

Preventive esophagomyobronchoplasty as a method to prevent the failure of the bronchial stump in pneumonectomy for lung cancer

R.A. Sulimanov*, R.R. Sulimanov, E.S. Spassky, T.V. Fedorova, M.A. Kholodova

Yaroslav-the-Wise Novgorod State University, Veliky Novgorod, Russia

Abstract

Aim. Comparative analysis of insufficiency rate of bronchial stump sutures in pneumonectomy for lung cancer, depending on suturing techniques.

Methods. A patented technique for bronchial stump suturing has been introduced into the practice of the GOBUZ clinic “Novgorod Regional Clinical Hospital” based on the Department of thoracic surgery since 2015 for pneumonectomy for lung cancer. Before the introduction of the developed technique, various generally accepted methods of bronchial stump forming were used (mechanical suture, manual suture, their combination, bronchial stump coverage with mediastinal pleura, pericardial flap). A retrospective analysis of 173 case histories and operational protocols of patients with lung cancer who underwent pneumonectomy was carried out for the failure of bronchial stump sutures when using conventional suturing techniques between 2010 and 2014 (the first group of patients). We also performed a retrospective and prospective analysis of 204 case histories and operational protocols of patients in a similar clinical group when using a patented suturing technique between 2015 and 2020 (the second group of patients). Statistical analysis was carried out by using Statistica 10.0 software (StatSoft, Inc. 2011). The qualitative and quantitative indicators were analyzed by using the Pearson’s χ^2 -test with Yates’s correction.

Results. A retrospective analysis shows that the failure rate in the use of generally accepted bronchial stump suturing techniques for 2010–2014 was 10.4%. After the implementation of the method of preventive esophagomyobronchoplasty, complications as bronchial stump suture failure were not detected in any case between 2015 and 2020.

Conclusion. The study shows high efficiency, a decrease in the incidence of complications as the failure of bronchial stump sutures in the use of the developed method of preventive esophagomyobronchoplasty in pneumonectomy for lung cancer.

Keywords: pneumonectomy, lung cancer, failure of bronchial stump sutures, preventive esophagomyobronchoplasty.

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Background. Lung cancer ranks first both in Russia and the world in the range of malignant neoplasms both in terms of morbidity and causes of mortality and steadily leads the range of oncological pathology [1].

Timely early diagnostics of lung cancer presents certain difficulties due to the paucity of clinical manifestations and objective data in early disease stages. Therefore, patients often seek help with advanced forms of lung cancer; however, organ sparing surgery in the form of a segment or lobectomy is impossible.

Over 10 years (2010–2019) in the Novgorod region, an increased proportion of cases were detected at stages I–II from 22.8% in 2010 to 26.0%

in 2019, as well as increased cases that are identified at stages III–IV from 68.4% in 2010 to 72.9% in 2019. Thus, the number of radical surgeries performed, including pneumonectomy, is growing [2].

One of the most hazardous surgical complications with high mortality is failed stump sutures of the bronchus. Nowadays, the bronchial stump suture failure ranges from 1 % to 20 %, and the mortality rate ranges from 20 % to 75 % despite its existing variety of suturing methods. The development of bronchial stump suture failure after pneumonectomy is always associated with the imperfection of the bronchial suture and unfavorable conditions for its healing [3].

The pathogenesis of bronchial stump suture failure remained controversial, and its prevention issues are not fully resolved [4]. Additionally, factors that affect the bronchial stump on healing, such as impaired blood supply, tissue trauma, and bronchial stump communication with the pleural cavity, should be studied [5].

Primary bronchial stump suture failure occurs due to the violations of the necessary conditions for wound healing by primary intention as follows [6]:

- crushing the bronchus by the apparatus branches;
- poor stump suturing with tantalum brackets;
- the additional imposition of frequent sutures, leading to blood supply disorder;
- isolating the bronchus from the root fiber where the bronchial vessels pass;
- passing sutures through the bronchial lumen, which contributes to the wound infection;
- intersection near the bifurcation, where the rigidity of the cartilaginous frame is expressed, which causes the wound edges to be cut with sutures.

The method of processing the bronchus stump is of great importance both for the patient and the operating surgeon and is one of the urgent problems of modern thoracic surgery. There is no generally accepted technique for bronchial stump treatment, and the methods of “covering” the stump remain controversial. Unfortunately, none of the existing methods of bronchial stump formation can ensure the prevention of its suture failure with a high degree of reliability [7].

On average, using manual sutures for suturing the bronchial stump, the failure rate is 5%–7%, whereas 9%–13% using a mechanical suture [8–10]. Omento- and myoplasty are effective methods of treatment. Researchers use a portion of the serratus muscle, diaphragm, pericardium, and omentum as a plastic material for “covering” the bronchial stump [11, 12].

Thus, such a hazardous complication as bronchial stump suture failure can be avoided with preventive myoplasty method application and prompt identification of problems. This paper presents an analysis of bronchial stump suture failure frequency during pneumonectomy for lung cancer using conventional methods for treating the stump and a patented method bronchial stump of suturing using the muscular wall of the esophagus.

This study aimed to perform a comparative analysis of the incidence of bronchial stump suture failure during pneumonectomy for lung cancer, depending on its suturing method.

Tasks.

1. Retrospective analysis of case histories and protocols of surgeries of patients with lung can-

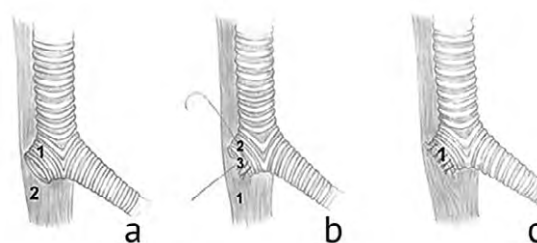


Fig. 1. Method of bronchial stump suture failure prevention: a—bronchus stump (1), the level of the esophagus for plastic surgery (2); b—the muscular wall of the esophagus (1), the cartilaginous part of the bronchus (2), the membranous part of the bronchus (3); c—superimposed interrupted sutures with taking the esophagus wall and closing the stump of the main bronchus in the form of a hood (1).

cer who underwent pneumonectomy for bronchial stump suture failure using conventional suturing methods.

2. Retrospective and prospective analysis of case histories and protocols of surgeries of patients with lung cancer who have undergone pneumonectomy, for bronchial stump suture failure using a patented method of its suturing.

Materials and methods. We have developed and patented a method of bronchial stump suturing during pneumonectomy for lung cancer using the esophageal muscular wall [13].

Description of our proposed method of preventing the bronchial stump suture failure [14]. We use Vicryl 2/0 suture material and an atraumatic needle. According to the bronchial stump level, we selected the level of the esophagus for subsequent plastic surgery (Fig. 1, a). We apply separate interrupted sutures (Fig. 1, b) on the muscular wall of the esophagus, with the distance between the needle entry and exit puncture from 7 to 10 mm (an experiment on 14 human corpses proved the need for this distance to create a “hood”). Subsequently, we made a needle entry puncture in the membranous part of the bronchus and a needle exit puncture in its cartilaginous part, departing 0.3 cm from the place of their junction. We leave the ligature as a holder, without tying it. We apply the subsequent sutures in the same way. The distance between the adjacent ligatures is approximately 0.3 cm. Subsequently, we tighten the knots (Fig. 1, c). We start tying knots with a suture located in the middle of the bronchial stump. If the above parameters of capturing the esophageal wall and the tissue of the bronchial stump are observed, the principle of hood-type myoplasty is created. After suturing, air pressure should be applied to the stump that is immersed in liquid to test the leak-tight integrity.

Since 2015, a patented method of bronchial stump suturing in pneumonectomy for lung cancer has been introduced in the practice of the Novgorod

Table 1. Index of bronchus stump suture failure during pneumonectomy, depending on its treatment method (group 1).

Method of the bronchus stump treatment	Total		Incidence of bronchus stump suture failure	
	n	%	n	%
Mechanical suture (UO-40, UO-60)	62	36	11	17.7
Mechanical suture with additional manual twisted suture (vicryl 2/0)	43	25	5	11.6
Manual suture (vicryl 2/0, single interrupted sutures)	36	21	1	2.8
Manual suture with the tying of pericardial fat (vicryl 2/0, single interrupted sutures)	23	13	1	4.3
Manual suture with tying the parietal pleura (vicryl 2/0, single interrupted sutures)	9	5	0	0
Total	173	100	18	10.4

Table 2. Distribution of operated patients depending on gender, age, and the side of the surgery.

Year	Gender of operated patients		Age of operated patients, years				Side of surgery	
	men	women	20–35	35–50	50–65	65–80	right	left
2010	39 (91.8%)	2 (8.2%)	1 (4.1%)	2 (8.2%)	36 (79.5%)	2 (8.2%)	25 (61%)	16 (39%)
2011	31 (96.8%)	1 (3.2%)	0	3 (9.6%)	19 (59.15%)	10 (31.25%)	13 (41.6%)	19 (58.4%)
2012	32 (96.7%)	1 (3.3%)	0	0	28 (84.8%)	5 (15.2%)	18 (54.5%)	15 (45.5%)
2013	26 (89.7%)	3 (10.3%)	0	0	21 (72.4%)	8 (27.6%)	20 (69%)	9 (31%)
2014	33 (86.8%)	5 (13.2%)	0	2 (5.2%)	29 (76.3%)	7 (18.5%)	19 (50%)	19 (50%)
2015	53 (94.6%)	1 (5.4%)	0	2 (3.7%)	33 (61.1%)	19 (35.2%)	22 (40.7%)	32 (59.3%)
2016	23 (62.9%)	14 (37.1%)	0	14 (40%)	21 (69%)	0	21 (60%)	14 (40%)
2017	20 (69%)	9 (31%)	0	9 (31%)	14 (48.3%)	6 (20.7%)	17 (58.6%)	12 (41.4%)
2018	30 (88.2%)	4 (11.8%)	0	4 (11.8%)	23 (67.6%)	7 (20.6%)	20 (58.8%)	14 (41.2%)
2019	20 (59.4%)	14 (40.6%)	0	10 (31.25%)	17 (53.1%)	5 (15.65%)	23 (71.9%)	9 (28.1%)
2020	15 (93.75%)	1 (6.25%)	0	4 (25%)	7 (43.75%)	5 (31.25%)	9 (56.25%)	7 (43.75%)

Regional Clinical Hospital, the department of thoracic surgery. Before the implementation of the developed method, various generally accepted methods of bronchial stump formation were used (mechanical suture, manual suture, their combination, covering the stump with mediastinal pleura or pericardial flap; Table 1).

A retrospective analysis of 173 case histories and protocols of surgeries of patients with lung cancer, who underwent pneumonectomy, was performed for bronchial stump suture failure using conventional methods of its suturing for 2010–2014 (group 1). A retrospective and prospective analysis of 204 case histories and protocols of surgeries of patients were also performed in a similar clinical group using a patented method of suturing for 2015–2020 (group 2 of patients). Statistical analysis of the data was performed using the Statistica 10.0 software (StatSoft, Inc. 2011). When working with qualitative and quantitative indicators, we used the Pearson χ^2 test with Yates' correction.

In absolutely all clinical cases, pneumonectomies were performed according to indications for lung cancer of various localization and extent of generalization.

For all the years of monitoring, due to various factors, the prevalence of males in pneumonectomy was noted, which corresponds to the all-Russian and world indicators of lung cancer incidence. The age category in the range of 50–65 years prevailed among those operated on during the selected time interval. Surgical intervention was performed in 60% of cases on the right lung (Table 2).

Results and discussion. The indicator of bronchial stump suture failure with the development of complications in group 1 was at the level of 10.4% (Table 3). In 90% of cases, both complications (bronchial stump suture failure and pleural empyema) simultaneously developed in one patient. Bronchus stump suture failure occurred more often during the right pneumonectomy (Table 3).

Clinical experiences

Table 3. Incidence of bronchial stump suture failure and empyema of the residual pleural cavity after pneumonectomy, depending on the side of the lesion.

Year	Complications after pneumonectomy		Side of complications	
	bronchus stump suture failure	pleural empyema (including as a result of the bronchopleural fistula)	right	left
2010	5 (12.2%)	6 (14.6%)	6 (100%)	0
2011	3 (9.3%)	3 (9.3%)	0	3 (100%)
2012	3 (9.1%)	4 (12.1%)	3 (75%)	1 (25%)
2013	4 (13.8%)	5 (17.2%)	3 (60%)	2 (40%)
2014	3 (7.9%)	6 (15.8%)	4 (66.7%)	2 (33.3%)
2015	0	1 (1.8%)	1 (100%)	0
2016	0	0	0	0
2017	0	0	0	0
2018	0	1 (2.9%)	1 (100%)	0
2019	0	1 (3.1%)	1 (100%)	0
2020	0	0	0	0

Depending on the method of the bronchial stump treatment before the introduction of the patented method, we divided the used techniques into three groups, namely mechanical sutures with staplers (UO-40, UO-60), mechanical sutures with an additional twisted manual suture, and manual sutures with separate interrupted sutures, and using plastic material (pericardial fat, parietal pleura; Table 1).

Using manual sutures, bronchus stump suture failure was registered in 2 (2.9%) cases. The use of UO apparatus in 105 patients, both with and without additional sutures, was accompanied by the greatest number of complications, in 16 (15.2%) cases. With the above-mentioned complications, a need for repeated surgical treatment occurred, which was performed in the form of re-thoracotomy with plastic surgery (suturing) of the bronchopleural fistula or re-amputation of the bronchial stump. Conservative treatment of complications was provided with pleural cavity drainage, followed by sanitation with antiseptic solutions, as well as antibacterial and detoxification infusion therapy.

In group 2 (204 people), empyema of the residual pleural cavity after pneumonectomy was detected in 3 (1.5%) cases, which was 9.3 times less than in group 1 (173 people), namely 24 (13.9%) similar cases ($\chi^2 = 19.35$, $p < 0.0001$).

After the introduction of a new bronchial stump suturing method (group 2), no complications in the form of bronchial stump suture failure were registered (Table 3). The mortality rate also significantly decreased in the presence of the above-mentioned complications. In group 1, the mortality rate was

3.5% (6 people), without lethal cases in group 2 ($\chi^2 = 5.03$, $p = 0.0249$).

CONCLUSIONS

1. Bronchus stump suture failure is a pneumonectomy complication, which, regardless of its direct cause, can be a factor in poor prognosis and predictor of a severe course of the disease.

2. The study revealed high efficiency, decreased complication incidence in the form of bronchial stump suture failure using the developed method of preventive esophagomyobronchoplasty for pneumonectomy for lung cancer.

3. The safest method of bronchial stump suture is the imposition of a manual suture using the muscular wall of the esophagus as a grafting material.

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Conflict of interest. The authors declare no conflict of interest.

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