Intraoperative recurrent laryngeal nerve monitoring during surgery for left lung cancer

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Objective: This study evaluated the safety and efficacy of intraoperative recurrent laryngeal nerve monitoring during surgery for left lung cancer.

Methods: From April 2008 to April 2009, a total of 25 patients at high risk for left recurrent laryngeal nerve injury agreed to and underwent intraoperative recurrent laryngeal nerve monitoring during surgery for left lung cancer in our hospital. Results and clinical records were reviewed.

Results: All the patients' left recurrent laryngeal nerves were identified during operation by intraoperative recurrent laryngeal nerve monitoring. Twenty-four patients retained normal left recurrent laryngeal nerves after the operation. One patient, in whom part of the left recurrent laryngeal nerve was found to be invaded, underwent single-stage nerve anastomosis under recurrent laryngeal nerve monitoring after the invaded nerve was resected. There were no significant intraoperative or postoperative complications among the other patients.

Conclusions: Intraoperative recurrent laryngeal nerve monitoring during thoracotomy is a safe and effective way of identifying the nerve. It may help surgeons to avoid injuring the recurrent laryngeal nerve during some thoracic procedures. (J Thorac Cardiovasc Surg 2010;140:578-82)

Recurrent laryngeal nerve (RLN) paralysis (RLNP) is a complication of thoracic surgery. Because of the specific anatomic location of the RLN, the incidence of RLNP, especially left RLNP, is higher for certain thoracic operations, such as surgery for left lung cancer, esophagectomy with 3-field lymph node dissection for carcinoma, and mediastinoscopy.[1-3] Injury of the RLN can result in some symptoms, such as hoarseness, liquid aspiration, swallowing disorder, and ineffective cough, that adversely affect patients' quality of life and recovery after surgery.

To date, however, no effective means of avoiding injury to the RLN during thoracic surgery has been available. By recording compound electromyographic (EMG) action potentials from the RLN, any injury to the RLN could be identified during the operation, an application that has been widely used and studied in neck surgery, especially thyroid surgery.[4,5] The studies from thyroid surgery have shown that the RLN is less likely to be injured permanently if it is clearly visualized during the surgical procedure by intraoperative RLN monitoring (RLNM).[6,7] Little research, however, exists regarding the application of RLNM to thoracic operations. In this study, we performed RLNM during surgery for left lung cancer to evaluate its safety and efficacy during thoracic operations.

MATERIALS AND METHODS

Patients

This study obtained the informed consent of all patients and was approved by our institutional ethics committee. From April 2008 to April 2009, patients who needed operation for left primary or suspected lung cancer and were at high risk for RLNP were enrolled in this research. The entry and exclusion criteria are shown in Table 1.

All patients enrolled in this study accepted assessment, including complete history, physical examination, complete blood cell count, biochemical profile, chest roentgenogram, computed tomographic scans of the chest and brain, ultrasonographic scan of the upper abdomen, electrocardiography, arterial blood gas measurement, routine pulmonary function tests, and fiberoptic bronchoscopy. Single-photon emission computed tomographic scans were performed for patients with anemia, bone pain, or elevated alkaline phosphatase or calcium levels to rule out bone metastasis. All patients underwent preoperative and postoperative evaluations of the movement of vocal cords by means of fiberoptic bronchoscopy.

Intubation and Anesthesia

All patients were intubated for general anesthesia with the Medtronic Xomed Nerve Integrity Monitor EMG endotracheal tube (Medtronic ENT, Jacksonville, Fla), which has 2 exploratory electrodes above the cuff (Figure 1). To ensure that the EMG can be recorded, the exploratory electrode should be adhered to each vocal cord during intubation. The correct location of the surface electrode was tested before and after positioning of the patient's body on the operating table.

All procedures were performed with standard general anesthesia. Cisatracurium besylate (INN cisatracurium besilate, a short-acting muscle

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Abbreviations and Acronyms
EMG = electromyography
RLN = recurrent laryngeal nerve
RLNM = recurrent laryngeal nerve monitoring
RLNP = recurrent laryngeal nerve paralysis

relaxant) was given to the patients for induction and maintenance of anesthesia. A neuromuscular monitoring (TOF-Watch SX; Organon Middle East Ltd, Cyprus) was used to monitor the effect of cisatracurium. Before the RLNM was performed, the first twitch percent was required to return to 50% to exclude the influence of muscle relaxants.[9]

Modified 4-Step Intraoperative RLNM Procedure

All patients underwent intraoperative RLNM with the NIM-Response system (Medtronic ENT) for EMG. The high-frequency electricity knife was not used during mapping of the left RLN. To standardize and evaluate the procedures, we modified the 4-step procedure of intraoperative RLMN that had been used during thyroid surgery as follows[4] (Figure 1).

Step 1. For V1 signal detection, an original EMG signal was obtained from the vagus nerve before identification of the RLN. The nerve was tested by being directly touched with the nerve stimulator. The stimulation level was set at 0.5 mA as a starting point, and the event threshold at 100 μV; if no signal was elicited, the stimulation was increased gradually to 3.0 mA. Equipment failure was considered if a V1 signal could not be received at a level of 3.0 mA.

Step 2. For R1 signal detection and RLN mapping, the signal was obtained from the originating site of RLN along the vagus nerve. Then the course of the RLN was labeled. During the operation, the signal was detected before suspected trabeculae were dissected.

Step 3. For R2 signal detection, the signal was obtained by stimulating the RLN after the tumor and lymph nodes had been completely dissected.

Step 4. For V2 signal detection, the final testing of the vagus nerve was performed after complete hemostasis of the operative field.

Intraoperative and Postoperative Assessments

Before RLNM was used during the operation, the left RLN and its course were firstly judged by the surgeon. Three kinds of judgment (right, uncertain, or wrong), relative to the later identification of the left RLN by RLNM, were recorded. The RLNM was then used to identify the left RLN and its course. The 4 kinds of signals were recorded. If the V1 and R1 signals were recorded, it was considered that the left RLN and its course had been identified. If either the R2 or V2 signal was lost, it was determined that the left RLN was injured. After surgery, hoarseness, stridor, feeding difficulties, and voice changes were assessed 24 hours and 3 months after operation.

RESULTS

From April 2008 to April 2009, a total of 25 patients (7 women and 18 men, 42–68 years old) who met the entry and exclusion criteria consented to intraoperative RLNM during thoracotomy. Patients' clinical characteristics and details of the operations are summarized in Table 2.

With RLNM, all the V1 and R1 signals were detected, meaning that the left RLNs of all the patients were found and detected. During operations, all except patient 12 had R2 and V2 signals detected. Before the use of RLNM, the surgeon made 8 correct judgments, 10 uncertain judgments, and 7 misjudgments. The mean time of mapping left RLN was 13.24 $\pm$ 3.73 minutes (range, 6–25 minutes). The mean evoked potential stimulated by current was 170.56 $\pm$ 63.36 μV (range, 101—348 μV). Interfering signals were caused by the stretch and the use of a high-frequency electric knife. The stretching was the primary cause of interfering signals. Although patient 12 had normal voice and vocal movement before the operation, it was found that the metastasis of lymph node station 5 had invaded the left RLN during operation. A portion of the left RLN was therefore resected. After removal of the tumor, we identified the ends of the left RLN with the help of RLNM and performed single-stage nerve anastomosis (Figure 2, *A*). RLNM showed that the R2 and V2 signals could be detected again after nerve anastomosis (Figure 2, *B*).

TABLE 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
T stage $\geq$2	Pacemaker
$\geq$1 node (L4, 5, 6) shortest axis >1.0 cm*	Severe heart disease
	No informed consent

*By computed tomography.[8]

All patients except patient 12 retained normal voices after operation. There were no cases of hoarseness, stridor,

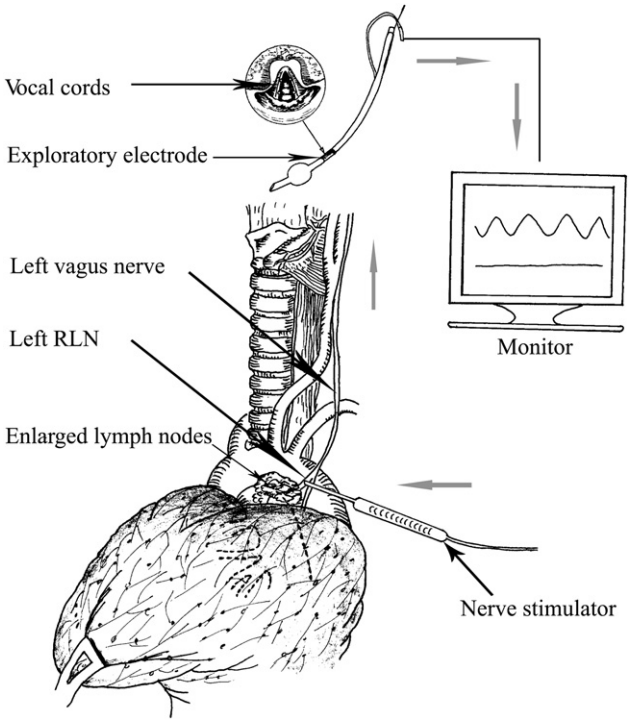

FIGURE 1. Procedure of intraoperative recurrent laryngeal nerve *(RLN)* monitoring. Patient is intubated for general anesthesia with endotracheal tube with exploratory electrode above cuff. Nerve stimulator is used during operation, and electromyographic signals are recorded. If electromyographic signals cannot be recorded, recurrent laryngeal nerve is considered to be injured.