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Evaluation of Pulmonary Artery Angioplasty for Lung Cancer Surgery: A Comparison with Pneumonectomy

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Abstract

We performed pulmonary artery angioplasty in 19 patients with lung cancer. The procedure consists of segmental or wedge resection of the infiltrated pulmonary artery stem followed by reconstruction to avoid pneumonectomy and preserve pulmonary function. Among these cases "double sleeve resection" was performed in 10 cases. The 5-year survival of the angioplasty patients was poor at a rate of 11%, but not significantly different from the survival rates for those patients who underwent bronchoplasmy alone or pneumonectomy. A promising prognosis may be expected in cases with N0 and N1 lymph node metastasis. However, this procedure may not replace pneumonectomy in patients with intact pulmonary function.

KEYWORDS: lung cancer, surgery, vascular invasion, bronchoplasmy

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We performed pulmonary artery angioplasty in 19 patients with lung cancer. The procedure consists of segmental or wedge resection of the infiltrated pulmonary artery stem followed by reconstruction to avoid pneumonectomy and preserve pulmonary function. Among these cases "double sleeve resection" was performed in 10 cases. The 5-year survival of the angioplasty patients was poor at a rate of 11%, but not significantly different from the survival rates for those patients who underwent bronchoplasty alone or pneumonectomy. A promising prognosis may be expected in cases with N0 and N1 lymph node metastasis. However, this procedure may not replace pneumonectomy in patients with intact pulmonary function.

Key words : lung cancer, surgery, vascular invasion, bronchoplasty

Bronchoplastic surgery is a well established and widely performed procedure for lung cancer (1, 2). A similar procedure can be applied for the pulmonary artery stem to avoid pneumonectomy and preserve pulmonary function in cases in which the tumor infiltrates into the artery stem. This angioplastic procedure consists of segmental or wedge resection of the infiltrated pulmonary artery stem followed by reconstruction. We have performed the procedure in 19 cases of lung cancer resection within the past 10 years. The results of this procedure were evaluated comparing with pneumonectomy.

formed on 19 of the 754 lung cancer surgery cases that were conducted by our department between January, 1981 and December, 1990. Bronchoplasty was also performed on 13 of the 19. We evaluated this procedure in terms of postoperative staging, presence of infiltration into the pulmonary artery intima, angioplasty method, and degree of lymph node metastasis in the PA-plasty cases. Postoperative pulmonary function and prognosis of the PA-plasty cases were compared with those of pneumonectomy cases which served as the control. Survival curves were calculated using the Kaplan-Meier method. Statistical analysis was performed using the Student's *t*-test or generalized Wilcoxon method.

Results

The cases of PA-plasty consisted of 18 men and 1 woman, whose ages ranged from 37 to 79 years with a mean of 63 years. The procedures were performed on the left lung in 13 cases and

Subjects and Methods

Pulmonary artery angioplasty (PA-plasty) was per-

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on the right lung in 6 cases. The procedures used to reconstruct the pulmonary artery were: segmental resection with end-to-end anastomosis in 10 cases (double sleeve resection), wedge resection and suture closure in 8 cases and fenestration with reconstruction by patch in 1 case. The histological types were squamous cell carcinoma in 14 cases, adenocarcinoma in 3 cases, adenosquamous cell carcinoma in 1 case, and small cell carcinoma in 1 case. Postoperative TNM staging was stage I, 3 cases; stage II, 2 cases; stage IIIA, 9 cases; stage IIIB, 3 cases; and stage IV, 2 cases. In most of the cases cancers were advanced and 14 cases (73.6 %) were diagnosed as stage III or more severe.

The 5-year survival was poor at a rate of 11 % in the PA-plasty cases. This survival rate was lower than the values for 70 pneumonectomy cases (23 %) and 50 bronchoplasty cases (33 %) chosen at random without any biases. However, the differences among the surgical procedures were not significant (Fig. 1). The 5-year survival rate for the stage I + stage II group was 53 %, and the patient with the longest postoperative survival in the stage III group died from recur-

rence 4 years and 3 months after the operation. The difference between the groups was not significant (Fig. 2). When grouped according to the degree of lymph node metastasis, the 5-year survival rate of the N0 + N1 group was 53 %. In contrast, no patients survived for 5 years in the N2 group, and the difference between the N0 + N1 group and the N2 group was significant (Fig. 3). Survival rates based on the presence of histological infiltration into the pulmonary artery intima are less contrastive. The 5-year survival rate for cases in which there was no infiltration was 18 %. No patients survived for 5 years among the cases in which there was infiltration, however, the difference was not significant in comparison with the cases without infiltration.

Postoperative pulmonary functions of the PA-plasty cases were compared to those of 20 lobectomy cases and 10 pneumonectomy cases which were approximately matched in age, sex, and pathological stage. Preoperative pulmonary function test results were normalized to 100 in order to evaluate postoperative pulmonary function. The postoperative percent forced vital capacity (%FVC) for the lobectomy, PA-plasty

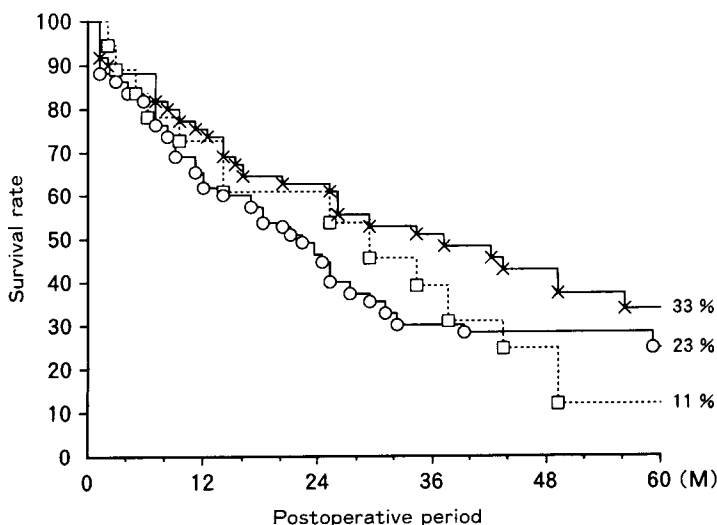


Fig. 1 Survival curves for pulmonary artery angioplasty (PA-plasty), pneumonectomy, and bronchoplasty. There is no statistical difference between the groups. ○—○, Pneumonectomy (n=70); ×—×, Bronchoplasty (n=50); □—□, PA-plasty (n=19).

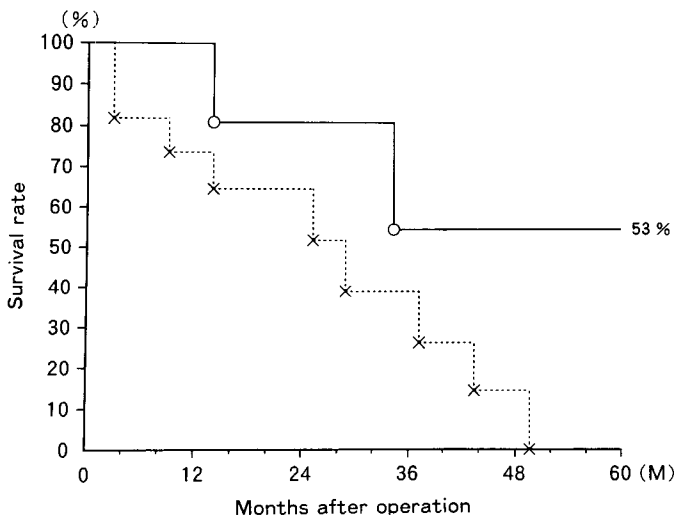


Fig. 2 Survival curves for stage I + II, and stage III angioplasty groups. There is no statistical difference between the groups. $\bigcirc$ — $\bigcirc$, Stage I + II (n=5); $\times$ — $\times$, Stage III (n=12).

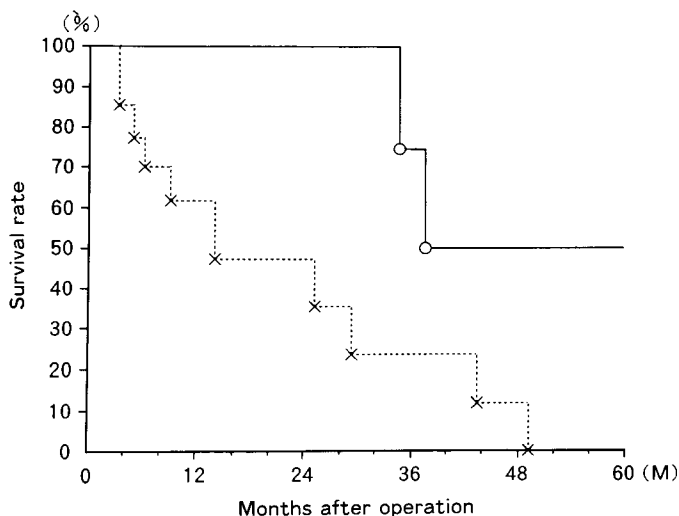


Fig. 3 Survival curves for the N0 + N1 group, and the N2 group. The difference is significant between the groups ($p < 0.05$). $\bigcirc$ — $\bigcirc$, Group N0 + N1 (n=7)*; $\times$ — $\times$, Group N2 (n=12)* (* $P < 0.05$).

and pneumonectomy cases were 73 %, 75 % and 61 %, respectively. The percent forced expiratory volume in 1 sec ratio (FEV_{1%}) for the lobectomy, PA-plasty and pneumonectomy cases were 76 %, 83 % and 66 %, respectively. Percent FVC or percent FEV₁ for the PA-plasty

cases were not significantly better than those for the lobectomy cases, however, they were significantly better than those for the pneumonectomy cases ($p < 0.05$). Postoperative percent FVC ratio for the lobectomy, PA-plasty and pneumonectomy cases were 63 %, 61 % and

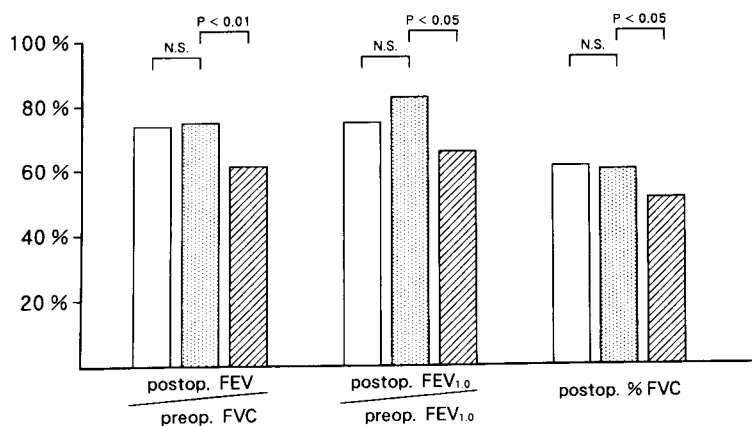


Fig. 4 Ratios of pre- and post-operative respiratory function. FEV; forced expiratory volume, FEV₁; forced expiratory volume one-second, FVC; forced vital capacity, %FVC; percent forced vital capacity. □, Lobectomy (n=20); ▨, PA-plasty (n=10); ▩, Pneumonectomy (n=10).

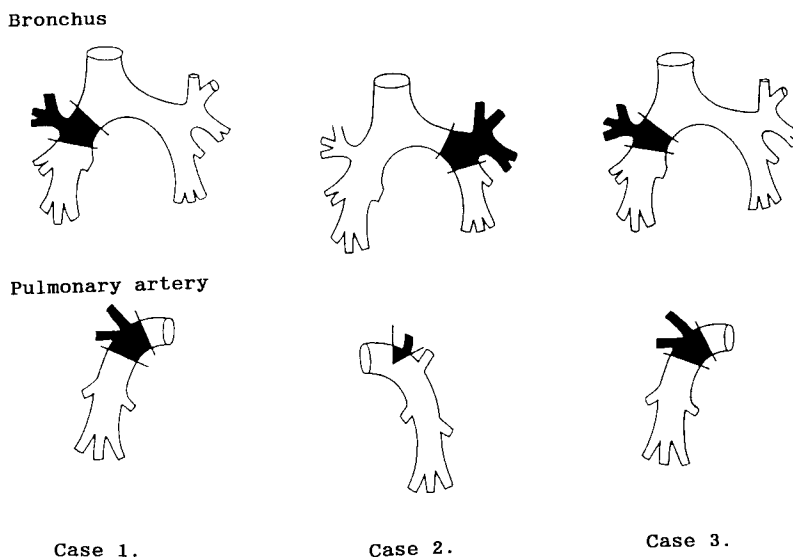


Fig. 5 The operative procedures of Cases 1-3. Case 1 (66-year-old male): procedure indicated due to low pulmonary function. Case 2 (54-year-old male): procedure indicated due to focal infiltration of the pulmonary artery. Case 3 (37-year-old male): procedure for preservation of pulmonary function for adjuvant therapy.

52 %, respectively. Percent FVC for the PA-plasty cases was not significantly different from that for the lobectomy cases, but were significantly better than that for the pneumonectomy cases ($p < 0.01$) (Fig. 4).

Postoperative complications developed in 8 cases; arrhythmia, 3 cases; air leak lasting for more than 7 days caused by a postoperative pleuro-pulmonary fistula, 3 cases; and atelectasis, 2 cases. These complications were not specific for this procedure. No operative deaths, defined as death within 30 days after surgery, occurred. However, one patient died on the 77th day after operation due to empyema resulting from postoperative pneumonia, and another patient died on the 61st day after surgery from respiratory failure resulting from pneumonia which occurred after receiving postoperative chemotherapy using cisplatin.

The three cases for which PA-plasty is indicated are reported in detail below. The operative procedures for these 3 cases are illustrated in Fig. 5

Case 1 (66-year-old man) with low pulmonary function. The patient was diagnosed by fiberoptic bronchoscopy as having squamous cell carcinoma which occluded the right upper lobe bronchus. He had a past history of pleuritis of the left side of the chest when he was 18 years old, and had a very shrunken left thoracic cage (Fig. 6). Preoperative pulmonary function test results were: vital capacity, 2,280 ml; percent FVC, 61 %; FEV₁, 1,610 ml; and percent FEV₁, 71 %; indicating that pneumonectomy of the right lung was impossible. The planned procedure was a sleeve lobectomy of the right upper lobe. However, since operative findings revealed infiltration into the intermediate truncus of the right pulmonary artery, sleeve lobectomy of the upper lobe and segmental resection followed by reconstruction of the pulmonary artery was performed.

Case 2 (54-year-old man) with focal infiltration of the pulmonary artery. The patient was diagnosed as having a squamous cell carcinoma of the left upper main bronchus. Preoper-

ative angiography of the pulmonary artery indicated constriction of the left pulmonary artery at the first ramification (Fig. 7). Infiltration into the base of the first ramification was confirmed during the operation, and wedge resection of the pulmonary artery and sleeve lobectomy of the left upper lobe was performed. The infiltration, determined by histological examination, extended to the pulmonary artery adventitia. The patient remains alive ten years later.

Case 3 (37-year-old man) in which pulmonary function was preserved for adjuvant therapy. This case may have been considered for pneumonectomy based on his pulmonary function, but pneumonectomy of the right lung was avoided in order to conduct sufficient postoperative adjuvant chemotherapy. The patient had a squamous cell carcinoma of the right upper lobe initially staged as T3N2M0 (Figs. 8, 9). He received 2 courses of systemic chemotherapy



Fig. 6 Chest roentgenogram of Case 1. A shrunken left thoracic cage was shown due to old tuberculous pleuritis and the tumor shadow in the right hilum (arrow).

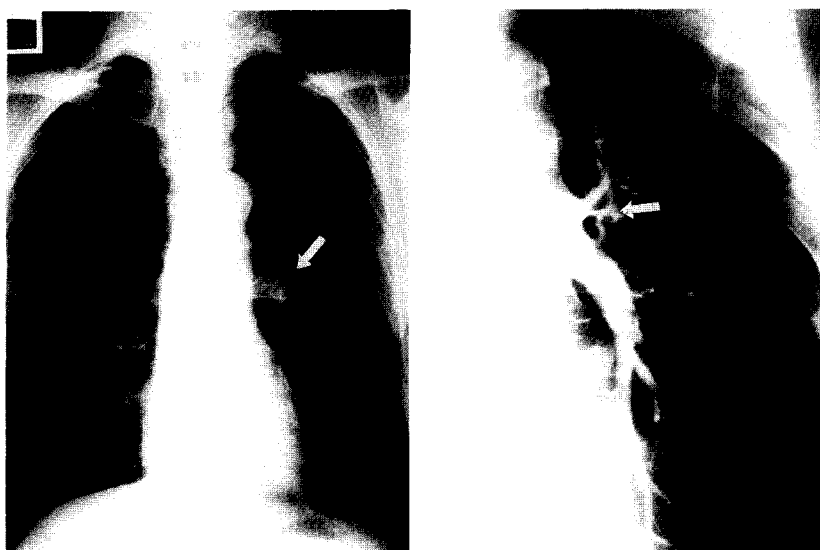


Fig. 7 Chest roentgenograms of Case 2. A (left): Plain chest roentgenogram showed a tumor shadow in the left hilum (arrow). B (right): Pulmonary arteriogram revealed narrowing of the first branch of the left pulmonary artery (arrow).



Fig. 8 Chest roentgenograms of pre (A, left) and post (B, right) neoadjuvant therapy for Case 3. A: The roentgenogram showed a mass in the right upper lobe which infiltrated into the mediastinum. B: The Roentgenogram revealed marked reduction of the mass.

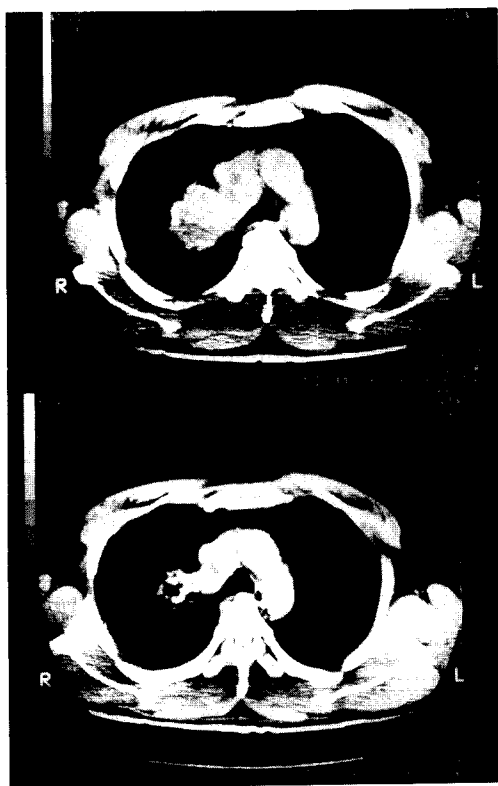


Fig. 9 Computed tomograms of pre (top) and post (bottom) neoadjuvant therapy for Case 3. They revealed marked reduction of the mass which invaded to the mediastinum.

(vindesine 5mg, ifosfamide 2,300mg $\times$ 5 and cisplatin 35mg $\times$ 5) and irradiation (Linac 30 Gray) of the primary tumor and mediastinum as preoperative neoadjuvant therapy. Preoperative adjuvant therapy was extremely effective in this case as the primary tumor and metastatic mediastinal lymph nodes regressed significantly, leading to a staging of T2N2M0 after therapy (Figs. 8, 9). The tumor infiltrated into the right pulmonary artery from the right main bronchus was resected by sleeve resection of the bronchus with the PA-plasty. This allowed one additional course of chemotherapy to be administered postoperatively with sufficient hydration. This patient is able to work without having experienced recurrence two years and six months later.

There are few reports on bronchoplasty preceded by preoperative adjuvant therapy. This case suggests that indications for bronchoplasty and PA-plasty should include the preservation of pulmonary function in order to conduct sufficient postoperative adjuvant therapy.

Discussion

Some hilar lung cancers focally infiltrate into the left or right stem of the pulmonary artery or their main branches directly. Exploratory thoracotomy or non-curative operation is inevitable in these cases when pulmonary function is not sufficient for pneumonectomy. However, by resecting the primary tumor and pulmonary artery infiltration en block and then reconstructing the pulmonary artery, complete curative resection can be performed. Vogt-Moykopf *et al.* (3) state that indications for this procedure are: 1) cases in which the primary tumor in the hilus region directly infiltrates into the pulmonary artery stem and in which the tumor can be resected by segmental resection of the pulmonary artery, 2) peripheral lung cancers in which the hilar lymph nodes infiltrate into the pulmonary artery stem and 3) cases in which only sleeve resection can be performed because of low pulmonary function. They state that there is no relationship with histological type. They recommend procedures for N2 cases that will preserve pulmonary function in order to conduct postoperative chemotherapy and irradiation.

Although our experience comprises only a small number of cases (4), it seems appropriate to include the following cases into the indication for PA-plasty: 1) squamous cell carcinoma cases, 2) cases with infiltration which is localized to the pulmonary artery stem or its ramification, 3) low pulmonary function or of advanced age, and 4) the case that is scheduled to receive postoperative adjuvant therapy sufficient for advanced cancer. Vogt-Moykopf *et al.* (3) preferred to perform pneumonectomy if pulmonary function allows.

Ayabe *et al.* (5), however, suggest that pulmonary artery angioplasty should be the basic procedure if radicality can be obtained even when pulmonary function is intact, and this procedure will allow a better quality of life by preserving pulmonary function. In a study of 86 cases, Vogt-Moykopf *et al.* (3) reported that the outcome of cases receiving PA-plasty was worse than that of cases receiving bronchoplasty alone because the 5-year survival rates for cases receiving PA-plasty with bronchoplasty, PA-plasty alone, and bronchoplasty alone were 14 %, 19 %, and 34 %, respectively. Ayabe *et al.* (5) reported that the 5-year survival rate for PA-plasty cases was 45.7 %, markedly better than the 10.5 % rate for pneumonectomy cases. In our present study, although no significant difference existed between the two, the 5-year survival rate for PA-plasty cases was lower than that for pneumonectomy cases, being 11.3 % and 23 %, respectively. Belli *et al.* (6) reported that among 19 bronchoplasty cases, reconstruction of the pulmonary artery was performed in 6 cases, and that 1 case survived for 51 months without complications. Because the prognosis of PA-plasty is not better than pneumonectomy, the indications for this procedure remain to be clarified. The 5-year survival rate for the N0 + N1 group was 53 % and better than that of the N2 group. Therefore, lung cancer cases having N0 or N1 disease may be considered for PA-plasty as long as radicality can be anticipated. However, most of the lung cancer cases that require PA-plasty are advanced hilar cancers having N2 or N3 disease. It may be anticipated that coordination of different therapeutic measures is necessary in such advanced cases (7).

Fujimura *et al.* (8) reported that postoperative pulmonary function, evaluated by spirometry, of the remaining lung is preserved in patients that received PA-plasty. These were almost the same results described by Brusasco *et al.* (9). Desleuriers *et al.* (10) and Ayabe *et al.* (5) reported that postoperative perfusion scintigraphy results of PA-plasty cases were

significantly better than those of pneumonectomy cases, and did not differ from that of lobectomy cases. In our study, postoperative FVC of the PA-plasty cases was 75 % and FEV₁ was 83 % of their preoperative values. These measurements did not differ significantly from those of the lobectomy cases, indicating that pulmonary function was preserved in the reconstructed lung. Therefore, the PA-plasty procedure is appropriate to preserve pulmonary function.

Reports on studies of neoadjuvant chemotherapy in treatment of lung cancer are gradually increasing (11, 12). Pujol *et al.* (7) recently reported that resection was possible in 20 (61 %) of 33 cases of focally advanced non-small cell carcinoma in their study, and that, histologically, no tumor cells were found in 5 cases. Therefore, some patients may benefit from selecting PA-plasty over pneumonectomy if preoperative and postoperative chemotherapy can improve radicality.

In conclusion we studied 19 cases of resection of lung cancer with PA-plasty. The 5-year survival rate of the angioplasty cases was lower, but not significantly, than those of bronchoplasty and pneumonectomy cases. A promising prognosis may be predicted in N0 or N1 cases that received PA-plasty. PA-plasty may be useful for patients with low pulmonary function, patients of advanced age and patients who receive chemotherapy, because pulmonary function is well preserved. However, this procedure may not replace pneumonectomy in patients with intact pulmonary function.

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