BRONCHOPLASTIC PROCEDURES IN MALIGNANT AND NONMALIGNANT DISEASE: MULTIVARIABLE ANALYSIS OF 144 CASES

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Objectives: We sought to analyze the experience with bronchoplastic procedures over a 7-year period and to determine putative prognostic factors for survival.

Methods: From 1991 to 1997, 144 bronchoplastic procedures were performed for non-small cell lung cancer (n = 123), small cell lung cancer (n = 5), carcinoid tumor (n = 10), and metastases of extrathoracic malignant tumors (n = 6). There were 111 sleeve lobectomies, 17 bilobectomies, 4 lobectomies with carinal resection, 8 sleeve pneumonectomies, and 4 bronchotomies without parenchymal resection. Multivariable analysis included risk factors, such as age, sex, type of bronchoplastic procedure (bronchotomy, lobectomy, bilobectomy, or pneumonectomy), additional angioplasty, TNM staging, histology, radicality of resection, respiratory risk (forced expiratory volume in 1 second, percent predicted < 60), cardiovascular risk, and adjuvant therapy.

Results: Overall 1- and 3-year survival was 72% and 52%, respectively. The overall 30-day mortality was 8.3% (5.4% for single sleeve lobectomies). Multivariable analysis demonstrated 4 risk factors for survival. High tumor stage, type of bronchoplastic procedure, impaired lung function, and presence of cardiovascular risk were associated with a poor outcome. Univariate analysis showed reduced survival in patients with sleeve pneumonectomies (1-year survival, 25%).

Conclusions: Bronchoplastic procedures for central tumors and sleeve pneumonectomies are associated with poor survival. Careful selection of these patients, as well as of patients with impaired lung function and cardiovascular risk factors, is mandatory. (*J Thorac Cardiovasc Surg* 2000;120:119-27)

Bronchoplastic procedures for malignant and nonmalignant disease are widely accepted procedures.

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Read at the Seventy-ninth Annual Meeting of The American Association for Thoracic Surgery, New Orleans, La, April 18-21, 1999.

Received for publication April 22, 1999; revisions requested Sept 16, 1999; revisions received Jan 17, 2000; accepted for publication March 8, 2000.

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0022-5223/2000 \$12.00 + 0 12/6106987

doi:10.1067/mtc.2000.106987

Several studies describe the results of bronchoplastic operations by using univariate analyses in most cases.¹⁻³ Multivariable analyses have been rarely performed.^{4,5} We carried out a multivariable analysis to determine putative prognostic factors for survival.

Patients and methods

Patients. Between January 1, 1991, and December 31, 1997, 144 bronchoplastic procedures were performed at the two main centers of thoracic surgery in Vienna (at the Department of Cardiothoracic Surgery, University of Vienna, and the Department of Thoracic Surgery, Center of Pulmology). The patients consisted of 110 (76%) men and 34 (24%) women, with a mean age of 59.8 ± 10.5 years (range, 24-79 years). Twenty-one (15%) patients were at least 70 years old, and 43 (30%) had a respiratory risk (ie, chronic obstructive pulmonary disease defined as forced expiratory volume in 1 second [FEV₁] of < 60% of predicted value). For all patients, the mean FEV₁ was $73.2\% \pm 15.7\%$. Fifty-five

Table I. Stage of tumor in patients undergoing bronchoplastic resection (n = 137)

Stage	No.	% of 137
I	44	32
T1 N0	20	
T2 N0	24	
II	44	32
T1 N1	12	
T2 N1	28	
T3 N0	4	
III A	32	23
T1 N2	5	
T2 N2	19	
T3 N1	6	
T3 N2	2	
IIIB	10	7
T4 N0	2	
T4 N1	5	
T4 N2	3	
IV	7	5
T3 N0 M1	1	
T1 N1 M1	1	
T2 N1 M1	4	
T2 N2 M1	1	

Six patients with metastases of extrathoracic malignant tumors and 1 patient with Tis N0 M0 are not listed.

(38%) patients had a cardiovascular risk factor (ie, cardiac insufficiency or arrhythmia, coronary disease, myocardial infarction, chronic cerebral occlusive disease, or stroke). Sixty-seven (47%) events (ie, deaths) occurred, and 77 (53%) patients were censored.

Preoperative staging included chest radiography, computed tomography of the chest and upper abdomen, bronchoscopy, and upper abdominal ultrasonography; computed tomography of the cerebrum and bone scintigraphy were done in selected cases.

Operative procedure. Bronchoplastic procedures consisted of 111 lobectomies (right upper lobe, n = 69; right middle lobe, n = 1; right lower lobe, n = 4; left upper lobe, n = 26; and left lower lobe, n = 11), 17 bilobectomies (upper, n = 12; lower, n = 5), 4 right upper lobectomies with carinal resection, 8 sleeve pneumonectomies, and 4 bronchoplastic procedures without parenchymal resection (wedge resection of the apical segmental bronchus of the right lower lobe, resection of the right upper lobe bronchus, resection of the stump of the left upper lobe bronchus, and resection of the left upper lobe carina and the proximal segment of the lower lobe bronchus). The procedures were performed on the right side in 103 (72%) patients and on the left side in 41 (28%) patients. Resection of the right upper lobe was the most common procedure and was performed in 72 (63%) of 115 resections of single lobes.

Type of resection. In 116 (81%) patients a full sleeve resection was performed, and in 28 (19%) patients an incomplete sleeve or wedge bronchoplasty was performed.

Additional angioplasty was performed in 23 (16%) patients, including angioplasty of the pulmonary artery in 19 patients (7 circular resections with end-to-end anastomoses and 12 tangential resections), 3 angioplasties of the superior caval vein (1 tube graft replacement and 2 tangential resections), and 1 local resection with patch angioplasty of the aorta. Five (3.5%) patients had en bloc resection of the thoracic wall and sleeve lobectomy, and 8 (5.6%) patients had an additional wedge resection of the remaining lobe. For extended resections, cardiopulmonary bypass was used in 3 cases (right-sided pneumonectomy with resection of the carina and superior caval vein, left-sided pneumonectomy with wedge resection of the trachea and aorta, or left-sided pneumonectomy with resection of the carina and the right main bronchus).

Histology. Indications for operation were non-small cell lung cancer (NSCLC; n = 123), small cell lung cancer (n = 5), carcinoid tumor (n = 10), and metastases of extrathoracic malignant tumors (n = 6; hypernephroid carcinoma in 4 cases and breast and endometrial carcinoma in 1 case each).

Radicality of resection. Resections with completely tumor-free bronchial resection margins were defined as complete resections and were achieved in 130 (90.3%) patients. In 14 (9.7%) patients incomplete resections with histologically residual tumor were performed. No patient had visible residual tumor at the bronchial resection margins.

Staging. The TNM classification is given in Table I in accordance with the most recent International Union Against Cancer (UICC) classification.⁶ Five patients with stage IV disease had cerebral metastases that had been resected before the lung operation, and 2 patients had single metastases in another lobe. One male patient had carcinoma in situ (stage 0).

According to the type of operation, the general characteristics of patients are listed in Table II. Follow-up of patients was completed in February 1999.

Statistical methods. To explore the influence of 10 risk factors on survival, we estimated a multivariable Cox regression model by using a stepwise variable selection procedure with the SAS procedure PHREG (SAS Institute, Inc, Cary, NC).⁷ The risk factors, as well as their mathematical terms and coding, are listed in Table III. One of the factors investigated is tumor stage. No TNM stage is assigned to 6 patients with metastases of extrathoracic malignant disease; they are included in the multivariable analysis by means of informative imputation. These patients are assigned a TNM stage value of 6, and this group is identified by its own dichotomous variable (Table III).

The probabilities for inclusion and exclusion of risk factors are chosen to equal .05. The Wald χ^2 test was used to test individual regression parameters. Ninety-five percent confidence intervals (CIs) for relative risk are given as appropriate. In addition, univariable analyses were performed to obtain survival curves according to the Kaplan-Meier estimate.⁸ The log-rank test was used to assess the difference in survival curves (SAS LIFETEST). For rejection of a null hypothesis, a P value less than .05 is considered statistically significant. Baseline values are given as means $\pm$ SD.

Table II. Characteristics of patients by bronchoplastic procedure ($n = 144$)

Surgical procedure	Bronchotomy	Lobectomy	Bilobectomy	Pneumonectomy
No. of patients	4	115	17	8
Age, y (mean $\pm$ SD)	47 $\pm$ 21	60 $\pm$ 10	63 $\pm$ 8	56 $\pm$ 11
Sex, M (%)	2 (50)	84 (73)	17 (100)	7 (88)
Angioplasty, yes (%)	0	18 (16)	2 (12)	3 (38)
TNM stage (%)				
I	3 (100)	39 (36)	2 (12)	0
II	0	33 (31)	10 (59)	1 (13)
IIIA	0	26 (24)	4 (23)	2 (25)
IIIB	0	5 (5)	0	5 (63)
IV	0	6 (6)	1 (6)	0
Histology (%)				
NSCLC	1 (25)	97 (84)	17 (100)	8 (100)
SCLC	0	5 (4)	0	0
Carcinoid	2 (50)	8 (7)	0	0
Metastasis	1 (25)	5 (4)	0	0
Complete resection (%)	4 (100)	106 (92)	16 (94)	4 (50)
Respiratory risk (%)	0	34 (30)	6 (35)	3 (38)
Cardiovascular risk (%)	0	45 (39)	8 (47)	2 (25)
Adjuvant therapy (%)				
None	4 (100)	62 (54)	12 (71)	3 (38)
Chemotherapy	0	28 (24)	2 (12)	0
Radiotherapy	0	15 (13)	3 (18)	4 (50)
Both	0	10 (9)	0	1 (13)

SCLC, Small cell lung cancer.

Table III. Risk factors (covariables) for survival investigated in the multivariable analysis of bronchoplastic procedures (1991-1997; $n = 144$)

Risk factor	Kind of variable	Terms	Code	Description
Age (at time of operation)	Numerical	Linear	Number	Years
Sex	Class	—	0,1	Male, female
Type of surgical procedure	Numerical	Linear + quadratic	0,1,2,3	Bronchotomy, lobectomy, bilobectomy, pneumonectomy
Angioplastic procedure	Class	—	0,1	Yes, no
TNM stage	Numerical	Linear + quadratic + cubic	0,1,2,3,4,5,6	0, I, II, IIIA, IIIB, IV, missing*
Histology	Class	—	1,2,3,4	NSCLC, SCLC, carcinoid, metastases*
Radicality of resection	Class	—	0,1	Complete, incomplete
Respiratory risk	Class	—	0,1	Yes, no
Cardiovascular risk	Class	—	0,1	Yes, no
Adjuvant therapy†	Class	—	0,1,2,3	Radiotherapy, chemotherapy, both, none

*Metastases of extrathoracic malignant tumors.

†Including 5 cases of neoadjuvant therapy.

Results

Univariable survival analysis. Overall median follow-up for all patients was 21 months (1 day–83 months). Median follow-up for patients alive is 27.5 months (0.5-83 months). Seventeen (12%) patients were followed up for less than 14 months. Median survival of the patients who died was 7.9 months (1 day–63 months). Overall survival is given in Fig 1.

Factors affecting survival. According to stage, 1-year survival was 86% in stage I (CI, 75%-96%), 77%

in stage II (CI, 64%-89%), 68% in stage IIIA (CI, 52%-84%), 30% in stage IIIB (CI, 2%-58%), and 29% in stage IV (CI, 0-62%). Three-year survival was 70% (CI, 54%-85%), 56% (CI, 39%-73%), and 42% (CI, 24%-60%) for stage I, II, and IIIA disease, respectively ($P = .003$ for all stages). There was a clear difference between stage I, II, and IIIA disease and stage IIIB and IV disease ($P = .0002$). Differences between stage I, II, and IIIA disease were not significant ($P = .29$), and

Fig 1. Overall survival after bronchoplastic operation (1991-1997; $n = 144$). Dashed lines and values in brackets present the 95% CIs for the 1-, 3-, and 5-year survivals.

there was also no difference between stage IIIB and IV disease ($P = .36$). The survival curve for stage IV disease lies above the curve for stage IIIB disease. In stage IIIB disease 2 patients are alive 2.8 and 5.1 years postoperatively; in stage IV disease 2 patients are alive at 1.1 and 2.6 years, respectively (Fig 2).

Survival between T stages differed significantly (Fig 3). For T1 to T4, 1-year survival was 95% (CI, 88%-100%), 69% (CI, 58%-79%), 54% (CI, 27%-81%), and 30% (CI, 2%-58%), respectively. For T1 to T3, 3-year survival was 72% (CI, 54%-91%), 47% (CI, 34%-61%), and 34% (CI, 5%-62%), respectively.

Fig 4 demonstrates survival by operative procedure. Bilobectomies tended to have poorer results than lobectomies within 3 years postoperatively; sleeve pneumonectomies had a 1-year survival of 25% (CI, 0%-55%). Regarding surgical techniques, the 1-year survival of patients with wedge bronchoplasties, full sleeve resections, and sleeve pneumonectomies was 82%, 73%, and 25%, and 3-year survival was 66%, 50%, and 13%, respectively ($P = .01$).

Patients with poor lung function survived for significantly shorter periods than patients without respiratory risk (Fig 5), as did patients with a cardiovascular risk factor (Fig 6).

The remaining factors tended to exert some influence on survival but exhibited no statistical significance. Survival according to nodal status demonstrated 1-year survivals of 80% for N0 (CI, 68%-91%), 71% for N1 (CI, 59%-83%), and 59% for N2 (CI, 41%-77%) and 3-year survivals of 63% (CI, 48%-78%), 53% (CI, 38%-68%), and 36% (CI, 18%-54%), respectively ($P = .2$). Concerning histology, patients with carcinoids seemed to have a better prognosis than patients with NSCLC

Fig 2. Survival after bronchoplastic surgery according to TNM stage ($n = 137$; metastases of extrathoracic malignancies and carcinoma in situ excluded). For 95% CIs, see text.

($P = .2$). Highly differentiated tumors had increased survival in contrast to undifferentiated tumors ($P = .1$). Additional angioplasty tended to influence survival adversely ($P = .2$). Adjuvant therapy also had no significant effect ($P = .2$). No influence was found for the variables of sex, surgeon, hospital, and radicality of resection.

Postoperative mortality and complications.

Overall 30-day mortality was 8.3% (12/144). The causes of death are listed in Table IV. Five patients died within 1 week, resulting in a 7-day mortality of 3.5% (5/144). For single sleeve lobectomies, 30-day mortality was 5.4% (6/136). Including bilobectomies, 30-day mortality was 6.2% (8/128).

Other fatal complications within 3 months and beyond 30 days are shown in Table V. Anastomotic dehiscence occurred in 3 (2.8%) patients who died after completion pneumonectomy (1 patient had empyema), 1 further patient had partial anastomotic necrosis but died of massive pulmonary embolism, and 1 patient with partial necrosis was managed conservatively by means of tube drainage. Thus, the overall anastomotic complication rate was 3.5% (5/144).

Major and minor morbidity. Nonfatal complications were managed conservatively in most cases. Patients with hemothorax required rethoracotomy, and the patient with adhesion ileus underwent laparotomy on the second postoperative day (Table V).

Recurrence and metastases. In 52 (36%) of 144 patients, local recurrence or distant metastases occurred. Thirty-seven patients died with disease, accounting for 56% (37/66) of all deaths.

Multivariable analysis. The model selection procedure includes the variables of TNM stage, type of bron-

Fig 3. Survival after bronchoplastic operation according to T status (n = 137; metastases of extrathoracic malignancies and carcinoma in situ excluded). For 95% CIs, see text.

Fig 4. Survival according to type of bronchoplastic procedure (n = 140; bronchotomies excluded). The 95% CIs are given in brackets.

choplastic procedure, and respiratory and cardiovascular risk factors. Table VI summarizes their estimated risk ratios (relative risks) of the Cox proportional hazard model, CIs, and *P* values of the Wald test. The hazard of patients with cardiovascular risk, for instance, is estimated to be 104% (CI, 22%-239%) above the hazard of patients without this risk. The hazard of patients with respiratory risk is estimated to be 126% (CI, 39%-268%) above the hazard of patients without such risk. Besides the results of multivariable analysis, Table VI gives the estimates and *P* values of univariable Cox regression analyses, which confirm the results of multivariable analysis.

The data provide no evidence for an additional influence of age, sex, nodal status, histology, radicality of

Fig 5. Survival after bronchoplastic operation according to preoperative respiratory risk (n = 144). Respiratory risk is defined as FEV₁ of less than 60% predicted and no respiratory risk as FEV₁ of 60% or greater. The 95% CIs are given in brackets.

Fig 6. Survival after bronchoplastic operation according to preoperative cardiovascular risk (n = 144). The 95% CIs are given in brackets.

resection, performance of angioplasty, and adjuvant therapy. The data, however, do show a strong dependence between age and respiratory and cardiovascular risk factors. Hence, the role of age as a risk factor may be covered and therefore concealed by these covariables. Histology as a risk factor is assumed to be covered by stronger factors as well. Moreover, the strong imbalance of sample sizes over different histologic types makes it difficult to distinguish between the histologic groups.

Discussion

Bronchial sleeve resection, first performed in the 1950s, has now evolved into a procedure of choice for patients with compromised lung function to avoid pneumonectomy with a curative or palliative intent.

Table IV. *Mortality within 3 months after bronchoplastic operation*

	No.
Cause of death <1 mo	
Cardiac failure-myocardial infarction	3
Pulmonary embolism	2
Sepsis after pneumonia	3
Hepatorenal failure	1
Stroke	1
Mesenteric infarction	1
Gastrointestinal bleeding	1
Cause of death <3 mo	
Anastomotic dehiscence	3
Septic multiorgan failure caused by pneumonia	2
Respiratory failure	1

Sleeve resections may also be performed in patients with good pulmonary function, achieving results as good as those achieved with pneumonectomy.^{2,8,10} Many studies deal with univariate analyses of sleeve resections in malignant and nonmalignant disease; multivariable analyses were only applied in a few studies.^{4,5}

We performed a multivariable analysis to determine putative prognostic factors of survival in a consecutive series of sleeve resections, including carinal resections, as did Watanabe and colleagues.¹¹ Like other series in the literature, this number is not very large, and therefore conclusions derived from a multivariable model must be approached with caution. From 9 investigated risk factors, 4 independent factors were entered into the analysis: TNM stage, type of surgical procedure (ie, sleeve lobectomy, sleeve bilobectomy, and sleeve pneumonectomy), and cardiovascular and respiratory risks. From a statistical point of view, this result does not mean that other factors have no influence; they may be concealed by stronger factors. It must also be taken into account that coding of the variables as done by statisticians may influence the outcome. In contrast to the long-term results of Van Schil and colleague's multivariate analysis⁴ with a minimum follow-up of 5 years for surviving patients, our results are based on a median follow-up period of 27 months for surviving patients and a median survival of 7.9 months for those who died. Thus, the number of patients at risk is small at the 3-year follow-up; we did not generally mention 5-year survivals. These small numbers might also be the reason that survival of patients with N2 disease tends to be worse but does not achieve statistical significance (3-year survival of 36% in N2 versus 63% in N0). In those series that were followed up for a longer period, however, nodal status is an important

Table V. *Causes of major-minor morbidity after bronchoplastic surgery*

Complication	No.
Empyema	2
Hemothorax (rethoracotomy)	3
Adhesion ileus	1
Delirium tremens	2
Pneumonia	9
Parenchymal leakage (>7 d)	7
Atelectasis	3
Cardiac arrhythmia	2
Gastrointestinal bleeding	2
Antibiotic colitis	2
Renal insufficiency	2
Nonpulmonary infection	1
Wound infection	1

prognostic factor.^{3,4} Our results correspond to the series of Rendina and colleagues,¹² who reported a 2-year survival of 72% for lung cancer (about 65% in our series) and favorable results in patients with benign lesions, with the latter being alive 8 months to 3 years after the operation. With the exception of 1 patient who died of cerebral aneurysm, all our patients with carcinoid tumors are alive.

In contrast to Van Schil and colleagues,⁴ we included patients with incomplete sleeve resections, so-called wedge resections described by Khargi and colleagues,¹³ and sleeve pneumonectomies to summarize our total experience with bronchoplastic procedures. Survival of total and partial bronchial resections of lobes did not significantly differ, although wedge resections tended to do better. The decision to perform a partial or total sleeve resection depended on the extent of bronchial infiltration by the tumor or lymph nodes but was also influenced by the decision of the individual surgeon. It must be considered that this 2-center study comprises the experience of a total of 8 main surgeons. The 30-day mortality of 5.4% for lobar sleeve resections lies within the range given in the literature.

In T4 tumors with carinal or tracheal invasion, however, 5-year survival may be as high as 20% but is significantly worsened by N2 disease.¹⁴ Therefore, most authors do not advocate resection in these cases. However, we accept bronchoplasties with palliative intent in cases with N2 disease or distant metastases (eg, single brain lesions, which are amenable to surgical resection). Because the 1-year survival is as high as 25% for sleeve pneumonectomies in our series, we strongly recommend that the indication for this type of operation be established with great caution, consider-

Table VI. Results of multivariable and univariable analyses for survival in 144 bronchoplastic procedures

Risk factor	Multivariable analysis			Univariable analysis	
	Hazard risk	95% CI*	P value	Hazard risk	P value
TNM stage	1.23	1.02–1.48	.0307	1.07	.0003
Surgical procedure	1.16	1.05–1.29	.0033	1.16	.0037
Cardiovascular risk	2.04	1.22–3.39	.0062	1.75	.0258
Respiratory risk	2.26	1.39–3.68	.0010	2.11	.0025

*CI, Confidence interval.

ing the patient's general condition and cardiorespiratory risk factors. Because some long-term survivors have been reported in literature,^{5,11} operation may be considered in the individual case despite the poor prognosis. Our series of 8 sleeve pneumonectomies included a midterm survivor who was alive at 6.7 months after the operation.

Because comorbidity has significant influence on survival, patients chosen to undergo bronchoplastic operations should be selected with caution. This concurs with the conclusions of Tedder and colleagues⁹ on the basis of a review of 1915 patients with bronchoplastic resections. Especially patients with cardiovascular risk factors, as well as those with impaired pulmonary function, require a careful preoperative evaluation. In these patients mediastinoscopy is strongly indicated to exclude those with mediastinal disease.

We thank Gerhard Dekan, Department of Pathology, University of Vienna, for cooperation.

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Discussion

Dr Thomas R. J. Todd (Toronto, Ontario, Canada). It is a privilege to be asked to be the formal discussant for this not small series of bronchoplastic procedures. My comments are made on my review of the abstract, because Dr End's unfortunate inability to attend this meeting precluded my reviewing the manuscript. I believe my comments are germane nonetheless.

The first issue, of course, is survival. Two articles have appeared within the last couple of years concerning the survival of patients with bronchogenic carcinoma after sleeve resections. I want to draw your attention to the fact that survival is related to nodal status, which is not surprising at all. Yet in the authors' article today, survival did not appear to be related to nodal status, and I would like you to comment as to why you think that might be the case. Your first slide did say that there were some 31 patients with N2 disease. Therefore, I am surprised that survival was not related to N2 disease.

I think the bigger issue in this article is the mortality, which you reported as 8%. However, your abstract also says that 4 deaths occurred beyond the 30-day limit as a result of anastomotic problems. If I add those in, I get a mortality of 11% and not 8%. However, even 8% is still high. Indeed, the highest mortality, 5%, is the one from my own center reported in 1979 by Dr Weisel. Why was the mortality in your series so high? Weisel's article pointed out that there were several ways that we could stratify the type of patients coming to operation. Indeed, it was 5% for those patients in whom the

sleeve lobectomy was undertaken because the surgeon believed it was the best operation for that patient. However, in a separate group of patients in that article, in whom sleeve lobectomy was done as a compromise procedure because of concern that the patient would not tolerate a pneumonectomy even though a pneumonectomy was thought to be indicated, the mortality was actually 22%.

As I look through your article, I note that 21 patients had an angioplasty, 31 patients had N2 disease, and 5 patients had chest wall resections. Therefore, I have to wonder whether the mortalities were related to compromised cardiopulmonary function or to the presence of N2 disease. With N2 disease, of course, you may be devascularizing a portion of the bronchus as you do your complete nodal dissection. Therefore, my question for you is simply this: How many of those 16 deaths were in the group of patients who had compromised cardiopulmonary function or who had N2 disease?

Dr Wolner. I apologize that you did not get the manuscript.

The overall mortality of the whole group, including this fatal second operation, was 8%. Of the 8 patients in the sleeve lobectomy group, 2 underwent pulmonary embolism and 1 underwent myocardial infarction. Perhaps a larger series will then bring other results, but what is true is this 5.8% mortality among patients with the sleeve lobectomy. I think that we had with this 60% cardiovascular risk and 60% respiratory risk a group of patients with a higher risk generally in pulmonary resection, and this could be my explanation.

Also surprising for us was the fact that these patients with N2 disease were not so very different from the patients with N0 or N1 disease. Perhaps this has something to do with the low number of these patients after 5 years. It has also something to do, I hope, with the extended lymph node dissection and all of the radiotherapy and chemotherapy after the operation. That would be my explanation for this unexpected result of our multivariate and univariate analysis.

Dr Todd. Do you know what the mortality was within the group of 21 patients who had angioplasty as well as sleeve resection?

Dr Wolner. No. However, in the long-term survival, angioplasty has no influence. Therefore, I must speculate that there was no difference.

Dr Steven J. Mentzer (*Boston, Mass*). Did you have any data on local recurrence, that is, on the pattern of failure? In addition, the abstract mentions dehiscence after 30 days. This seems like a long time after the initial reconstruction. What were the causes of the dehiscence?

Dr Wolner. No, we have no dehiscence.

Dr Mentzer. Did you have any local recurrences?

Dr Wolner. Yes. Of the 50 patients who died, 60% died of local or distant disease, and 40% died of different reasons.

Dr Douglas E. Wood (*Seattle, Wash*). I agree with Dr Todd's points about the relationship to nodal disease and angioplastic procedures, which is contradictory to several other articles regarding sleeve resections. However, I am going to restrict my questions and comments to the carinal pneumonectomies. This is clearly a very difficult group of patients, and in very experienced hands they have a mortality

of approximately 15%, ranging up to 30% at best. In your series I believe it was 50%, which I think gives us all just about when to consider carinal pneumonectomy as an extended resection for NSCLC.

I want to go back to your point that 2 of your patients required cardiopulmonary bypass. My adage that I give to the residents is that in bronchoplastic procedures, including carinal pneumonectomies, most of them are straightforward enough that they do not require cardiopulmonary bypass, and if they are enormously complicated, then cardiopulmonary bypass is contraindicated. Therefore, we always come up with some routine to manage to do the operations off-pump. Did the 2 patients who had cardiopulmonary bypass undergo carinal resections, and did they die in the postoperative period? I think that would be useful to know and potentially provide experience in favor of or against cardiopulmonary bypass to support of bronchoplastic procedures.

Dr Wolner. First, let me start my answer by saying that we are a department of cardiothoracic surgery and we do about 1300 heart operations per year besides these 700 different general thoracic procedures. Therefore, in general I am sure we are more liberal in using cardiopulmonary bypass if it seems to be necessary. However, these patients are not among those who died. One patient who died had an infiltration in the aorta and a piece of the aorta was replaced. The other patients were in severe trouble on admission because of bleeding at the junction of the superior vena cava and the innominate vein. Fortunately, this situation is rare in cardiac operations, but it is very difficult to treat. This was the second case with the heart-lung machine. Therefore, cardiopulmonary bypass was used in 2 of these 3 patients because of catastrophic vascular problems during the operation.

Dr Wood. Neither one died?

Dr Wolner. No.

Dr David J. Sugarbaker (*Boston, Mass*). I have two comments. At the Brigham Hospital, any patient who would be considered for carinal pneumonectomy would undergo a mediastinoscopy, and if N2 disease was determined to be present, that patient would be ruled out for routine carinal pneumonectomy outside of some specific protocol or clinical trial. My first question to you is this: Because in your particular abstract N2 disease was indeed a poor predictor of survival, what is the role of mediastinoscopy for any patient whom one might consider for carinal pneumonectomy? Second, what is your technique in terms of using a parathymic-pericardial fat pad or other buttress of your bronchoplastic suture line?

Dr Wolner. With regard to the first question, usually we try to obtain complete staging of the disease in all of our patients. As you know, in the last year there has been some change in staging with the computed tomographic scan, but I cannot tell you what the percentage is or how many mediastinoscopies were done. In general, when we have a suspicion that there is N2 disease on the basis of the computed tomographic scan, the x-ray film, and so on, a mediastinoscopy or a thoracoscopy will be performed.

To answer the second question, we use polydioxanone sutures (PDS-40; Ethicon, Inc, Somerville, NJ) and in some

cases, but not all, we use intercostal flaps or pericardial flaps and fibrin glue.

Dr Douglas J. Mathisen (*Boston, Mass*). Could you please describe the technique you use to do bronchoplasty? Is it open, interrupted, or running?

Second, a number of your patients had bilobectomies and bronchoplastic procedures. In that group did you notice any size discrepancy, and if you did find size discrepancy, could you share with us how you dealt with that problem?

Dr Wolner. This is from two hospitals, and the majority of the anastomoses were done with a polydioxanone running suture, but I cannot tell you how many. There were some with a single-stitch technique. If there is a size discrepancy, we use the usual technique with a longitudinal incision, which I use in vascular operations, to bring together the two stumps.

Dr L. Penfield Faber (*Chicago, Ill*). Quoting from the abstract, "The presence of cardiac risk factors, chronic obstructive disease, N2 disease, R1 resection, performance of sleeve pneumonectomy with a 50% mortality had an adverse influence on survival." With these points in mind, I would appreciate your telling us what your absolute contraindications are for bronchoplastic procedures.

Dr Wolner. That is a very good question. I would say my personal feeling is that if you have a patient who is under 70 years with a bronchial carcinoma and no distant metastases who seems, from your staging, to be a candidate for resection, then I am more in favor of resection. Also, there was this discussion before of brain metastasis and N1 disease and whether we should resect. My personal attitude for many years in such cases is to be more on the side of the operation. It is clear that if you have distant metastases, pleural involvement, or diseased lymph nodes outside of the mediastinum (contralateral), then you have contraindications. Those are the typical indications for chemotherapy and radiotherapy.

Dr Todd. I will just make one other technical comment. Somebody did bring up the role of mediastinoscopy before doing sleeve pneumonectomy. Coming from a place where mediastinoscopy is really quite routine, the one lesson we have learned is that if we are contemplating from the endobronchial appearance that we are going to need to do a sleeve pneumonectomy, that is the one time when I really do want to do the mediastinoscopy at the same time as the procedure. If you do it before the procedure and then go back, it is a little harder to pull that trachea down to get your anastomosis done without tension.

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