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# Sensitivity and Specificity of Intraoperative Recurrent Laryngeal Nerve Stimulation Test for Predicting Vocal Cord Palsy after Thyroid Surgery

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**Abstract**

*Introduction:* Recurrent laryngeal nerve (RLN) palsy after thyroidectomy, although infrequently encountered, can decrease quality of life. In addition to the hoarseness that occurs with unilateral RLN palsy, bilateral RLN palsy leads to dyspnea and often to life-threatening glottal obstruction. Therefore, intraoperative awareness of the nerve's status is of great importance. This study examined the sensitivity and specificity of a palpation technique to detect contraction of the posterior cricoarytenoid muscle (PCA) through the posterior hypopharyngeal wall while the RLN was being stimulated with a disposable nerve stimulator during thyroid surgery (the laryngeal palpation test) to predict postoperative RLN deficits.

*Methods:* A total of 2197 RLNs in 1376 patients were identified to be at risk of injury during thyroidectomy performed between July 2003 and August 2004. Postoperative RLN integrity was assessed using direct laryngoscopy or laryngofiberoscopy to visualize vocal fold mobility.

*Results:* Altogether, 76 RLNs failed to elicit a PCA contraction in response to nerve stimulation, and 80 cases of temporary vocal cord palsy and 21 cases of permanent vocal cord palsy were recognized on postoperative evaluation. For postoperative vocal cord palsy, the sensitivity and specificity of the laryngeal palpation test were 69.3% and 99.7%, respectively, with a positive predictive value of 92.1% and negative predictive value of 98.5%. For permanent vocal cord palsy, the sensitivity and specificity were 85.7% and 97.3%, respectively, with a positive predictive value of 23.7% and negative predictive value of 99.8%.

*Conclusions:* The laryngeal palpation test is not a particularly useful method for predicting the level of RLN function after thyroidectomy. All patients must be examined postoperatively by direct laryngoscopy or laryngofiberoscopy to check vocal cord mobility. Even if there is no contraction of the PCA and we detect vocal cord palsy immediately after surgery, vocal cord palsy often recovers within 1 year when visual preservation of RLN is successful.

The incidences of temporary and permanent vocal cord palsy after thyroid surgery were reported to range from 3.4% to 7.2% and 0.2% to 0.9%, respectively, based on the number of nerves at risk.[1,2] Visual identification of the RLN during thyroid surgery has been shown to be associated with better outcomes than other

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methods of neural avoidance during thryoidectomy.[3,4] Electrical identification and monitoring of the recurrent laryngeal nerve (RLN) has been proposed as an adjunct to standard visual identification of the nerve during thyroid surgery.[5,6] In a multiinstitutional prospective study of more than 4000 patients, Thomusch *et al.* found significantly lower rates of transient and permanent vocal cord palsy with intraoperative monitoring during surgery for benign goiters than with standard visualization alone.[7]

A recent prospective study claimed that intraoperative laryngeal palpation during RLN neural stimulation was useful for predicting postoperative RLN deficits.[8] However, in that series there was no permanent vocal cord palsy and only one case of temporary vocal cord palsy. We report here on our experience with this method including advanced thyroid cancer cases with extensive dissection of RLNs.

## MATERIALS AND METHODS

We prospectively investigated 1489 surgical patients treated between July 2003 and August 2004 (benign thyroid disease 784, thyroid cancer 705) with 2342 nerves at risk. Excluded from the study were 11 patients with thyroid cancer in the presence of preoperative cord dysfunction due to RLN palsy, 16 patients with thyroid cancer with a resected RLN because of tumor involvement of the RLN, and 86 patients who could not be rigorously followed. The remaining 1376 surgical patients with 2197 nerves at risk were enrolled in this study.

Because different diseases might have different rates of postoperative RLN palsy, we analyzed benign thyroid disease (952 nerves at risk) and thyroid cancer (1245 nerves at risk) separately. Patients undergoing primary surgery (no prior thyroid surgery) and secondary interventions (one or more thyroid operations before this intervention) were evaluated separately. Patients were investigated after extubation using direct laryngoscopy or laryngofiberoscopy to visualize vocal fold mobility. When RLN palsy was identified at this time, patients were investigated again 1 to 3 days after surgery using laryngofiberoscopy and followed every 1 to 3 months until the RLN palsy resolved. After 1 year, vocal cord paralysis was considered permanent.

Complete RLN identification and dissection were accomplished in all patients. RLN neural stimulation was performed to test the nerve at the end of the surgery. Neural stimulation was performed with a disposable nerve stimulator (Xomed, Jacksonville, FL, USA) with the current set at 1.0 mA. Palpation for contraction of the posterior cricoarytenoid muscle (PCA) was performed after identifying the thyroid cartilage. A finger was inserted deep to the posterior lamina and fascia overlying the vertebral column. In this way, the posterior lamina of the PCA was palpated through the wall of the hypopharynx.

Our study population consisted of consecutive patients undergoing thyroid surgery by one of six endocrine surgeons.

## RESULTS

The overall incidences of temporary and permanent RLN palsy (considered as a percentage of the nerves at risk) were 3.6% and 1.0%, respectively. The rates of temporary and permanent RLN palsy were 2.7 (0.4%) and 8.9 (1.7%) for benign thyroid disease and thyroid cancer, respectively. The rate of temporary/permanent RLN palsy after secondary surgery was 12.9 (9.8%). Secondary surgery was associated with significantly higher rates of permanent and temporary RLN palsies than primary surgery. The recovery time for temporary RLN palsy ranged from 7 days to 12 months (mean 5.1 months). Of the 80 temporary RLN palsy cases, 73 (92.1%) recovered within 6 months. More details are presented in Tables 1 and 2.

There were 30 cases of hoarseness that appeared or intensified after surgery and were not caused by RLN palsy. These cases included five postoperative hematomas, eight cases of postoperative edema with vocal cord or arytenoid (or both) involvement, and seven cases of postoperative acute laryngitis. Five patients had chronic laryngitis, and two had a vocal cord polyp with intensified hoarseness postoperatively. Abnormal findings were not identified in eight patients by laryngoscopic examination, but they complained of a change of voice. In contrast, 11 patients with unilateral postoperative RLN palsy had no hoarseness after surgery. In most of these cases the vocal cord stayed in a median position.

Tables 3 and 4 show the relation between the results of intraoperative testing of the RLN and immediate or permanent RLN palsy, respectively. Intraoperative RLN stimulation failed to elicit a PCA contraction in 76 RLNs. Of the 76 positive results, 70 vocal cord palsies were subsequently diagnosed during the immediate postoperative period by fiberoptic examination, and 18 of these palsies had not resolved within 1 year. Altogether, 31 RLNs that were negative for injury were found to be nonfunctional during the immediate postoperative period.

**Table 1.**
Data from malignant thyroid tumors

| Parameter | Primary | Secondary |
|---|---|---|
| Patients | 670 | 8 |
| Women | 604 | 6 |
| Men | 66 | 2 |
| Nerves at risk | 1237 | 8 |
| Age (years) | 53 (16–82) | 58 (33–68) |
| Temporary RLN palsy | | |
| Patients (no.) | 51 | 3 |
| Nerves (no.) | 58 | 3 |
| | Ex0:30 | |
| | Ex1:28 | |
| Interval until recovery (months) | 6 (1–12) | 4 (1–11) |
| Permanent RLN palsy | | |
| Patients (no.) | 16 | 1 |
| Nerves (no.) | 16 | 1 |
| | Ex0:9 | |
| | Ex1:7 | |

RLN: recurrent laryngeal nerve; Ex0: tumor did not involve the RLN; Ex1: tumor involved the RLN, but the RLN did not have to be sacrificed.

**Table 2.**
Data from benign thyroid tumors

| Parameter | Primary | Secondary |
|---|---|---|
| Patients | 678 | 20 |
| Women | 591 | 17 |
| Men | 87 | 3 |
| Nerves at risk | 929 | 23 |
| Age (years) | 4 (15–77) | 55 (40–62) |
| Temporary RLN palsy | | |
| Patients (no.) | 17 | 1 |
| Nerves (no.) | 18 | 1 |
| Interval until recovery (months) | 3 (1–6) | 3 |
| Permanent RLN palsy | | |
| Patients (no.) | 2 | 2 |
| Nerves (no.) | 2 | 2 |

**Table 3.**
Results of intraoperative stimulation of the RLN and postoperative observations of vocal cord mobility

| | Vocal cold palsy | |
|---|---|---|
| Intraoperative stimulation test | Yes | No |
| No contraction (positive) | 70 | 6 |
| Contraction (negative) | 31 | 2085 |

However, 28 of these 31 RLNs had resolved at reexamination within 1 year.

For the immediate postoperative vocal cord palsy, the sensitivity and specificity were 69.3% and 99.7%, with a positive predictive value (PPV) of 92.1% and negative predictive value (NPV) of 98.5%. For permanent vocal cord palsy, the sensitivity and specificity were 85.7% and 97.3%, with a PPV of 23.7% and an NPV of 99.8%.

**Table 4.**
Results of intraoperative stimulation of the RLN and permanent vocal Cord palsy

| | Permanent vocal cord palsy | |
|---|---|---|
| Intraoperative stimulation test | Yes | No |
| No contraction (positive) | 18 | 58 |
| Contraction (negative) | 3 | 2113 |

## DISCUSSION

Palpation to detect contraction of the PCA is a simple, readily available technique for any thyroid surgeon and can be performed with a variety of handheld, disposable, widely available nerve stimulators. Six patients had false-positive results in this study. Randolph *et al.* suggested that if contraction of the PCA is lost several possibilities should be considered, including neural injury.[8] First, the RLN should not have any significant overlying tissue, and the field must be strictly bloodless, as fluid can shunt stimulating current away from the nerve. Second, the site of palpation should be checked to make sure that it is the posterior lamina of the cricoid. Third, the surgeon must ask the anesthesia team if a neuromuscular paralytic agent has been inadvertently administered, which would obviously ablate all muscular response after RLN stimulation. In these situations, a laryngeal palpation twitch response is present; the surgeon may reliably expect normal ipsilateral vocal cord function postoperatively. In our cases, the operating times of false-positive cases were short, within 1 hour. We could not rule out a neuromuscular paralytic agent. When these factors are ruled out, we should also consider whether intraoperative maneuvers caused associated nerve stretch, compression injury, or thermal injury. It is best to leave the nerve alone and allow the presumed neuropraxic injury to resolve spontaneously.[5] In this study, 70 RLNs did no show PCA contraction or postoperative vocal cord palsy; of these RLNs, 52 (74%) recovered spontaneously. Our policy for surgical treatment of well-differentiated thyroid carcinoma is to preserve the recurrent nerve from the adjacent tumor unless there is preoperative cord dysfunction or definitive evidence of nerve encasement by the tumor intraoperatively. This study included patients

whose RLNs underwent shaving (43 RLNs at risk). Among them, 33 RLNs (78.5%) had postoperative palsy, and 30 RLNs had resolved upon reexamination within 1 year. When we must resect an RLN because of tumor invasion, it is best to perform primary neurorrhaphy.

We detected RLN palsy in 31 patients who had normal RLN stimulation findings (false-negative results). We think that the site of stimulation of the RLN is also important for predicting RLN deficits. When the tumor shows adhesion or invasion of the nerve, we often shave the RLN during tumor resection. In these cases, we stimulate the proximal site of the RLN or vagus nerve. If the surgeon stimulated the distal site of the RLN, contraction of the PCA would occur even though RLN palsy exists. False-negative results could be also caused by nerve stimulation of the PCA abductor fibers. PCA abductor fibers are assessed during posterior laryngeal palpation, whereas adductor fibers are not. Extralaryngeal division of the RLN has been reported in 80%[9] and in as few as 35% or 43%.[10,11] The number of extralaryngeal branches they described is also variable. The distance of bifurcation or trifurcation from the inferior border of the cricoid cartilage ranged from 0.6 to 4.0 cm, with an average distance of division occurring at 1.96 cm.[12,13] Maranillo *et al.* reported that in 88% of cases the nerve supply to the adductor muscle and abductor muscle arose from a common trunk of the RLN, whereas it did not in 12%.[14] In patients with extralaryngeal branching of the RLN, stimulation of the branch that innervates the PCA muscle could give false-negative results (contraction present, but vocal cord palsy exists).

Especially in early studies but also in recent studies, hoarseness was considered a measure of vocal cord palsy.[15] We think that this an incorrect conclusion because we observed several cases of unilateral vocal cord palsy with no subjective hoarseness. Furthermore, hoarseness may be caused by a vocal cord hematoma or postoperative laryngitis. Along with direct laryngoscopy or laryngofiberoscopy, an examination should be performed in all cases to assess the integrity of the RLN postoperatively even if patients undergo palpation to detect contraction of the PCA during surgery and have a normal voice after surgery.

## CONCLUSIONS

We believe that the laryngeal palpation test does not reliably predict the initial RLN status after thyroid surgery. All patients should be examined by direct laryngoscopy or laryngofiberoscopy postoperatively to check their vocal cord mobility. Even if there is no contraction of the PCA and we detect vocal cord palsy immediately after surgery, vocal cord palsy often recovers within 1 year when visual preservation of the RLN is successful.

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