a major complication, such as tracheal or brachial plexus injury. In the study with the largest patient population, four patients experienced hematoma, but none had postoperative bleeding requiring reoperation.⁵

ONCOLOGIC COMPLETENESS OF ONCOPLASTIC THYROID SURGERY

Stimulated thyroglobulin level

In most patients who undergo total thyroidectomy, recurrent or residual disease is detected by measuring serum thyroglobulin (Tg) levels. Stimulated Tg (sTg) after total thyroidectomy reflects the amount of remnant thyroid tissue and may be used to predict persistent or recurrent disease by measuring thyroid bed ¹³¹I uptake after first radioactive iodine (RAI) ablation. The sTg level is measured prior to RAI treatment after elevating the thyroid-stimulating hormone (TSH) concentration, either by thyroid hormone withdrawal or the injection of recombinant human TSH, and compared with control sTg measured 6~12 months after RAI. Therefore, a low sTg level is a reliable indicator of complete resection of the thyroid. A study in 453 patients who underwent BABA RT found that the

Table 3. Summary of published studies reporting other complications in patients who underwent BABA robotic thyroidectomy (BABA RT)

First author /year	Affiliate	Sample size (BABA RT)	Tracheal injury (n)	Brachial plexus injury (n)	Hematoma (n)	Seroma (n)	Chyle leakage (n)
Kim, 2011 (6)	Sungkyunkwan University	69	NA	NA	NA	1	1
Kim, 2012 (10)	Korea University	93	NA	NA	0	0	NA
Lee, 2013 (5)	Seoul National University	1,026	NA	NA	4	NA	NA
Kim, 2014 (7)	Chung-Ang University	123	NA	NA	0	NA	NA
Kwak, 2015 (8)	Korea University	206	NA	NA	0	1	NA
Cho, 2016 (11)	Kyung Hee University	105	NA	NA	0	0	0
*Kim, 2015 (9)	Chung-Ang University	13	NA	NA	0	NA	1

BABA = bilateral axillo-breast approach; RT = robotic thyroidectomy; NA = not available. *Total thyroidectomy with modified radical neck dissection (MRND).

median sTg level at the first RAI ablation was 0.4 ng/ml (range, 0.1~79.84 ng/ml), with 295 of these patients (65.1%) having sTg levels <1.0 ng/ml (Table 4).⁵ Other studies found that sTg levels at the first RAI treatment were similar in patients who underwent BABA RT and OT.^{3,6,7,9,11} sTg levels at diagnostic whole body scan after RAI ablation were also similar in patients who underwent BABA RT and OT (1.01 ± 2.16 vs. 1.17 ± 3.73 , $p=0.778$),^{13,14} as was RAI uptake rate at the first whole body scan (11.1% vs. 5.9%, $p=0.564$).¹⁴⁻¹⁷

POSTOPERATIVE QUALITY OF LIFE AFTER ONCOPLASTIC THYROID SURGERY

Cosmesis

Scarring of the face and neck scar after thyroidectomy is associated with patient quality of life. The cosmetic superiority of absence of neck scarring is the major factor for patients to choose RT.¹⁸ A prospective questionnaire study addressing surgical scarring and physical and psychological distress in 129 patients who underwent thyroidectomy found that the degrees of surgical scarring and psychological distress were lower in the 51 patients who underwent BABA RT than in the 78 who underwent OT. The level of physical distress, including pain and exercise limitation, however, did not differ in these two groups.¹⁹

Postoperative pain

Because BABA ET and RT require a larger flap than OT, concerns have been raised regarding postoperative neck and chest pain in the former. However, one study reported a similar degree of postoperative pain, as measured by a visual analogue scale, after BABA RT and OT in 27 patients each.²⁰ In that study, pain scores were compartmentalized for the throat, anterior neck, left and right chest, posterior neck, and back and were recorded on postoperative days 1, 2, 3, and 14. Postoperative analgesic requirements and postoperative pain in the four compartments were similar in the two groups. Another study reported that postoperative pain score at operation day and postoperative 1day was no significant differences between patients who underwent BABA RT or OT (3.84 ± 1.11 vs. 3.76 ± 1.22 , $p=0.069$).¹¹

Sensory changes

BABA RT requires more extensive skin flap dissection than OT, including in the neck subplatysmal area, anterior chest subcutaneous area, and subcutaneous tissue tunneling in the bilateral breast and axillae. Thus, there is concern about potential sensory changes of the skin flap, especially of the anterior chest area. Although a prospective study found that sensory changes in the anterior chest area occurred 1 month after BABA RT, these changes were normalized by 3 months.²¹

Table 4. Studies reporting rates of surgical completeness in patients undergoing BABA robotic thyroidectomy (BABA RT)

First author /year	Affiliate	Sample size (BABA RT vs. OT)	Mean ablation sTg (ng/ml) (BABA RT vs. OT)
Kim, 2011 (6)	Sungkyunkwan University	69 : 138	0.8 : 0.8 (<i>p</i> = 0.97)
Lee, 2011 (3)	Seoul National University	174 : 237	1.4 : 1.2 (<i>p</i> = 0.99)
Lee, 2013 (5)	Seoul National University	1,026	0.4
Kim, 2014 (7)	Chung-Ang University	123 : 392	1.3 : 1.1 (<i>p</i> = 0.65)
Kwak, 2015 (8)	Korea University	206 : 634	NR
Cho, 2016 (11)	Kyung Hee University	105 : 105	0.2 : 0.25 (<i>p</i> = 0.954)
*Kim, 2015 (9)	Chung-Ang University	13 : 65	2.5 : 2.8 (<i>p</i> = NS)

BABA = bilateral axillo-breast approach; RT = robotic thyroidectomy; OT = open thyroidectomy; sTg = thyrotropin-stimulated serum thyroglobulin; NR = not reported. NS = not significant. *Total thyroidectomy with modified radical neck dissection.

Therefore, sensory changes after surgery were considered transitory.

Breast imaging

Because BABA RT requires subcutaneous tunneling in the bilateral breast for flap dissection, concerns have been raised that this procedure might interfere with subsequent breast imaging. Unpublished data from our institute found that breast imaging, by mammography or ultrasonography, identified 180 breast nodules in 108 patients who underwent BABA RT, with postoperative structural or fibrotic changes having no effect.

EXPANSION OF APPLICATIONS OF ONCOPLASTIC THYROID SURGERY

Saving of the external branch of the superior laryngeal nerve

The external branch of the superior laryngeal nerve (EBSLN) innervates the cricothyroid muscle and acts on the thyroarytenoid muscle to increase tension of the ipsilateral vocal fold, indicating that the function of this nerve is especially associated with an increase in pitch.^{22,23} A study of patients who underwent BABA RT combined with ligation of the superior thyroid poles after intraoperative monitoring confirmed the location of the EBSLN found that the phonation-efficient in-

dex was significantly lower 1 month after surgery than before treatment.²⁴ EBSLN were identified in 73% through neuro-monitoring. Laryngeal EMG results showed 4 cases of neuropathy among 19 nerves at 1 month postoperatively, but they were completely recovered after 3 months.²⁴ Intraoperative monitoring of the RLN and EBSLN during BABA RT was feasible and may be helpful in preserving patients' voices.

Graves' disease

Graves' disease is considered a relative contraindication for ET because of the narrow operative view, increased vascularity, a large-sized thyroid gland, and difficulties controlling bleeding. Recent technical advances and accumulated experience with BABA RT have enabled its use in patients with Graves' disease, although conventional OT is still considered one of the safest and most effective approaches. BABA RT was successfully performed in 30 patients with Graves' disease, with none experiencing major complications, such as postoperative bleeding, conversion to open surgery, or permanent RLN injury.²⁵ Another study in patients with Graves' disease compared BABA RT in 44 patients with OT in 145, finding that none of these experienced recurrence of Graves' disease after a median follow-up of 35 months. Complication rates, including permanent RLN palsy (0% vs. 2.3%; *p* = 0.315) and permanent hypoparathyroidism (2.3% vs. 2.3%; *p* = 1.000), were comparable in the BABA RT and OT groups after pro-

pensity score matching. These findings suggest that BABA RT may be feasible and safe for patients with Graves' disease who are concerned about cosmesis.²⁶

Thyroid carcinoma larger than 2 cm

The application of BABA RT has gradually expanded beyond small-sized thyroid carcinomas to relatively large-sized thyroid carcinomas.²⁷ A comparison in patients with 2~4 cm-sized thyroid carcinomas found no significant differences between the BABA RT (n=21) and OT (n=65) groups in rates of vocal cord palsy (transient, 19.0% vs. 9.2%; permanent, 0% vs. 1.5%) and postoperative hypoparathyroidism (transient, 19.0% vs. 33.8%; permanent, 4.8% vs. 1.5%). At the time of initial RAI treatment, 64.7% (11/17) of patients in the BABA RT group and 66.0% (35/53) in the OT group had serum sTg levels <1.0 ng/ml ($p=0.920$). In addition, none of these patients experienced anatomical recurrence or died during a median follow-up of 40.2 months.

BABA robotic MRND

Although MRND is standard treatment in patients with lateral cervical metastasis, the procedure leaves an extensive transverse cervical scar on the skin in the neck area. Robotic MRND using BABA may be a good alternative to avoid an extensive incision scar. BABA robotic MRND was found to be as safe and show similar postoperative oncologic outcomes as OT.⁹ A similar number of lateral lymph nodes was retrieved following BABA robotic and open MRND, without postoperative bleeding (Horner's syndrome). Chyle leakage was lower with robotic BABA than with MRND. Our unpublished data in 15 patients also showed that BABA robotic MRND was safe, with none experiencing permanent RLN injury or hypocalcemia. Horner's syndrome occurred in one patient, but this patient showed symptom improvement 6 months after surgery without further treatment. The median sTg concentration level was 0.8 ng/ml at the first RAI treatment, with 53.3% and 90% of these patients having sTg levels <1 ng/ml and <2 ng/ml, respectively. The operation time was longer in the robotic group than in the open group (210 min vs 382 min, $p<0.001$).

BABA Sistrunk operation

The standard surgical approach to thyroglossal duct cyst (TGDC) is a Sistrunk operation.²⁸ Complications and recurrence rates are rare in this procedure,²⁹ but it leaves a scar on the neck. Sistrunk operation using BABA in two patients with TGDC resulted in a total blood loss of 100 and 80 ml, respectively.³⁰ TGDC was completely removed along the TGDC tract,

including partial resection of the hyoid bone. Both patients were discharged on postoperative day 3 without complications.

CONCLUSIONS

Oncoplastic thyroid surgery using BABA offers constructive surgical safety, excellent oncologic outcomes, and good quality of life, including excellent cosmetic results. In addition, BABA RT has expanded beyond patients with benign thyroid nodules and small-sized papillary thyroid carcinomas (PTCs) to include patients with Graves' disease, relatively large-sized PTCs, PTCs with lateral neck metastasis, and TGDC. Oncoplastic thyroid surgery is therefore a good alternative surgical method for patients who desire surgical safety, oncological completeness, and better cosmetic outcomes.

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