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ORIGINAL ARTICLE

Attempt of peripheral nerve reconstruction during lung cancer surgery

Hanyue Li[1*], Yingjie Hu[1*], Jia Huang[1], Yunhai Yang[1], Kaichen Xing[2] & Qingquan Luo[1]

1 Department of Thoracic Surgery, Shanghai Chest Hospital, Shanghai Jiao Tong University, Shanghai, China
2 Shanghai Cinoasia Institute, Shanghai, China

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Correspondence
Qingquan Luo, Department of Thoracic Surgery, Shanghai Chest Hospital, Shanghai Jiao Tong University, Shanghai 200030, China.
Tel: +86 130 0324 7676
Email: qingquan_luo@hotmail.com

*These authors contributed equally to this work.

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Abstract

Background: Vagus nerve and recurrent laryngeal nerve (RLN) injury are not rare complications of lung cancer surgery and can cause lethal consequences. Until now, no optimal method other than paying greater attention during surgery has been available.

Methods: Four patients underwent lung surgery that involved RLN or vagus nerve injury. The left RLN or vagus nerve was cut off and then reconstructed immediately during surgery. Two patients underwent direct anastomosis, while the remaining two underwent phrenic nerve replacing tension-relieving anastomosis.

Results: All patients were able to speak immediately after recovery. No or minimal glottal gap was observed during laryngoscopy conducted on the second day after surgery. Most patients achieved full recovery of voice quality.

Conclusions: Immediate reconstruction of RLN is technically feasible and can be carried out with satisfying short-term and long-term outcomes.

Introduction

Injury to the recurrent laryngeal nerve (RLN) and vocal cord paralysis are not rare complications of thoracic surgery because of the anatomy of the RLN, which could cause symptoms of hoarseness, aphonia, dysphagia, and water aspiration. Such complications greatly compromise patient quality of life. Water aspiration can be life threatening as it can induce aspiration pneumonia. Lobectomy and lymph node dissection are standard treatment for lung cancer. Subaortic and para-aortic lymph nodes should be dissected for lung cancers in the left lung. Therefore, the left RLN is more frequently exposed to injury during subaortic and para-aortic lymph node or tumor dissection because of its path around the aortic arch.[1] The reported incidence of RLN injuries from esophagus and lung surgery varies greatly. RLN injury occurs at a rate of < 2% in most reported tracheal surgery series.[2] However, the rate is much higher in lung and esophagus surgeries, ranging from 4% to 31%.[1] Although there have been several reports of immediate recurrent laryngeal nerve reconstruction in the thyroid or laryngeal surgical fields, this procedure is rarely conducted during thoracic surgery.[3–5]

Previous reports reveal a high rate of spontaneous RLN recovery six months after thoracic surgery.[1] In patients with permanent RLN paralysis, consultation and intervention by an otolaryngologist is usually required. Herein, we report RLN recovery by direct repair and reconstruction of RLN during surgery in four patients who underwent thoracic surgery. In the present report, we show that intraoperative RLN reconstruction maybe feasible and effective for thoracic surgery patients with RLN or vagus nerve injuries. To our knowledge, this is the first report of RLN repair in the thoracic field.

Methods

General data

From June 2016 to March 2017, we treated four lung cancer patients with unexpected visible left RLN or vagus

nerve injuries using direct anastomosis or phrenic nerve replacing tension-relieving anastomosis during surgery. None of the patients exhibited any symptoms of invasion or injury of the RLN before surgery, and underwent bronchoscopy, pulmonary function test, treadmill exercise, brain computed tomography (CT), bone scan, and abdominal ultrasonography. In one case the patient's left RLN was accidently cut off while dissecting the mediastinal lymph nodes. The other three patients had to have their vagus nerve cut to achieve thorough resection of the tumor, which closely surrounded the vagus nerve but had not invaded. Preoperative examinations were conducted to evaluate each patient's tolerance for lung surgery and to eliminate metastasis. Preoperative enhanced chest CT scanning at our hospital is mandatory for every patient. Three patients underwent open surgery and one underwent video-assisted thoracoscopic surgery (VATS). There were two women and two men with a median age of 55. One patient had received neoadjuvant chemotherapy for two months before the surgery.

Surgical technique

All patients were placed in the decubitus position under general anesthesia. One patient underwent lobectomy and three underwent pneumonectomy; one was minimally invasive surgery, while three were open surgery. Minimally invasive surgery was performed through four portals: a camera port in the seventh intercostal space on the anterior axillary line; two portals in the eighth intercostal space on the mid and posterior axillary lines for assistance (to lift lung lobes, enter endoscopic staplers, or electrocautery); and utility incision in the third or fourth intercostal space before the anterior axillary line according to the tumor location. Open surgery is performed through a standard posterolateral incision and we entered the thoracic cavity above the sixth rib. During thoracotomy, we cut one rib to allow a wider operating space and a clearer surgical field.

Reconstruction of the RLN can be performed by two methods. Direct anastomosis of the ends of the RLN was applied in two patients who did not exhibit massive defects (Fig 1). Based on experience during surgery, we have found out that if a defect is ≤ 5 mm, using direct anastomosis is feasible and safe with satisfying tension (Fig 2). In two of the three patients who underwent pneumonectomy, a segment of the vagus nerve was cut. In this situation, we remove part of the phrenic nerve to help connect the broken ends of the vagus nerve and the left RLN (Fig 3), which can lower the tension of anastomosis. End-to-end nerve anastomosis was achieved by continuous suture using 5-0 polypropylene, as it is a monofilament that allows the smooth passage of sutures through the nerve. Knots were tied intracorporeally during open surgery or extracorporeally during VATS. Knots should not be tied too tight to avoid incised injury from the polypropylene. Space should be left between the stitches (usually four to five stitches) otherwise the nerve impulse will be hindered. The tension of the anastomosis also needs to be treated carefully as it interferes with nerve regeneration. Two 24F chest tubes were placed for postoperative drainage during lobectomy, and one 28F chest tube was placed for drainage during pneumonectomy.

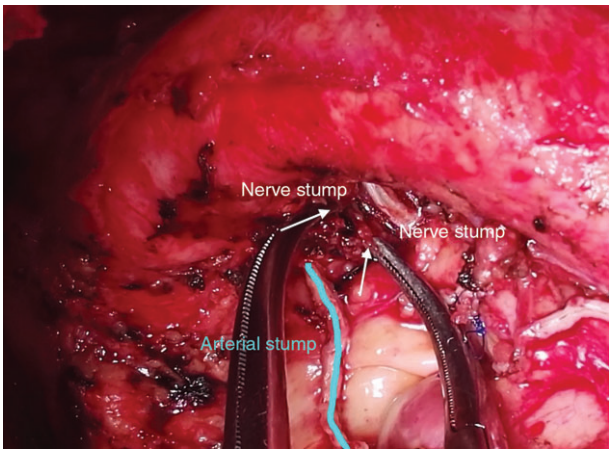

Figure 1 Minor defect of recurrent laryngeal nerve (white arrow: broken nerve stump; blue curve: pulmonary arterial stump).

The patients were encouraged to speak after recovering from the anesthesia. A semi-fluid diet was provided six hours after surgery. Laryngoscopy was performed in all patients immediately after surgery and is highly recommended every two months postoperatively. The patients completed questionnaires concerning voice-related quality of life six months after the surgery.

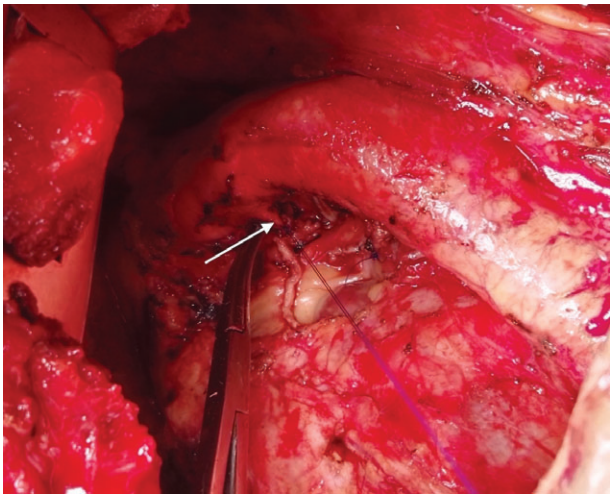

Figure 2 Direct anastomosis of dissociated nerve stumps (white arrow: the anastomosed recurrent laryngeal nerve).

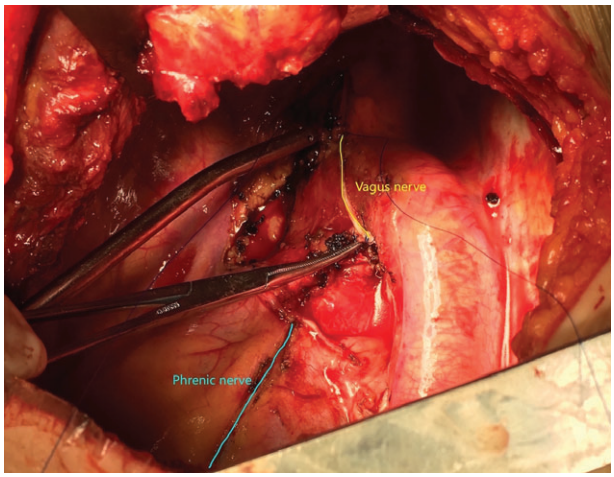

Figure 3 Phrenic nerve replacing tension-relieving anastomosis (blue curve: the original location of phrenic nerve; yellow curve: anastomosed phrenic nerve between the stumps of vagus nerve and recurrent laryngeal nerve).

Results

Four cases of left RLN reconstruction were performed, including two direct RLN anastomoses and two phrenic nerve replacing tension-relieving anastomoses. No perioperative death occurred. The mean operation duration was 78.75 ± 11.41 minutes, with a mean blood loss of 155 ± 42 mL. No massive bleeding (≥ 800 mL) occurred during the procedure. The R0 rate was 100%. The mean drainage was 5 ± 1.4 days. The major and only complication was atrial fibrillation (25%, 1 out of 4). The pathologic features of the patients are listed in Table 1. The patients were all able to speak clear sentences immediately after recovering from the anesthesia, with changed tones. No postoperative lung infection was observed. No dysphagia presented, but three patients complained of bucking while drinking water. However, using a straw to drink alleviated the bucking symptom. During monthly follow-up in the first three to four postoperative months, the patients' voice tone remained the same as the first day after surgery and then there was a gradual increase in voice quality. Two patients gained a subjective normal voice by the end of the observation period, while two patients are still improving. The postoperative bucking symptom disappeared three to seven months after surgery.

Under laryngoscopy the first day after surgery, three patients showed a slight posterior gap between the non-membranous portions and one patient experienced complete closure of the glottis. Six months after surgery, bronchoscopy examination revealed that two patients had normal movement of their vocal cords (Fig 4). The average voice-related quality of life grades were 90 ± 3.54 after one month and 93.75 ± 4.79 after six months, which presented no statistical difference with healthy counterparts.

At the end of the follow-up period, all patients were alive.

Table 1 Pathologic characteristics

Pathologic characteristics	Value
Cell type	
Squamous cell carcinoma	2 (50%)
Adenocarcinoma	2 (50%)
Stage	
I	1 (25%)
II	1 (25%)
III	2 (50%)
R0†	4 (100%)
R1‡	0

†Complete resection with no cancer cells seen microscopically at the resection margin. ‡Cancer cells presented microscopically at the resection margin.

Discussion

It is widely believed that the peripheral nerve system has high regeneration potential when the continuity of the nerve is maintained or, if lost, adequately reconstructed.[6,7] Normally we are very careful when dealing with RLN and try not to harm the nerve. However, the heat transmitted from surgical tools can sometimes cause damage to the nerve and results in some hoarseness, although this improves with time. In these four patients, accidental injury occurred during lymph node dissection, thus we did not record their preoperative voice to statistically compare and assess a change. Because these injuries occurred

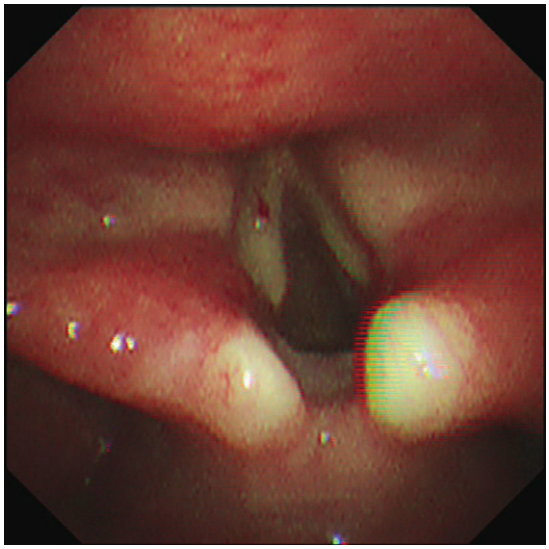

Figure 4 Normal movement and morphology of vocal cords under laryngoscopy.

accidentally during surgery, a nerve monitor was not used, and any damage to the nerve could not be ascertained. This may have contributed to the outcome.

One of the critical parts of peripheral nerve reconstruction is tension of the anastomosis. During surgery measure of the tension is dependent on the operator's experience without a nerve monitor. Another critical part is isolation of the phrenic nerve, as we believe using an electric scalpel would damage the neural fiber. During pneumonectomy in patients who require phrenic nerve tension-relieving anastomosis, cutting off the phrenic nerve would paralyze the diaphragm. This does not cause harm to the patient as paralyzing the diaphragm can alleviate mediastinal shifting and be beneficial to reduce the rest of the cavity. One of the patients only had minor improvement to voice tone, which may be attributed to the relatively short follow-up period. Use of a straw alleviated bucking as the oral cavity can create a negative pressure environment, thus the epiglottis is tightly closed. The amount of water intake is also lower when drinking through a straw.

Although many studies have shown that the RLN nerve can partly regenerate months after surgery,[1,8] postoperative dysfunction such as dysphagia and water aspiration after RLN injury can lead to severe complications, including lung infection or even asphyxia, which may be fatal in certain patients. In patients who present with symptoms of nerve invasion, commonly regarded as a contraindication of surgery, nerve reconstruction can be considered to improve the symptoms if chemotherapy or radiotherapy has failed. It remains unclear whether lung cancer surgery indications can be expanded. If the peripheral nerve is cut off during surgery, thoracic surgeons usually suggest that patients seek an otolaryngologist for help. The primary surgical modalities for treatment are transoral injection medicalization and laryngoplastic phonosurgical reconstruction.[9] Because no previous reports of RLN reconstruction in the thoracic field have been published, our experiences could shed light on intraoperative nerve repair and therefore reduce the rate of postoperative complications for patients with RLN injury. A previous report showed that nimodipine associated with microsurgery could induce vocal cord recovery after RLN resection in thyroid surgery.[10] Another study showed satisfactory vocal cord recovery after immediate RLN reconstruction in thyroid cancer patients.[3] If intraoperative recurrent nerve reconstruction is efficient in practice, we can expect a decrease in postoperative complication rate and improved quality of life for patients who require RLN reconstruction.

This study is a small single center report; therefore, prospective studies and more cases are required to prove the feasibility and effectiveness of RLN reconstruction.

Disclosure

No authors report any conflict of interest.

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