Effect of Vagal Nerve Protection on Heart Rate in Patients Undergoing Minimally Invasive Lobectomy

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Abstract

OBJECTIVES: As a common malignant tumor worldwide, lung cancer receives substantial attention from specialists. Surgery occupies an important position in lung cancer treatment, particularly early treatment. To better improve quality of life for patients after surgery, we report our surgical approach to protect vagal nerve branches during lung cancer surgery, especially the thoracic branch, which is important to maintain a suitable heart rate after surgery.

METHODS: We selected 40 patients who underwent lobectomy and systematic dissection of mediastinal lymph nodes during the same period. Patients were divided into two groups: the control group (traditional surgery) and the experimental group (surgery with vagal nerve/vagal branch protection). During surgery, vagal nerve function was preserved as much as possible.

RESULTS: There were no significant differences in operation time, intraoperative bleeding, postoperative pain, and discharge time between the two groups. Heart rate at discharge was significantly reduced in the experimental group compared with the control group (75.30 bpm vs. 86.00 bpm, respectively; $P = 0.038$). Heart rate at discharge was compared with heart rate at admission in both groups. The change in heart rate after surgery compared with heart rate at admission was less marked in the experimental group compared with the control group.

CONCLUSIONS: Preserving the thoracic and cardiac branches of the vagus nerve during surgery can effectively reduce heart rate in patients after surgery and maintain pre-surgical heart rate.

1. Introduction

Lung cancer is a type of malignant tumor and is the most common cause of cancer-related death worldwide. Many clinicians and researchers are working to overcome this disease. Every year, 1.8 million people are diagnosed with lung cancer and 1.6 million people die from lung cancer.⁽¹⁾ In the 1960s, the standard surgical treatment for lung cancer was pulmonary leaf excision, which involved removal of pulmonary leaf units, as well as removal of the lung door and vertical lymphatic tubes in specific areas. However, in the 1970s, presence of metastatic mediastinal lymph nodes in lung cancer was considered a factor precluding long-term survival. This was classified as N2 disease independent from ipsilateral or contralateral node involvement. With decades of research and clinical practice, there is now a general consensus on lymph node categorization.^(2,3) In lung cancer surgery, it is generally accepted that an accurate assessment of lymph node condition is the basis for judging prognosis, determining tumor treatment signs, and comparing the results of treatment between institutions. However, a series of complications caused by lymph node cleaning, such as nerve damage, arrhythmia, celiac chest, and bleeding, have been considered by clinicians. To improve the prognosis of patients undergoing thoracic mirror-assisted pulmonary leaf removal, we attempted to expose and protect the cardiac and thoracic branches of the vagus nerve during lymphatic cleaning to maximize retention of normal cardiopulmonary nerve domination.

2. Materials And Methods

2.1 General clinical data

Twenty-seven females and 13 males were included in the study, with an age range of 41–78 years. The inclusion criteria were as follows: 1) preoperative computed tomography prompted by unilateral left lung swelling; 2) imaging credit phase T1; 3) no coronary heart disease, diabetes mellitus, or other chronic disease; 4) no other treatment for tumor. Preoperative lung function, echocardiography, electrostatic mapping, cranial nuclear magnetism, and abdominal ultrasound were performed to meet surgical requirements. Patients were randomly divided into two groups: the control group and the experimental group. Patients in the control group underwent a single pulmonary leaf excision and traditional lymph node cleaning, and the experimental group underwent surgery with a simultaneous lymph node sweep, focusing on exposure of the main vagus nerve and its cardiac and thoracic branches. The general condition of patients is shown in Table 1.

Table 1
General condition of patients.

	Control group n = 20		Treatment group n = 20		P-value
Sex	n	%	n	%	0.311
Male (n)	5	25	8	40	
Female (n)	15	75	12	60	
Age					0.275
Median	63		60		
Range	51–78		41–72		
Lung function					
FEV1(mean)	2.25		2.36		0.126
FVC(mean)	3.12		3.22		0.374
Base heart rate BPM (mean)	79.9		80.35		0.215
Basic blood pressure (mean)	128/77		136/76		0.691/0.428
The location of the tumor					0.212
Upper left lung (n)	10	50	13	65	
Lower left lung (n)	10	50	7	35	
Tumor size					
0–1 cm (n)	2	10	3	15	
1–2 cm (n)	12	60	9	45	
2–3 cm (n)	3	15	4	20	
> 3 cm (n)	3	15	4	20	

2.2 Key points of surgery

The control group underwent routine systemic lymph node dissection. First, remaining pulmonary loin tissue was pulled sideways to the head, and the lower lung ligament was opened from the rumbling lymph nodes by approximately 2 cm to open the pleura. To ensure the electric knife did not approach too close to the vagus nerve, blunt separation was used to expose the vagus nerve and the lung plexus branch leading to the lung door. Angled double-jointed instruments were used to gently open the branch and fully sweep the lymph nodes. If a large cleaning range led to excessive nerve freeing, proper use of hemostable fillers was performed to fill the gap between the protrusions and avoid the effect of excessive freeing of the vagus nerve. When dissecting the upper mediastinal lymph nodes, the same priority was

given to finding and exposing the vagus nerve and its branches. Then, the lymph nodes were removed as far away as possible from these vagal branches. After surgery, the 20# chest drain pipe was placed.

2.3 Follow up

Patients were admitted to hospital the day before surgery. Patients were required to sit in a calm state so that heart rate could be measured. Two days after surgery, heart rate was measured more than three times per day, and the average heart rate was calculated. The day before discharge, heart rate was measured again with removal of the chest drain. On the first and third days after surgery, chest flakes next to the bed were examined to evaluate the condition of the lung. Postoperative pain was assessed using the Numerical Rating Scale.⁽⁴⁾ A score of 0 indicates no pain, a score of 1–3 indicates mild pain, a score of 4–6 indicates moderate pain, a score of 7–9 indicates severe pain, and a score of 10 indicates severe pain.

2.4 Statistical analysis

All data were analyzed using SPSS 22.0 software, and the χ^2 test or Fisher's precision probability method was used to compare the incidence of complications between the two groups. The t-test was used to compare the averages of continuous variables. A P value of < 0.05 was considered statistically significant.

3. Results

Surgery was successful in all patients. There were no cases of transition to open chest surgery, and there were no deaths during surgery. The results of surgery are shown in Table 2. Continuous variables are expressed as mean $\pm$ standard deviation, and categorical variables are expressed as percentages.

Table 2
Surgical and clinical measurements in the control and experimental groups.

	Control group n = 20	Treatment group n = 20	
Operation time (h)	2.65 ± 0.65	3.03 ± 1.00	0.158
Intraoperative bleeding (ml)	52.8 ± 44.62	50.5 ± 33.63	0.850
Postoperative drainage days	3.33 ± 1.52	2.95 ± 2.06	0.502
Pain score	1.76 ± 0.70	1.55 ± 0.60	0.307
heart rate			
be hospitalized	79.9 ± 11.36	80.35 ± 9.13	0.903
Before anesthesia	77.80 ± 10.19	77.20 ± 6.53	0.822
After waking up	85.66 ± 13.58	80.90 ± 6.47	0.163
The first day after operation	84.09 ± 10.68	85.30 ± 9.56	0.706
Before discharge	86.00 ± 11.063	78.30 ± 6.82	0.034

The operation time in the control group and the experimental group was 2.65 hours and 3.03 hours, respectively ($P = 0.158$). The volume of intraoperative bleeding in the control group and the experimental group was 52.8 ml and 50.5 ml, respectively, and there was no significant difference between the two groups.

The drainage tube time was calculated from the end of surgery. When uniform standards were met (i.e., no leak during coughing, pale blood drainage fluid, no fever, and drainage not exceeding 300 ml/day), the drainage tube was removed and the patient was discharged home. The control group had an average drainage tube time of 3.33 days, and the experimental group had an average drainage tube time of 2.95 days. On average, the experimental group had the drainage tube removed approximately 12 hours earlier than the control group, but there was no significant difference between the two groups ($P = 0.502$).

Before discharge from the hospital, pain score was assessed by a nurse. The average pain score in the control group was 1.76, while the average pain score in the experimental group was 1.55 ($P = 0.307$).

Heart rate was recorded five times, including at admission, during preoperative anesthesia, during postoperative recovery, on the first day after surgery, and before discharge. All measurements were performed with patients in a resting state. The average heart rate values in the control group were 79.9, 77.8, 85.6, 84.0, and 86.0, at the specified time points, respectively, while the average heart rate values in the experimental group were 80.3, 77.2, 80.9, 85.3, and 75.3, at the specified time points, respectively. There was a significant difference in heart rate between the two groups before discharge ($P = 0.038$).

4. Discussion

The vagus nerve is a mixed nerve that contains four types of fibers, including fibers that control somatic movement, visceral movement, visceral sensation, and somatosensory function.⁽⁵⁾ The vagus nerve has multiple branches that extend into the neck, chest, and abdomen.⁽⁶⁾ The left vagus nerve descends between the left common carotid artery and the left subclavian artery to the front of the aortic arch, runs down the mediastinum, and separates the thoracic, bronchial, and esophageal branches in the middle, forming the cardiac plexus, lung plexus, and esophageal plexus.⁽⁷⁾

With continuous development of thoracoscopic technology,^(13, 14) tumor resection and lymph node sweeping/sampling are no longer the only concerns of surgeons.⁽¹⁵⁾ Clearer thoracoscopic cameras give the surgeon a better understanding of the deep structures of the thoracic cavity. Surgical details that could not be identified using traditional surgery in the past^(17, 18) may be achieved using newer technologies.⁽¹⁹⁾ At present, most vagal nerve protection during thoracoscopy^(20, 21) occurs at the main trunk. Many vagal nerve branches that originate from the main trunk are often ignored or systematically swept together. However, with our surgical approach, we found that during mediastinal lymph node dissection, effective methods could be used to expose and protect vagal nerve branches, especially the thoracic branch, which directly affects heart rate.^(6, 22, 23) This type of surgery can be performed via the left or right mediastinum.

In this study, we selected patients undergoing left thoracic cavity surgery for lung cancer. Compared with the right side, surgery on the left side is more difficult. However, according to anatomical evidence, the effect of left-sided surgery on heart rate may also be more obvious compared with right-sided surgery.^(10, 24, 25) With left-sided surgery, the operation time is slightly longer, but this difference is not significant. There were no significant differences in incision size, intraoperative bleeding, and postoperative pain between the experimental group and the control group. Moreover, there were no significant differences between heart rate at admission, during preoperative anesthesia, during postoperative recovery, and during the first day after surgery. The heart rate of patients in the experimental group at the end of hospitalization was significantly lower compared with the control group during the same period. Heart rate at discharge and heart rate at admission were compared. The fluctuation in heart rate in the experimental group was significantly smaller compared with before surgery (Fig. 1). We speculate that this occurred because of our intention to protect the vagus nerve and the cardiac plexus during surgery. We also minimized use of electro-surgery to ensure that vagal nerve stimulation was reduced.

As the incidence of lung cancer increases, lobectomy and lymph node dissection are performed at an increasing number of cancer treatment centers, and therapists aim to effectively treat this disease while minimizing cost, allowing patients to achieve a long life after surgery and better restore social activity. These demands increase the need for skilled surgeons. We will continue to refine our intraoperative processes, expand our experimental samples, and conduct long-term follow-up observations on patients to measure changes in the condition of the lung after surgery. We hope that our observations will prompt more surgeons to protect the vagal nerve during surgery and enable more patients to benefit from this approach.

5. Conclusion

The results of this study preliminarily indicate that vagal nerve protection can effectively reduce heart rate changes during treatment. Reasonable surgical planning and skill control do not increase pain, surgical bleeding, or hospitalization time.

List Of Abbreviations

No abbreviations.

Declarations

Ethics approval and consent to participate

The research has been approved by the Biomedical Research Ethics Committee of Peking University First Hospital, project number: 2021-032

Consent for publication

All data and information involved in this study have obtained the consent of the patient.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

SZ completed and recorded the surgical information, and revised the manuscript. XS and ZC collected and analyzed relevant data. XL compiled the manuscript.

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Figures

Figure 1

Heart rate before ending hospitalization compared with heart rate on admission in the control and experimental groups.

Figure 2

The cardiothoracic branch of the vagus nerve exposed during mediastinal lymph node dissection.

Figure 3

The cardiothoracic branch of the vagus nerve after mediastinal lymph node dissection.