

Methods of main bronchus stump closure and incidence of bronchopleural fistula after pneumonectomies for lung cancer (a retrospective single center review)

Saulius Cicėnas^{1,2},

Algirdas Jackevičius³,

Renatas Aškinis¹,

Arnoldas Krasauskas¹,

Nerijus Šileika¹,

Narimantas Evaldas

Samalavičius^{1,4},

Pranas Naujokaitis¹

¹ Department of Thoracic Surgery and Oncology of the Institute of Oncology, Vilnius University

² Vilnius University Faculty of Medicine

³ Scientific Research Center, Institute of Oncology, Vilnius University

⁴ Clinic of Internal Diseases, Family Medicine and Oncology, Vilnius University Faculty of Medicine

Background. Bronchopleural fistulas (BPFs) development after pneumonectomy remains a serious complication and is associated with high mortality rate. We evaluated incidence and risk factors, that influenced BPF rate after pneumonectomies for lung cancer patients treated at the Department of Thoracic Surgery and Oncology of the Institute of Oncology, Vilnius University, and compared different bronchial stump suturing techniques.

Methods. It is a retrospective study. We reviewed 580 lung cancer patients who underwent pneumonectomies from January 1990 to January 2009. The average patient's age was 60.1 ± 7.9 years (range from 34 to 76). Patients according to postoperative staging: stage IIA – 30 patients, IIB – 80, IIIA – 320, IIIB – 96, IV – 54. The most common tumor histology was planocellular carcinoma – 301, adenocarcinoma – 108, small-cell carcinoma – 76.

Results. There were 327 (56.4%) right and 253 (43.6%) left pneumonectomies. Mediastinal lymph node dissection (LND) was performed to 387 (66.7%) and lymph node sampling (LNS) to 193 (33.3%) patients. The bronchial stump was covered in 285 (49.1%) patients. Bronchopleural fistula after pneumonectomy developed in 48 (8.3%) patients (bronchial dehiscence was confirmed by bronchoscopy), and 7 patients with BPF died (14.5%). BPF after right pneumonectomy occurred in 30 cases (9.5%) and after left pneumonectomy in 18 cases (7.1%), the difference was not statistically significant ($p > 0.05$). BPF after LND occurred in 38 cases (9.82%) and after LNS in 10 cases (5.18%), the difference was statistically significant ($p < 0.05$). BPF rate using suturing devices with changeable staples (UKL-40, UKL-60, UO-40, UO-60) was 12.6%, using mechanical staplers and hand-made suture it was 4.1% and 8.8%, respectively. The difference between the groups was statistically significant ($p = 0.0071$).

Conclusions. 1. BPF rate after pneumonectomies for lung cancer patients was lowest using mechanical staplers (4.1%). 2. BPF occurrence rate after right and left pneumonectomy had no statistically significant difference. 3. BPF rate after pneumonectomy was higher in the LND group (9.82%) than in the LNS group (5.18%), the difference was statistically significant ($p < 0.05$).

Key words: pneumonectomy, lung cancer, bronchial stump closure, bronchopleural fistula, staplers

BACKGROUND

Recent advances in perioperative management, antibiotics and surgical materials have decreased the operative risk of pulmonary resection. Bronchopleural fistula (BPF) development after pneumonectomy remains a serious complication and is associated with high mortality rate.

The first successful one-stage pneumonectomy for lung cancer was performed on 5th April 1933 by Evarts A. Graham at Barnes Hospital (St. Louis). The left thoracotomy was done and crushing clamps were placed on the hilus near the trachea without individual ligation of the hilar vessels and the bronchus (1, 2). In June 1933, E. Archibald of the Royal Victoria Hospital (Montreal) also performed a successful pneumonectomy in a 31-year-old man with a left upper lobe sarcoma. W. Rienhoff at the Johns Hopkins Medical School (Baltimore) also successfully executed two one-stage pneumonectomies in July and October 1933. Notably, both Archibald and Rienhoff employed a technique of individual ligation of the hilar vessels and the bronchus, important advances that helped to reduce postoperative morbidity and mortality (2, 3).

Closure of the main bronchus remains a serious problem and there are controversial reports which suturing technique – hand-sewn or mechanically stapled – should be used.

The incidence of BPF rate after pneumonectomies varies from 0.8% to 28% (4, 5).

We evaluated incidence and risk factors that influenced BPF rate after pneumonectomies for lung cancer patients treated at the Department of Thoracic Surgery and Oncology of the Institute of Oncology, Vilnius University, and compared different bronchial stump suturing techniques.

Vasculature of the main bronchi

Bronchial arteries supply blood for nutrition of the structures making up the root of the lungs, the supporting tissues of the lungs, and the visceral pleura. They arise from the systemic circulation and account for about 1% of the cardiac output. The origin of the arteries are variable from the aorta, intercostal arteries, and, occasionally, subclavian, innominate and internal mammary arteries or even a coronary artery. The small bronchial arteries provide branches to the upper

esophagus and then typically pass along the posterior aspects of the main bronchi, supplying them and their branches as far distally as the respiratory bronchioles.

The most extensive anatomic study was reported by Caudwell and associates. These investigators recorded nine patterns of origin. The level of origin of bronchial arteries was most commonly between the fifth and sixth thoracic vertebrae, and they arose from the descending thoracic aorta and rarely from the arch. In most instances, the bronchial vessels that arise from the aorta pass in the back of the trachea (6, 7).

MATERIALS AND METHODS

The main bronchus closure technique after pneumonectomies for lung cancer

Group I: the bronchial stump after pneumonectomy was closed using suturing devices with changeable staples (UKL-40, UKL-60, UO-40, UO-60) – 190 patients, 32.8%.

Group II: the closure was performed using mechanical staplers (TA-30; TA-40; Proximate RL-30, 60; Linear stapler 40) – 220 patients, 37.9%.

Group III: the bronchial stump was manually sutured in the fashion of Sweet (15 patients), Overholt (63 patients) or Goldstraw (92 patients) methods using the 3-0 or 4-0 PDS or Prolene suture.

Bronchopleural fistula is a communication between the bronchial air space and the pleural cavity. BPF was confirmed by bronchoscopy.

Mediastinal lymphadenectomy

Lymph node dissection (LND) removing lymph nodes from mediastinal levels 2R, 3, 4R, 7, 8R, 9R, 10R, 11R in right pneumonectomies and 4L, 5, 6, 7, 8L, 9L, 10L, 11L in left pneumonectomies was performed.

In aged patients or patients with limited cardiopulmonary reserves lymph node sampling (LNS) was performed: only macroscopically abnormal lymph nodes were removed.

Statistics

Continuous variables were presented as mean \pm SD (standard deviation). Discrete variables between groups were compared using the χ^2 -test. A P-value of <0.05 was considered statistically significant.

RESULTS

From January 1990 to January 2009, 580 lung cancer patients underwent pneumonectomies in the Department of Thoracic Surgery and Oncology of the Institute of Oncology, Vilnius University.

The average patient's age was 60.1 ± 7.9 years (range from 34 to 76).

There were 327 (56.4%) right and 253 (43.6%) left pneumonectomies. Mediastinal LND was performed to 387 (66.7%) and LNS to 193 (33.3%) patients.

The bronchial stump was covered in 285 (49.1%) patients. Table 1 presents methods of the main bronchus stump covering.

Postoperative staging (according to the TNM Classification of Malignant Tumors, 1997) and a histologic type of the tumor are presented in Table 2.

Number of stages IIIB (96 patients) and IV (54 patients) is high. Most of pneumonectomies in these stages were performed during the period of 1990–1999. Indications were destruction of advanced lung cancer with lung abscess formation, bleeding. Lung surgery for stage IV was performed in solitary brain or adrenal metastasis. After

pneumonectomies these patients underwent metastasis surgery.

Bronchopleural fistula after pneumonectomy developed in 48 (8.3%) patients, and 7 patients with BPF died (14.5%). Bronchopleural fistula occurrence time was divided into three periods: 1–10, 11–30 and ≥ 31 postoperative days.

In Group I bronchopleural fistula developed in 24 (12.6%) patients (7, 14 and 3, respectively, according to occurrence time).

In Group II BPF occurred in 9 (4.1%) patients (3.6 and 0, respectively, according to occurrence time).

In Group III 15 (8.8%) patients suffered from BPF (4.7 and 4, respectively, according to occurrence time).

BPF occurrence rate had statistically significant difference between the groups ($p = 0.0071$).

The main bronchus suturing methods and BPF rate are shown in Table 3.

BPF after right pneumonectomy occurred in 30 cases (9.5%) and after left pneumonectomy in 18 cases (7.1%), the difference was not statistically significant ($p > 0.05$).

Ten patients (1.7%) died within 30 days after operation: 7 patients died because of BPF and

Table 1. Methods of the main bronchus stump covering

Method of the main bronchus stump covering	Number of patients, %
Pericardial fat pad	110 (38.6)
Parietal pleura	38 (13.3)
Tissues surrounding vena azygos	22 (7.7)
Vascularised intercostal muscles	15 (5.3)
Omentum patch	2 (0.7)
Mediastinal pleura	98 (34.4)
Bronchial stump was not covered	295 (50.9)

Table 2. Postoperative staging and tumor histology

Histology / Stage	IIA	IIB	IIIA	IIIB	IV	Total
Planocellular	19	54	189	26	13	301
Adenocarcinoma	6	13	56	18	15	108
Small-cell	1	7	37	19	12	76
Large-cell	4	3	35	14	10	66
Carcinoid		2		8		10
Alveolar carcinoma				8	2	10
Carcinosarcoma			1	3	2	6
Angiosarcoma			1			1
Type unspecified		1	1			2
Total	30	80	320	96	54	580

Table 3. The main bronchus suturing methods and BPF rate

Suturing method	Group I Suturing devices with changeable staples	Group II Mechanical staplers	Group III Handmade suture		
			Sweet	Overholt	Goldstraw
Number of patients, %	190 (32.8%)	220 (37.9%)	170 (29.3%)		
			15 (8.8%)	63 (37.1%)	92 (54.1%)
Number of BPF, %	24 (12.6%)	9 (4.1%)	15 (8.8%)		
P = 0.0071					

related empyema, pneumonia and cardiovascular disorders; 2 patients died because of massive thrombembolia; 1 patient died because of uncontrolled bleeding.

BPF after lymph node dissection (LND) occurred in 38 cases (9.82%) and after lymph node sampling (LNS) in 10 cases (5.18%), the difference was statistically significant ($p < 0.05$).

DISCUSSION

Authors describing BPF development after pneumonectomy emphasize importance of the bronchus (the stump should be short) and its circulation preservation (lymph nodes dissection can cause circulatory disturbances) (8, 9, 11, 13). Also, local risk factors involve tumor infiltration at the edges of the stump and surgeons' technical skills (19). The following general risk factors are described in the literature: general status of the patient (cachexia), destructive changes in lungs, anemia, hyperglycemia, chronic obstructive pulmonary disease, preoperative chemo- or radiotherapies applied for lung cancer, hypoalbuminemia, previous steroid therapy, ASA class ≥ 3 , long-lasting postoperative intubation because of respiratory dysfunction (14–18, 20, 22–24). Some authors state that preoperative chemo- or chemoradiotherapy does not increase BPF rate (10, 12).

Our study showed that the BPF occurrence rate after right and left pneumonectomy had no statistically significant difference (BPF after right pneumonectomy occurred in 30 cases (9.5%) and after left pneumonectomy in 18 cases (7.1%, but $p > 0.05$). Some studies show higher BPF rate after right pneumonectomies (21).

LND has higher BPF rate after pneumonectomy (9.82%) than LNS (5.18%), the difference is statistically significant ($p < 0.05$).

Another question being discussed in the literature is the method of bronchial stump suturing: Should it be sutured by hand or using suturing devices? The possible advantages of using staplers in pulmonary resections are as follows: the contamination of operation area can be minimized, the time required for closure can be markedly reduced, staplers can also be used safely in vascular division, but staplers have disadvantages when dealing with thickened airways or in close proximity to a tumor. In our series mechanical staplers had the lowest rate of BPF (4.1%), while the BPF rate using suturing devices with changeable staples (UKL-40, UKL-60, UO-40, UO-60) is 12.6% and the BPF rate using hand-made suture is 8.8%. The difference between the groups is statistically significant ($p = 0.0071$). More BPF was observed when Russian mechanical suturing devices were used because of their design causing excessive pressure on the bronchial stump, also the stapler incompletely closes the tissue particularly at the end points where the staple line of the stapler has exceeded the length of the bronchus.

Alloubi et al. presented a retrospective study of 168 pneumonectomies for lung cancer patients. In all cases radical mediastinal lymph node dissection was performed and the bronchial stump was closed with a manual suture.

BPF occurred in 7 patients (4.17%). Induction chemotherapy and bronchial stump reinforcement with the adjacent tissue did not affect the BPF rate (25).

Ucvet et al. (21) reviewed bronchial closure techniques in 625 patients (511 for malignant diseases and 114 for benign ones). They performed 419 lobectomies and 206 pneumonectomies. The incidence of BPF was 5.0% (21/421) in the stapling group and 1.5% (3/204) in the manual suturing group ($p = 0.04$). BPF after pneumonectomy was 10.2% (17.4% after right pneumonectomies and 5.0 after left pneumonectomies, $p < 0.01$). Neo-

adjuvant and postoperative adjuvant therapy increased the BPF rate.

Goldstraw et al. (18) reported low BPF rate after 471 pneumonectomies for lung cancer patients. In all cases bronchial closure was achieved by using a non-absorbable monofilament 2–0 Prolene in a continuous double row. BPF occurred in 7 patients (1.5%). The senior surgeon performed 374 pneumonectomies with two fistulas (0.5%) while other surgeons in training performed 97 pneumonectomies with five fistulas (5.1%).

Cardillo et al. (26) evaluated factors that influenced morbidity and mortality in patients undergoing completion pneumonectomy. Thirteen patients (7.9%) developed BPF. Stapled compared with hand closure for the bronchus did not affect the bronchopleural fistula rate ($p = 0.4$). No statistically significant relationship was found in mortality and morbidity according to the side, gender, induction therapy or surgical approach.

CONCLUSIONS

1. The bronchopleural fistula rate after pneumonectomies for lung cancer was lowest using mechanical staplers (4.1%), the difference between the groups is statistically significant ($p = 0.0071$). No late BPF (≥ 31 postoperative days) was observed in this group.

2. The BPF occurrence rate after right and left pneumonectomy had no statistically significant difference.

3. The lymph node dissection (LND) group has higher BPF rate (9.82%) than the lymph node sampling (LNS) group (5.18%), the difference is statistically significant ($p < 0.05$).

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**Saulius Cicėnas, Algirdas Jackevičius,
Renatas Aškinis, Arnoldas Krasauskas,
Nerijus Šileika, Narimantas Evaldas Samalavičius,
Pranas Naujokaitis**

PAGRINDINIO BRONCHO SUSIUVO METODAI IR BRONCHOPLEURINĖS FISTULĖS DAŽNIS PO DĖL PLAUCIŲ VĖŽIO ATLIKTO PULMONEKTOMIJOS

Santrauka

Įvadas. Bronchopleurinė fistulė (BPF), susiformavusi po pulmonektomijos, yra rimta komplikacija ir gali sukelti ligonio mirtį. Mes išanalizavome ligonius, operuotus dėl plaučių vėžio VUOI Krūtinės chirurgijos ir onkologijos skyriuje, ir įvertinome bronchopleurinių fistulių rizikos veiksnius, jų dažnį bei palyginome skirtingas bronchų bigės siuvimo metodikas.

Metodai. Į šį retrospektyvinį tyrimą buvo įtraukta 580 ligonių, operuotų 1990–2009 metais. Vidutinis ligonio amžius buvo $60,1 \pm 7,9$ metai (nuo 34 iki 76). Pooperacinė stadija: IIA – 30, IIB – 80, IIIA – 320, IIIB – 96, IV – 54.

Dažniausi histologiniai naviko tipai: plokščialąstelinė karcinoma – 301, adenokarcinoma – 108, smulkialąstelinė karcinoma – 78.

Rezultatai. Atlikta 327 (56,4 %) dešniosios ir 253 (43,6 %) kairiosios pulmonektomijos. Radikali tarpuplaučio limfonodektomija atlikta 387 (66,7 %) ligoniams, o pasirinktinis pakitusių tarpuplaučio limfmazgių šalinimas – 193 (33,3 %).

Broncho bigė aplinkiniais audiniais buvo padengta 285 (49,1 %) ligoniams. Bronchopleurinė fistulė susiformavo 48 (8,3 %), 7 (14,5 %) iš jų mirė. Po dešniosios pulmonektomijos bronchopleurinė fistulė susidarė 30 (9,5 %) ligonių, po kairiosios – 18 (7,1 %), tačiau skirtumas statistiškai nepatikimas ($p > 0,05$).

Bronchopleurinė fistulė po radiklios limfonodektomijos susiformavo 38 (9,82 %) ligoniams, po pasirinktinio tarpuplaučio limfmazgių šalinimo – 10 (5,18 %), $p < 0,05$. Naudojant mechaninius siuvimo aparatus (UO-40, 60, UKL-40, 60) BPF susidarė 12,6 %, staplerius (TA-30, 40; Proximate RL-30, 60; linijinis – 40) – 4,1 %, siuvant ranka – 8,8 % ligonių. Tarp grupių nustatytas statistiškai patikimas skirtumas.

Išvados. BPF susiformavo rečiau naudojant staplerius (4,1 %). Palyginus BPF dažnį po dešinėsios ir kairiosios pulmonektomijos, statistiškai reikšmingo skirtumo nenustatyta. Radikali limfonodektomija padidina bronchopleurinių fistulių dažnį, palyginti su „samplingu“ (9,82 vs 5,18), $p < 0,05$.

Raktažodžiai: pulmonektomija, plaučių vėžys, bronchų bigės siuvimas, bronchopleurinės fistulės, stapleriai