

EXPERIMENT STUDY AND CLINICAL OBSERVATION WITH LIGATION METHOD FOR CLOSING BRONCHIAL STUMP FOLLOWING LOBECTOMY FOR LUNG NEOPLASMS

Chen Keneng¹ 陈克能 Yang Guoliang¹ 杨国梁 Xie Wei¹ 谢伟 Hu Minbo¹ 胡名柏
Feng Ruiqing² 冯瑞庆 Shi Xiaotian² 师晓天

¹ Institute of Oncology, Hubei Medical University, Wuhan 430071

² Anyang Tumor Hospital, Henan, Anyang 455000

Objective: Traditional method of closing bronchial stumps after lobectomy was whole layer suture by hand or by stapler. Little is known about the ligated bronchial stump following lobectomy. To evaluate the characteristics of ligation method for closing bronchial stumps. **Methods:** In this study 90 lobectomies on 15 mongrel dogs and 75 bronchial stump models on fresh cadaver bronchus were performed. Multivariable comparison experimental studies were made on the results of three different closing methods: simple ligation, manual suture and stapling. **Results:** In the ligation group, the operation time was significantly shortened ($P < 0.01$). The depth of stump cavity between ligation group and suture group was of no difference significantly ($P > 0.05$). The resistance against intrabronchial pressure was greater in the ligation group than in the suture group ($P < 0.01$). Pathological studies illustrated earlier healing of mucosal membrane with milder inflammatory reactions. In clinical practice, 121 lobectomies were successfully performed with simple ligation of the stumps. **Conclusion:** Simple ligation is a safe, reliable, simple, and applicable method for closing bronchial stump following lobectomies.

Key words: pneumonectomy, Surgery, Bronchial stump, Clinical practice, Animal experiment

Since the first pulmonary resection by Graham in 1933, the management of bronchial stumps has

always been regarded as one of the key procedures. Appropriate closing method can reduce the incidence of bronchial stump fistula. Many investigators have worked on this problem and so far a dozen methods are currently in use, with Reinhoff-Sweet's suture and their modifications¹⁻⁸ being the most popular. In 1955, stapling devices were first introduced into pulmonary surgery by the former Soviet scholars,⁹ and great advances have been sustained since then. The present article made a comparative study on suture closing and ligation closing in animal experiments. Experience with ligation on 121 lobectomies in clinic was also drawn.

EXPERIMENT STUDY

Materials and Methods

Animal and operation

The animal experiment protocol was approved by the Animal Study Management Committee of Hubei Medical University. Fifteen adult mongrel dogs, weighing between 11—20kg, were anesthetized with intravenous sodium barbiturate and intubated. Respiration was maintained by an intermittent insufflating apparatus. Thoracotomy was performed through the fifth or the fourth intercostal space, and the target pulmonary artery, pulmonary veins and bronchial vessels successively ligated. Trauma to the

Accepted June 19, 1997

bronchus and its blood supply was avoided. The bronchus was then designed to transect 0.5 cm distal to the bifurcation. Every dog received three thoractomies for multiple lobectomies. Thus, a total of 90 lobectomies were succeeded. After slain, 75 bronchial stump models were performed on the remaining lobar bronchus and main bronchus with three different methods.

Groups

The bronchial stumps were divided into three groups according to different methods.

Group I (n=66) In this group, bronchial stumps were closed with interrupted 1—0 silk sutures using the modified open technique of Sweet. At operation the time consumption of closing bronchus was calculated. Dogs were sacrificed at once and within 7–10, 11–25, 26–30 days postpneumonectomy. The respiratory tract was en bloc removed from thoracic cavity, and an endotracheal tube was inserted. The endotracheal tube was connected to a cylinder of compressed air and a pressure manometer (LIFE SCOPE 12, Japan) with a “Y” type tube to measure endotracheal pressure, but the stumps were sunk into a container filled with saline. The endotracheal pressure was increased until an air leak at the bronchial stump was observed, and this pressure was designated as the leakage pressure. Besides, dogs’ clinical manifestations were observed, and their thoracic cavity, remaining lung and stump were pathologically evaluated.

Group II (n=46) In the second group, bronchial stumps were closed with an automatic stapling device (Golden bell “414”, Shanghai). The technique of pneumonectomy, the bronchial stump age at the time of study, the method of determining leakage pressure, and the pathological evaluation were identical to those of Group I.

Group III (n=53) In the third group, bronchial stumps closed with simple ligation which was detailed as in the clinical application. The studies performed were identical to those described for Groups I and II.

Results

Time consumed in operation

Time consumed in closing stump was shorter for ligation than for Sweet ($15.5 \pm 9.78s$ vs $267.77 \pm 87.31s$,

$P < 0.01$). Stapling stump also spend shorter time than manually suturing ($13.6 \pm 4.99s$ vs $267.77 \pm 87.31s$, $P < 0.01$). But there was no significant difference in time consumption between ligating and stapling.

Resistance against intrabronchial pressure

In the ligation group and those sutured ones with residual lung in thoracic cavity after 7–10 days, the intrabronchial pressure tolerated was more than 40 kPa regardless of the stumps made *in vitro*, or *in vivo*, or 7–10 days after lobectomies. In the manually sutured group the intrabronchial pressure tolerance was 25.9 ± 5.73 kPa for *in vivo* stumps and 11.22 ± 5.66 kPa for *in vitro* models. In the stapling group, the figure *in vitro* was 6.91 ± 2.98 kPa. But there is significant difference between with (more than 40 kPa) or without (31.84 ± 3.0 kPa for Sweet, 30.16 ± 2.8 kPa for stapling) remaining lung tissues in thoracic cavity after 7–10 days. Comparison among them showed that the ligation group had much higher tolerance to increased intrabronchial pressure than that in either suture group or stapling group.

Clinical manifestations of the dogs

All the dogs survived the operations uneventfully. There were no coughs, hemoptysis, bronchial stump fistula or death.

Pathology evaluation

For those stumps where there were residual lobes in the thoracic cavity, the stumps were covered by the expanded residual lung tissue and became invisible. There was diffuse adhesion in the thoracic cavity. The degree of adhesion was in direct proportion to postoperative duration. For those stumps where there were no residual lobes, the stumps had different pictures according to different closing methods. In the ligation group, the inflammatory reactions were much less severe than in the suture ones. The stump cavity looked like cone or small plate. The silk did not cut into the wall of the stump, and there were no retention of secretions. By contrast, in the suture group (by hand or by stapler), the mucosa in the stump approximated less well leaving a “saw”-shaped line. There were deep pits at both angles of the stump cavity, where retained secretions were frequently found. From the mucosa suture materials

were easily seen lined up across the wall of the stump. The depth of dead end of stump in the two groups were of no statistical difference.

CLINICAL OBSERVATION

From January 1974 to June 1995, 121 successive lobectomies were performed in the authors' institute. The patients included 83 males and 38 females, with age ranging from 38 to 72 years (mean 59.5 years). The diseases involved 78 cases with squamous cell carcinoma, 30 with adenocarcinoma, 10 with undifferentiated carcinoma, 2 with carcinosarcoma and 1 with bronchial adenoma. The tumor locations were 38 cases in the right upper lobe, 6 in the right middle lobe, 34 in the right lower lobe, 12 in the left upper lobe, and 32 in the left lower lobe. In all of these operations the bronchial stumps were closed by simple ligation, which was detailed as the following. When adventitial tissues around the target bronchus were cleared up, ligation with a single 10—0 silk of the bronchus were made as close to the bifurcation as possible. The other 10—0 silk was ligated at the same site but in opposite direction against the former. 0.5 cm beyond the ligation, the bronchus was dissected and the cut end was sterilized in a standard fashion. When increased intrabronchial pressure confirmed no air leak, the step was over. Other procedures were the same with standard operations. Pathological studies showed that all the cut ends were free of tumor. In all these 121 cases, only one small bronchopleural fistula occurred, with no extensive intrathoracic infection due to adhesion of adjacent tissues and expansion of remaining lobes. The rest 120 cases recovered well with no complications.

DISCUSSION

The Key Factors of Early Healing Following Lobectomy

The main causes of bronchial stump leakage/fistula are infection, long stumps, and inaccurate approximation of the transected bronchus, inappropriate closing method or technical error, too much damage to blood supply and surrounding tissues during mobilization of the bronchus.¹⁰⁻¹² The all ligated bronchial stumps under the tested conditions

and those sutured ones with remaining lung in thoracic cavity after 7–10 days were secure to more than 40 kPa. We chose to measure leakage pressure of stumps within 7–10 days because fistula often take place during this period. In this experiment, it was found that 7 to 10 days after closure of the stump, the closing materials were still needed to maintain approximation of the bronchial wall, because no healing took place within this time span. However, the leakage pressure, for the sutured stumps *in vivo*, *in vitro* at once and those without residual lung tissue in the thoracic cavity after 7–10 days, were much lower than that in ligated ones. In a previously published study, the average mean intraluminal bronchial pressure during vigorous coughing in young adult men was reported as 26.6 Kpa. Hence, we are reasonably sure that early expansion of the remaining lobes and adequate resistance against intrabronchial pressure are key factors conducive to early healing of the stumps and avoidance of stump leakage/fistula. From the viewpoint of intrabronchial pressure resistance, ligation eliminates main factor leading to leakage/fistula, and is superior to whole-layer suture.

Comparison between the Ligation and Suture

Compared with manual suture, ligation and stapling are both time-saving and easy-doing. Moreover, ligation requires no special devices, which makes it more convenient. Studied pathologically at various times after lobectomies, the sutured stumps especially those done by hand, had severer tissue damage and inflammatory reaction. Furthermore, the mucosa of sutured ones approximated unevenly. The "V"-shaped pits at both angles of the suture were apt to retain secretions which led to infection. The suture itself functioned as a drain leading infection from within the lumen to the outside. The result was that all layers of the sutured stumps became inflamed or infected, increasing the likelihood of leakage/fistula. In contrast, the ligation was an once and for all closing procedure. It had no suture drainage. These stumps receive even force from ligation, which caused little damage to the stumps. All these worked together to lessen inflammation and infection, and diminish the possibility of fistula. Besides, in the animal experiment, it was found that 9 days after ligation, scar tissues had developed not only at the cut end but also in the submucosal layer at the ligation site. While in the suture group these occurred after 19 days.

Therefore, from the viewpoint of tissue healing, ligation is also better than suture.

Clinical Practice

In the authors' practice of 121 lobectomies using ligation to close the stumps, only one pleural fistula occurred (0.8%). According to literature, the whole-layer suture method had a fistula incidence of about 3% at home¹³ and 1.6%—4.5% abroad.¹⁴⁻¹⁵

The key to the success of ligation is that the technique must be correct. We chose 10—0 silk, not too much finer, to ligate in order to avoid cutting damage, and stress single silk lest the intervention between double silk. And then at the same site repeat the step exactly in the opposite direction, which means even stress from ligation made on every parts of the target bronchus. We once had a case that the diameter of whose bronchus was bigger than usual. For fear of unreliability of simple ligation, additional suture was made. The patient died from stump fistula 25 days after operation. This case demonstrates that ligation should be done only, and ligation plus suture not only intensify tissue damage, but also apt to infection in the dead space between ligation and suture, which lead to fistula. From the above animal experiment and clinical experiences, it can be reasonably concluded that when placed properly using above technique, ligation is a simple and reliable method for closing bronchial stumps.

REFERENCES

1. 陈克能, 杨国梁。肺切除时支气管残端的处理方法。兰州医学院学报 1997; 22:71.
2. 陈克能, 杨国梁, 袁宏银。肺口切除时结扎支气管残端的实验研究。中华胸心血管外科杂志 1995; 11:108.
3. 陈克能, 杨国梁, 师晓天。肺切除时不同方法处理支气管残端的动物实验。中华实验外科杂志 1997; 14:173.
4. 杨国梁, 陈克能, 袁宏银。结扎法处理支气管肺肿瘤肺叶切除时支气管残端。中华肿瘤杂志 1995; 13:309.
5. 陈克能, 师晓天, 杨平。累及呼吸道的 T₄ 食管癌切除后 OB 胶加固气管成形术。中华胸心血管外科杂志 1998; 14:84.
6. 师晓天, 陈克能, 韩孝存, 等。OB 胶加固气管支气管成形术及支气管残端的实验研究与临床应用。中华实验外科杂志 1997; 14:161.
7. Sweet TH. Closure of the bronchial stump following lobectomy of pneumonectomy. *Surgery* 1945; 18: 85.
8. Rieniiff WF, et al. Closure of the bronchus following total pneumonectomy. *Ann Surg* 1942; 116: 481.
9. Takaro T. Institute for experimental surgical instrumens in Moscow. *Science* 1963; 142: 195.
10. Scott RN, et al. Bronchial stump closure techniques following pneumonectomy: a serial cooperative study. *Ann Surg* 1976; 8: 205.
11. Forrester-Wood CP. Bronchopleural fistula following pneumonectomy for carcinoma of the bronchus. *J Thorac Cardiovasc Surg* 1980; 80: 406.
12. Goffi FS, Goncalves EL. Closure of bronchial stump after pneumonectomy: comparison of some techniques through evaluation of tensile strength of suture. *Surgery* 1957; 42: 511.
13. 孙即昆。肺切除术后并发症。见: 孙即昆主编。肺外科学。北京: 人民卫生出版社, 1987; 426.
14. Weissbery D. Suture closure versus stapling of bronchial stump in 304 lung cancer operations. *Scand J Thorac Cardiovasc Surg* 1992; 26: 125.
15. Vester SB. Bronchopleural fistula after stapled closure of bronchus. *Ann Thorac Surg* 1991; 52: 1253.