Laryngeal Nerve Monitoring and Minimally Invasive Thyroid Surgery

Complementary Technologies

David J. Terris, MD; Susan K. Anderson, DO; Tammara L. Watts, MD, PhD; Edward Chin, MD

Objective: To determine the feasibility of the combined use of laryngeal nerve monitoring and minimally invasive thyroid surgery.

Design: Prospective, nonrandomized analysis of single-surgeon experience.

Setting: Academic institution.

Patients: Consecutive series of patients undergoing both minimally invasive thyroid surgery and laryngeal nerve monitoring.

Main Outcome Measures: Incision length and incidence of temporary or permanent laryngeal nerve injury.

Results: Two hundred eighty-three patients underwent thyroid surgery at the Medical College of Georgia, Augusta, between January 2004 and November 2006. Some type of minimal-access approach (endoscopic or nonendoscopic) was used in 137 cases (48.4%) in which general anesthesia was administered. Laryngeal nerve monitoring was performed in 73 (53.3%) of these 137 cases, although the proportion of cases in which it was performed increased significantly from 8.7% (2 of 23 cases) in 2004 to 95.2% (58 of 61 cases) in 2006 (P < .001). There were no cases of permanent nerve injury. The incidence of temporary recurrent laryngeal nerve paresis was 4.3% (4 of 92 nerves at risk) in the cases in which laryngeal nerve monitoring was used and 6.0% (5 of 84 nerves at risk) in the cases in which the nerve was visually identified without use of a monitor. This difference failed to reach statistical significance (P = .73), which may reflect an insufficient sample size.

Conclusion: Monitoring of the laryngeal nerves is feasible in minimal-access thyroid surgery and may serve as a meaningful adjunct to the visual identification of nerves.

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LARYNGEAL NERVE INJURY IS A well-defined risk in thyroid surgery. The reported incidence of recurrent laryngeal nerve (RLN) injury varies considerably, with rates of permanent paralysis ranging from 0.5% to 2.4% and temporary paresis ranging from 2.6% to 5.9%.

However, these reports may underestimate the true incidence of RLN injury, because most surgeons do not routinely perform preoperative and postoperative laryngoscopy. There is a wide spectrum of clinical findings associated with iatrogenic RLN injury, including no discernible affect, hoarseness, impaired vocal register, swallowing difficulties, and aspiration.

Several studies have demonstrated that the incidence of nerve injury is reduced when the RLN is identified during surgery. Numerous methods to augment visual identification of the RLN have been described. These techniques require special equipment and the introduction of additional steps during the procedure. The introduction of commercially available electromyography (EMG) endotracheal tubes (ETTs) has facilitated the incorporation of intraoperative laryngeal nerve monitoring (LNM) into the practice of thyroid surgery. While the merits of monitoring continue to be debated, a number of studies have suggested improved functional neural outcomes.

To our knowledge, the use of LNM during minimal-access thyroid surgery has not been assessed. While the value of LNM may prove to be independent of the length of the incision, there are currently insufficient data to reach this conclusion. As an initial investigation, we sought to determine the feasibility of monitoring and stimulation of
these nerves during endoscopic and minimally invasive thyroid surgery.

**METHODS**

The study included all patients who underwent thyroidectomy in the otolaryngology department at the Medical College of Georgia, Augusta, between January of 2004 and November of 2006. Their medical records were reviewed to identify those patients who underwent minimal-access thyroidectomy with LNM (LNM group) and those who underwent minimal-access thyroidectomy without LNM (non-LNM group). Data regarding age, gender, the extent of surgery performed (total thyroidectomy or hemithyroidectomy), incision length, and final pathologic findings, including specimen weight, were also recorded and analyzed.

**SURGICAL PROCEDURES**

Minimal-access surgery was defined as procedures performed through an incision of less than 6 cm. Several types of surgical techniques, including minimally invasive video-assisted thyroidectomy, minimally invasive nonendoscopic thyroidectomy, and reoperative minimal-access surgery, were used, and their descriptions may be found in the references provided. All thyroidectomies were performed by the senior author (D.J.T.), with substantial involvement by the endocrine–head and neck surgery fellow or a senior level resident.

**NERVE MONITORING**

Patients were intubated with a surface electrode laryngeal EMG ETT (NIM 2; Medtronic Xomed, Jacksonville, Florida), with correct positioning between the vocal cords verified by either the anesthesiologist or the otolaryngologist. Briefly, once the patient was intubated with the surface electrode EMG ETT, the cuff was placed at the lower subglottis and trachea, allowing the electrodes to contact the luminal surface of the bilateral vocal cords. Grounding electrodes were placed in the skin overlying the sternum, and the integrity of the system was verified. The nerve integrity monitor served as the central processing unit, where the ground and ETT electrodes were connected. The EMG tracings were visualized on the monitor and supplemented with audio feedback, allowing for both visual and audio output for laryngeal nerve activity. The RLN was usually identified inferiorly after the mobilization of the superior pole of the thyroid and before complete dissection of the inferior pole. Routine intraoperative nerve stimulation is not our common practice. Therefore, LNM functions to alert the surgeon to the proximity of the nerve during blunt dissection or to impending injury from traction, for example. However, in cases in which positive identification of the nerve was a challenge (particularly during reoperative surgery), intraoperative RLN identification was occasionally accomplished by stimulation with a pulse-generated monopolar electrode (Prass probe; Medtronic Xomed) at 0.5 to 1.0 mA.

It is worth mentioning that there are a number of limitations to the surface electrode LNM system. Chief among them is the high rate of false-positive indicators. Manipulation of structures substantially superficial to the location of the nerve, eg, the strap muscles, will sometimes cause the monitor to alarm. This characteristic requires the surgeon to filter the information received, so that the alarm is ignored when it is anatomically impossible to be in the vicinity of the nerve. False-negative indicators may also occur. It is critical that the surgeon not rely on a negative indication in deciding to cut a potentially vital structure.

**EVALUATION OF LARYNGEAL FUNCTION**

Patients who are to undergo thyroid procedures have their vocal cord function assessed in the office with either indirect mirror laryngoscopy or flexible fiberoptic laryngoscopy before surgery. They are routinely evaluated with flexible fiberoptic laryngoscopy in the postanesthesia care unit after surgery. Temporary true vocal cord paresis is defined as dysfunction that resolves within 6 months. Permanent true vocal cord paralysis is defined as nerve dysfunction that fails to resolve within the 6-month period.

**STATISTICAL ANALYSIS**

Statistical analysis was performed using a contingency table analysis with $\chi^2$ test, Mantel-Haenszel linear-by-linear association, and a commercially available software package (SPSS Version 11; SPSS Inc, Chicago, Illinois). For comparisons of gland weight and incision length, the Wilcoxon rank sum test was used. $P <.05$ was considered statistically significant.

**RESULTS**

A total of 283 patients underwent thyroidectomy during the study period. A minimal-access approach was used in 139 of the 283 patients. Two patients were excluded because the thyroidectomy was performed with the patient under local anesthesia (thereby obviating the possibility of nerve monitoring), resulting in 137 patients for evaluation. Of those patients who underwent minimal-access thyroid surgery, 73 had LNM (LNM group). The unmonitored group consisted of 64 patients (non-LNM group). In the LNM group, 54 patients (74.0%) underwent a hemithyroidectomy and 19 patients (26.0%) underwent a total thyroidectomy, resulting in a total of 92 nerves at risk (NARs). In the non-LNM group, 44 patients (68.8%) underwent a hemithyroidectomy and 20 patients (31.3%) underwent a total thyroidectomy, representing a total of 84 NARs.

Similar pathologic findings were observed when the LNM group and the non-LNM group were compared (Table). There were no significant differences in gland weight between the 2 groups ($P = .39$). The mean ± SD specimen weight was $19.1 \pm 14.1$ g (range, $1.9$-$62.3$ g) in the LNM group and $20.8 \pm 15.0$ g (range, $3.5$ to $68.1$ g).

<table>
<thead>
<tr>
<th>Histopathologic Findings</th>
<th>LNM</th>
<th>Non-LNM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multinodular goiter</td>
<td>23 (31.5)</td>
<td>19 (29.7)</td>
</tr>
<tr>
<td>Papillary carcinoma</td>
<td>13 (17.8)</td>
<td>7 (10.9)</td>
</tr>
<tr>
<td>Follicular adenoma</td>
<td>12 (16.4)</td>
<td>11 (17.2)</td>
</tr>
<tr>
<td>Thyroiditis</td>
<td>5 (6.8)</td>
<td>7 (10.9)</td>
</tr>
<tr>
<td>Hurthle cell neoplasm</td>
<td>4 (5.5)</td>
<td>3 (4.7)</td>
</tr>
<tr>
<td>Normal thyroid</td>
<td>3 (4.1)</td>
<td>3 (4.7)</td>
</tr>
<tr>
<td>Benign nodule</td>
<td>4 (5.5)</td>
<td>2 (3.1)</td>
</tr>
<tr>
<td>Adenoma</td>
<td>3 (4.1)</td>
<td>2 (3.1)</td>
</tr>
<tr>
<td>Colloid</td>
<td>2 (2.7)</td>
<td>4 (6.3)</td>
</tr>
<tr>
<td>Graves disease</td>
<td>2 (2.7)</td>
<td>3 (4.7)</td>
</tr>
<tr>
<td>Follicular carcinoma</td>
<td>2 (2.7)</td>
<td>2 (3.1)</td>
</tr>
<tr>
<td>Hurthle cell carcinoma</td>
<td>0 (0.0)</td>
<td>1 (1.6)</td>
</tr>
</tbody>
</table>
in the non-LNM group. The LNM group had a significantly smaller incision length (3.0 ± 1.0 [mean ± SD] cm) than the non-LNM group (3.7 ± 0.9 cm) (P < .001).

There were no cases of permanent RLN or superior laryngeal nerve paralysis. However, 4 cases of temporary RLN paresis were identified in the LNM cohort, and 5 cases of temporary paresis were identified in the non-LNM cohort. These findings were distributed throughout the study period, with no apparent temporal bias (4 occurred among the first 70 patients; 5 occurred among the final 67 patients), yielding a temporary paresis incidence of 4.3% (4 of 92) in the LNM group and 6.0% (5 of 84) in the non-LNM group. This difference was not statistically significant (P = .73, Fisher exact test).

The increase in the use of LNM in minimal-access thyroidectomy in our practice from January 2004 through November 2006 is shown in the Figure. The use of LNM in minimal-access thyroidectomy increased significantly during the study period (from 8.7% in 2004 to 95.2% in 2006; P < .001, Mantel-Haenszel test).

Regardless of the approach to thyroid surgery, a thorough understanding of the complex anatomy of the RLN and its relationship to other structures in the neck is essential. This knowledge is particularly important in minimally invasive thyroid surgery, since the aperture to expose these critical anatomical structures is reduced. However, the use of high-resolution endoscopes facilitates the identification of important neurovascular structures as the incision lengths get smaller. To our knowledge, the present study is the first one to examine the use of intraoperative LNM in minimally invasive thyroid surgery. Several features of our investigation merit comment.

Few surgeons would still debate the value of RLN identification, which has been shown to decrease the rate of postoperative nerve paresis in multiple studies.\(^4\) The use of LNM appears complementary to visual identification of the nerve to avoid permanent injury and may provide a measure of safety in challenging cases in which visual identification of the nerve is limited. For example, the most comprehensive assessment of LNM was undertaken in a multi-institutional German study spearheaded by Dralle et al.\(^8\) Although the technique of monitoring differed from ours, this robust analysis of 29,998 NARs at 63 medical centers demonstrated statistically significant reductions in nerve injury when monitoring was used at medium-volume hospitals and in patients with Graves disease.

Because of the low incidence of permanent vocal cord paralysis in our study, it is not possible to conclude that LNM reduces the risk of nerve injury in the setting of minimally invasive thyroidectomy. Indeed, this challenge will likely always exist, as a result of 2 main factors. The prevailing incidence of permanent vocal cord paralysis associated with thyroid surgery is so low (1%-2%) that it would require large numbers of patients to demonstrate even a 30% to 50% improvement in the incidence of nerve injury. In the absence of these numbers, a type II error is likely. More importantly, it is probable that nerve monitoring is least valuable in the hands of the very surgeons who are most likely to investigate its benefit (high-volume surgeons working in thyroid centers and/or academic settings).

Nevertheless, we suspect that LNM does decrease the incidence of vocal cord paralysis in a clinically meaningful way when it is used by the low-volume surgeon (Dralle and colleagues\(^8\) have suggested a threshold of fewer than 45 NARs per year, and their data would support this). Furthermore, we believe that there are a number of merits associated with LNM, even in experienced hands. Laryngeal nerve monitoring provides important feedback regarding traction, particularly when the gland is exteriorized during endoscopic thyroidectomy. Early indications of unanticipated anatomical variants (nonrecurrent laryngeal nerves or early branching RLNs) may allow management to be undertaken more safely. Identification of the nerves can be facilitated in patients who are heavily scarred or who have undergone previous surgery. Finally, surgeons who are teaching thyroid surgery to others (residents and fellows) may not benefit as much from LNM as their trainees will; therefore, there is some burden of responsibility to prepare the trainees with the skills they will need in practice. This burden, of course, is predicated on the supposition that LNM carries meaningful value to patients who are undergoing thyroidectomy by low-volume surgeons.

The difference in mean incision length between the unmonitored patients (3.7 cm) and the monitored patients (3.0 cm) may reflect an evolution in technique wherein our incision lengths have gotten smaller as we have grown comfortable with endoscopic and harmonic technology. This progress has occurred simultaneously with an increasing propensity toward using LNM, resulting in an incidental inverse correlation between nerve monitoring and incision length.

There are limitations to LNM. The surface electrode monitoring system that we used in this study is prone to numerous false-positive signals, so the surgeon is required to filter the information received. It is important not to rely on LNM, because a false-negative indicator...
may lead to inadvertent transection of a neural structure. Therefore, it is important for surgeons pursuing LNM to learn the technique properly and to be instructed regarding interpretation of the data yielded. Used judiciously, however, the technology is safe and provides benefit in many clinical circumstances. Limitations of the current study include a relatively small sample size, which was studied in a nonrandomized fashion.

Despite several well-recognized limitations of LNM, and although it will be difficult and probably impossible to prove its value, we believe that this technology may be useful in certain circumstances. In particular, LNM is complementary to minimally invasive thyroid surgery, in which the aperture to expose critical anatomical structures is necessarily reduced.

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Correspondence: David J. Terris, MD, Department of Otolaryngology–Head and Neck Surgery, Medical College of Georgia, 1120 15th St, BP-4109, Augusta, GA 30912-4060 (dterris@mcg.edu).

Author Contributions: Dr Terris had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Study concept and design: Terris. Acquisition of data: Terris, Anderson, Watts, and Chin. Analysis and interpretation of data: Terris, Anderson, Watts, and Chin. Drafting of the manuscript: Terris, Anderson, and Watts. Critical revision of the manuscript for important intellectual content: Terris and Chin. Statistical analysis: Terris. Administrative, technical, and material support: Terris, Anderson, and Chin. Study supervision: Terris and Chin.

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REFERENCES