Is Nerve Monitoring Required in Total Thyroidectomy? Cerrahpasa Experience

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Abstract Thyroidectomy is an elective operation performed in an anatomically complex region in which certain structures are responsible for vital functions and special senses. This study aims to compare the effects of two different technical approaches—nerve dissection combined with intraoperative nerve monitoring (IONM) and no nerve identification—on recurrent laryngeal nerve (RLN) damage in total thyroidectomy. One hundred and sixty-one consecutive cases that underwent total thyroidectomy and 322 RLN under risk were evaluated. In group 1 ($n=162$), nerve dissection combined with IONM was performed, whereas no RLN identification was performed in group 2 ($n=160$). While the duration of operation in group 1 (34.23 ± 12.21 min) was statistically shorter than that in group 2 (36.98 ± 16.79 min, $p=0.017$), there was no significant difference between groups related to RLN palsy (group 1 $n=10$, group 2 $n=7$). Use of IONM was found only to shorten the duration of operation. According to our presented experience, there is no benefit of IONM-combined routine dissection of RLN during total thyroidectomy on the prevention of RLN palsy.

Keywords Nerve monitoring · Recurrent laryngeal nerve (RLN) · Total thyroidectomy · Nerve injury

Introduction

Thyroidectomy is an elective operation frequently performed by surgeons. Thyroid surgery is performed in an anatomically complex region in which certain structures are responsible for

vital functions and special senses. Injury to the recurrent laryngeal nerve (RLN) is a major complication of thyroid surgery, which causes distinct changes in the voice. The reports on the incidence of injury to the RLN following thyroid surgery are variable. In a review that covers 27 recently analyzed articles and evaluates over 25,000 patients who have undergone thyroidectomy, it has been reported that the rate of vocal cord paralysis is approximately 10 %, ranging from 23 to 26 % [1]. Even in medical centers with experience, nerve injury is inevitable, at a rate of 1 %. Today, it is widely accepted that to reduce the rate of nerve injury to acceptable values, the RLN must be located and visualized [2–4]. However, in a prospective, randomized study conducted by Koch et al. [5], which involved 800 cases of subtotal unilateral resection divided into two groups, one group consisted of cases in which the nerve was completely visualized and in the other group it was not, and there was no significant difference between the two groups in terms of vocal cord paralysis.

Most surgeons apply a variety of methods to avoid complications involving nerves. Nerve monitoring is considered as the most important accessory tool for visualizing nerves [6, 7]. There are diverse methods used for nerve monitoring. During surgery, methods such as the palpation of cricothyroid muscle synchronous with the nerve impulse, observation of the movement of vocal cords by using direct or fiberoptic nasopharyngoscopy, measurement of the pressure on the endotracheal tube exerted by the movement of vocal cords, placement of electrodes on the vocal cord muscles, and formation of contact between the vocal cord mucosa and the electrodes placed on the surface of the endotracheal tube are performed [7–10]. Whereas in some studies, it has been reported that nerve dissection using intraoperative nerve monitoring (IONM) reduces the rate of permanent nerve damage following surgery [11–14], there is no consensus on this subject [15–17]. This study aims to compare and contrast the

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effects of two different technical approaches—visual identification of RLN combined with IONM and no RLN identification—on RLN damage in total thyroidectomy.

Materials and Methods

One hundred and sixty-one consecutive cases that underwent total thyroidectomy between October 2011 and May 2012 and 322 RLNs under risk were evaluated. Patients who underwent total thyroidectomy including visual identification of RLN combined with IONM were identified as group 1 ($n=162$), whereas those who underwent total thyroidectomy without RLN identification were identified as group 2 ($n=160$). Patients were randomized using the sealed envelope method into two similarly sized groups. The demographics, surgical indications, durations of operation, weights of the specimens and histopathological findings of all cases, and data related to 322 RLNs under risk were collected prospectively and evaluated retrospectively.

Patients who had previously undergone surgical intervention and those who were determined to have RLN palsy during preoperative vocal cord examination and those who also underwent simultaneous central neck dissection were excluded from the study.

All cases underwent routine vocal cord examination with laryngoscopy 1–2 days before and after surgery by an independent experienced laryngologist [18]. Those who were determined to have vocal cord paralysis during postoperative vocal cord examination were reevaluated at first, third, and sixth postoperative months. Vocal cord paralysis lasting more than 6 months was regarded as permanent. All patients were followed up for at least 6 months.

Key points in this study were the injury to the RLN and the benefits of nerve monitoring in defining the RLN with the prediction of postoperative vocal cord dysfunction. The study was reviewed and approved by local ethical committee and an informed consent was obtained from each patient.

Surgical Technique

The patient was placed in supine position with the left arm by his/her side and the right arm extended; shoulders, neck, and head were supported transversely from the back with soft pads allowing the neck to be in extended position. A 3- to 4-cm collar incision was made and the platysma with subplatysmal flaps was raised superiorly and inferiorly with the help of the Bovie cautery. The strap muscles were retracted for lateral exposure of the middle thyroid vein if present to be divided. All vessels were occluded with a vessel-sealing device. The Bovie cautery was used to dissect the pyramidal lobe and the isthmus. The isthmus was then divided using a vessel-sealing device. The superior pole of

the thyroid gland was dissected free of the overlying strap muscle and then retracted inferolaterally to facilitate entry to the relatively avascular cricothyroid space. The medial and lateral borders of the superior pole were mobilized and the external branch of the superior laryngeal nerve was identified. Where necessary, the nerve was dissected free of the superior pole to avoid thermal injury during vessel sealing. While using a vessel-sealing device, it was our practice to perform two separate but parallel seals on this pedicle prior to dividing it close to the superior pole of the thyroid gland. This pattern of sealing was repeated two to three times to seal all branches of the superior thyroid artery. Dissection of the superior pole should not continue below the level of the inferior border of the cricoid cartilage as this would put the superior parathyroid and the RLN at risk. The overlying strap muscles were dissected off the inferior pole of the thyroid and the superficial inferior thyroid veins near the midline were divided. The inferior parathyroid was identified when possible in the vicinity of the inferior pole of the thyroid and released. This preserved the inferior parathyroid in situ with its vascular pedicle. Then, the thyroid gland was retracted medially and elevated out of the wound. The capsule of the thyroid gland was released with scissors, allowing the exposure of the branches of the inferior thyroid artery and tubercle of Zuckerkandl. The RLN was encountered in this region, and the branches of the inferior thyroid artery were sealed close to the thyroid capsule. Further dissection of the gland was carried out with the identification of the inferior parathyroid, taking care to preserve this in situ with its vascular pedicle that arose as a branch of the inferior thyroid artery. The ligament of Berry could be safely divided using a sutureless approach, provided care was taken to avoid thermal injury to the RLN as it entered the cricothyroid muscle. Techniques to minimize thermal spread in the region of the nerve include vessel sealing as far away as possible from the nerve (close to the capsule of the thyroid) and the use of a wet gauze square placed and held in place by surgeon's finger over the nerve (to detect thermal spread) while sealing was undertaken. For total thyroidectomy, the contralateral lobe was dissected as described previously. Before closing the incision, a Mini-vac drain was inserted into the surgical field. The wound was covered by sterile strips alone after subcuticular suturing of the surgical wound.

In the IONM group, intubation was performed without using neuromuscular blocking agents. Endotracheal monitoring system (i.e., Medtronic NIM, Jacksonville, FL) was used to monitor neural stimulation with 1.5 mA. Event threshold was determined as 100 mV. In spite of the other studies, no vagal nerve monitoring was performed. RLN was first identified at the tracheoesophageal groove and then dissected completely from Berry's ligament. The first signal was obtained from that RLN when RLN was identified in

tracheoesophageal groove and last signal was obtained after completion of resection. If a signal could not be received at a level of 2 mA and patient had normal vocal cord examination in postoperative 1–2 days, it was accepted as equipment failure. Strategy of the surgery was not changed even when no signal was received on the first side of resection.

Statistics

All data were analyzed using SPSS 20.0 for Windows. Results were expressed as mean $\pm$ SD. Comparisons of data were done by Student's *t* test and Pearson's chi-square test. The results were considered statistically significant when the two-tailed *p* value was less than 0.05.

Results

Considering all patients, the female/male ratio was 123:38 and the averages were as follows: age, 49.50 $\pm$ 13.92; body mass index (BMI), 27.74 $\pm$ 5.78; neck circumference, 35.79 $\pm$ 4.34 cm; sternomental distance, 15.10 $\pm$ 2.28 cm; duration of operation, 35.60 $\pm$ 14.69 min; duration of anesthesia, 51.22 $\pm$ 16.72 min; and weight of the specimens, 56.66 $\pm$ 89.09 g. Regarding all nerves (*n*=322), rate of permanent vocal cord paralysis was determined as 0.31 % (*n*=1), whereas the rate of temporary vocal cord paralysis was determined to be 4.96 % (*n*=16). While there was no significant difference between the groups in terms of age, gender, BMI, neck circumference, sternomental distance, size of incision, duration of anesthesia, weight of the specimens, surgical indication, histopathological diagnosis, and RLN palsy (*p*>0.05), the duration of operation was determined to be significantly shorter in the IONM group (group 1, 34.23 $\pm$ 12.21 min; group 2, 36.98 $\pm$ 16.79 min, *p*=0.017) (Tables 1, 2, and 3). Within the IONM group, there was no significant difference when findings of postoperative vocal cord examination were compared to the difference between the signal values received before and after resection

(*p*=0.467; Table 4). There was no loss of follow-up or drop-out in duration of study.

Discussion

The conservation of the RLN is one of the key components in thyroid surgery. In 1898, Theodor Kocher reduced the mortality rate in thyroidectomy to below 0.18 from 14.8 % in 1882. His meticulous surgical technique allowed to achieve results similar to current surgical interventions on the incidence of RLN injury [19]. Lahey [20] dissected the RLN in almost every case. He stated that careful dissection reduced the number of injuries to the RLN.

Whereas the causes of RLN paralysis can be listed as damage to the anatomical integrity of the nerve, thermal injury, excessive nerve skeletization, axon damage due to excessive tension, edema, hematoma, forced tracheal intubation, viral neuritis, and neuritis originated from scar tissue, the factors that affect nerve injury have been reported to be the area of resection, the surgeon's experience, and underlying diseases, such as substernal goiter, malignancy, and Graves' disease [2–4, 6].

To assist the identification of the RLN and immediately measure its function before and after thyroid resection, a variety of medical devices have been developed in the last two decades for intraoperative use [6, 7]. During surgery, methods such as the palpation of cricothyroid muscle synchronous with the nerve impulse, observation of the movement of vocal cords by using direct or fiberoptic nasopharyngoscopy, measurement of the pressure on the endotracheal tube exerted by the movement of vocal cords, placement of electrodes on the vocal cord muscles, and formation of contact between the vocal cord mucosa and the electrodes placed on the surface of the endotracheal tube are performed [7–10]. Visual identification of RLN during thyroid surgery has been associated with low rates of permanent RLN paralysis and also has been considered as gold standard for the

Table 1 Demographics and comparison of measured values

	Group 1 (<i>n</i> =81)	Group 2 (<i>n</i> =80)	<i>p</i> value
Gender			0.743
Male	20	18	
Female	61	62	
Age (years)	48.29 $\pm$ 14.58	50.72 $\pm$ 13.18	0.269
BMI (kg/m ²)	27.61 $\pm$ 5.58	27.86 $\pm$ 5.99	0.756
Neck circumference (cm)	35.47 $\pm$ 4.15	36.11 $\pm$ 4.51	0.120
Sternomental distance (cm)	15.73 $\pm$ 2.07	14.45 $\pm$ 2.31	0.358
Size of incision (cm)	4.27 $\pm$ 1.18	4.79 $\pm$ 1.55	0.427
Duration of operation (min)	34.23 $\pm$ 12.21	36.98 $\pm$ 16.79	0.017
Duration of anesthesia (min)	50.16 $\pm$ 15.6	52.3 $\pm$ 17.81	0.114
Weight of specimen (g)	60.49 $\pm$ 89.16	52.77 $\pm$ 89.4	0.498

Table 2 Surgical indications and histopathological diagnosis

	Group 1	Group 2	Total
Surgical indications ($p=0.064$)			
Basedow–Graves disease	4	7	11
Follicular lesion	4	4	8
Follicular neoplasia	2	0	2
Hurthle cell neoplasia	10	3	13
Multinodular goiter (MNG)	100	52	152
Toxic MNG	16	5	21
Suspicious of malignancy	0	2	2
Substernal goiter	2	0	2
Papillary thyroid cancer	24	7	31
Histopathological diagnosis ($p=0.103$)			
Adenomatous hyperplasia	43	43	86
Basedow–Graves disease	2	4	6
Follicular adenoma	2	8	10
Follicular carcinoma	1	0	1
Microinvasive follicular carcinoma	1	2	3
Hurthle cell carcinoma	0	1	1
Hurthle cell microinvasive carcinoma	3	2	5
Medullary carcinoma	1	0	1
Anaplastic carcinoma	1	0	1
Papillary carcinoma	8	12	20
Follicular variant papillary carcinoma	5	3	8
Papillary microcarcinoma	11	3	14
Hashimoto thyroiditis	3	0	3
Thyroiditis	0	2	2

prevention of RLN injury in most studies [1, 3, 20–22]. Jatzko et al. [22] have reevaluated ten studies covering 12,211 thyroid operations and demonstrated that there is a lower rate of RLN paralysis in the group with nerve identification compared to the group without (2.7 vs. 7.9 % for temporary paralysis; 1.2 vs. 5.2 % for permanent paralysis). Wagner and Seiler [23] reported that in total lobectomy patients, nerve paralysis rate was 6.9 % with nerve identification and 21 % without nerve identification. Karlan et al. [24] reported a consecutive case series of 1,000 thyroid operations and demonstrated no permanent RLN paralysis. These results suggest that permanent nerve damage will be less if the nerve is clearly visualized during the surgical procedure.

Table 3 RLN palsy after surgery ($p=0.370$)

	Group 1	Group 2	Total
No palsy	152	153	305
Transient palsy	10	6	16
Permanent palsy	0	1	1
Total	162	160	322

Koch et al. [5] prospectively created two groups from 800 subtotal unilateral thyroid resections. In the first group (382 subtotal resections, 48.4 %), the nerve was not intraoperatively identified. In the second group (413 subtotal resections, 51.6 %), the RLN was routinely identified in all cases. Even though only four (0.5 %) cases of temporary vocal cord paralysis were observed, two of them were in the first group the other two in the second. These data demonstrate that routine laryngeal nerve dissection during thyroid resection does not provide any benefit. Therefore, mandatory requirement of intraoperative identification of the RLN cannot be justified. Also, in our series of a total of 322 RLNs under evaluation, in group 1 ($n=162$), which consisted of total thyroidectomy cases with nerve dissection using IONM, temporary paralysis was observed in 6.17 % ($n=10$) cases,

Table 4 Comparison of palsy finding in vocal cord examination and voltage differences in patients of group 1 ($p=0.467$)

	Amplitude differences (mV)
Palsy in vocal cord examination	-194 ± 294.06
No palsy in vocal cord examination	-61.28 ± 399.6

whereas in group 2 ($n=160$), which consisted of total thyroidectomy cases without nerve dissection, temporary paralysis was observed in 3.75 % ($n=6$) cases and permanent paralysis in 0.63 % ($n=1$). At the end of the study, there was no significant difference between the groups.

Without any doubt, RLN paralysis can occur in routine identifications of RLN, even in combination with IONM, but in most cases only temporarily [21]. Most studies have shown that although surgeons ascertain the integrity of the RLN by visual inspection in most cases, they are not aware of the injury to the nerve [25–27].

There are three topics about IONM still in debate. First, neuromonitoring increases the ability of the surgeon to pinpoint the RLN, which could be one of the reasons for its increasing popularity. Second, it can be used to determine the functional integrity of the RLN before completion of surgery. And third, neuromonitoring can guide the surgeon under difficult circumstances, such as anatomical variations, reoperations, and malignancies [11]. Despite all these advantages, in case series with and without IONM among various studies, no significant difference has been determined in terms of nerve paralysis complications. In a prospective, randomized study conducted by Barczynski et al. [28], in two groups of 500 patients each, who previously did not undergo thyroid or parathyroid surgery, a total of 2,000 nerves under risk were evaluated. In one group, only surgical exploration was performed, and in the other both surgical exploration and IONM were performed, and there was a significant difference between the groups only in terms of temporary nerve paralysis [28]. Dralle et al. [9] have reported in a multicenter prospective study, in which 16,488 thyroidectomy patients were participated, that 29,998 nerves were under risk. The patients were divided into three groups: no RLN identification, only visual identification, and visual identification in combination with neuromonitoring. No significant difference was found between the group with only visual identification and the group with both visual identification and neuromonitoring. In a prospective study conducted by Sari et al. [8], 409 RLNs from 237 patients were at risk and therefore examined in two separate groups. In group 1 ($n=210$), thyroidectomy was performed without IONM, and in group 2 ($n=199$), IONM was utilized. At the end of this study, it was determined that there was no significant difference between the groups in terms of postoperative complications. Also, in this study, it was reported that RLN was anatomically revealed earlier in the group with neuromonitoring compared to the group without neuromonitoring [8]. At first glance, this feature may not appear clinically important, but it has been stated that by decreasing the duration of surgery, earlier identification of the nerve reduces the surgeon's stress level [8]. Similarly in our study, while there was no significant difference between the two groups in terms of RLN paralysis, the

duration of operation in the group with nerve monitoring was significantly shorter. Even though some studies report that nerve dissection using IONM reduces the rate of permanent nerve damage following surgery [11–14], there is no consensus on this subject [15–17]. As the results of our study support us, we clinically suppose that nerve monitoring does not provide any contribution to an experienced surgeon; however, it might be used to assist less experienced surgeons with anatomical identification.

Conclusion

The results are consistent with those of previous studies and, as demonstrated, continuous or discontinuous IONM does not lower the rates of injury to the RLN, let alone makes an accurate prediction about postoperative paralysis of the vocal cords. Thus, IONM provides no any contribution to an experienced surgeon concerning the avoidance of RLN palsy.

Conflict of Interest None.

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