CARDIOTHORACIC TRANSPLANTATION

SUPERIORITY OF END-TO-END VERSUS TELESKOPED BRONCHIAL ANASTOMOSIS IN SINGLE LUNG TRANSPLANTATION FOR PULMONARY EMPHYSEMA

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Objective: To assess the influence of surgical technique (telescoped versus end-to-end anastomosis) on the incidence of bronchial anastomotic complications in patients who underwent single lung transplantation for pulmonary emphysema.

Methods: Seventy-six adult recipients of single lung transplants for pulmonary emphysema were evaluated for the presence of 3 types of major bronchial anastomotic complications: ischemia, dehiscence, and severe stenosis. Surgical technique, clinical course, and mortality were reviewed retrospectively.

Results: The 3 major complications were observed in 11 (34%; ischemia), 8 (25%; dehiscence), and 11 (34%; severe stenosis) of 32 telescoped bronchial anastomoses. In contrast, ischemia, dehiscence, and severe stenosis occurred in only 4 (9%), 1 (2%), and 2 (5%) of 44 end-to-end anastomoses ($P = .0087$, $P = .0034$, and $P = .0012$, respectively). The relative risk of ischemia, dehiscence, and severe stenosis in telescoped anastomoses was 2.1, 2.5, and 2.5, respectively, compared with end-to-end anastomoses. Five (13%) telescoped anastomoses required stent placement as compared with only 2 (5%) end-to-end anastomoses ($P = .1244$). Early postoperative pneumonia was more common in the telescoped anastomosis group (56%) than in the end-to-end group (32%; $P = .0380$). There was a trend toward shorter survival in the telescoped anastomosis group (mean survival 1045 ± 145 days) as compared with the end-to-end group (mean survival 1289 ± 156 days), but these differences did not achieve statistical significance ($P = .2410$).

Conclusions: In patients who underwent single lung transplantation for pulmonary emphysema, telescoped anastomoses were associated with a higher incidence of bronchial anastomotic complications than end-to-end anastomoses. (J Thorac Cardiovasc Surg 2001;121:149-54)

Impaired healing of the bronchial anastomosis threatens successful outcome after lung transplantation.^{1,2} Some centers prefer the traditional end-to-end technique in con-

structing the bronchial anastomosis, whereas others prefer the "increased security" of the telescoped anastomosis.³⁻⁵ Reported rates of bronchial anastomotic complications for these two techniques vary widely between transplant centers.⁴⁻¹³ Other than technical factors, variables that may influence anastomotic healing are preoperative corticosteroid therapy, presence of purulent airway secretions such as in patients with cystic fibrosis, single lung versus bilateral lung transplants, use of cardiopulmonary bypass, postoperative infusion of prostaglandin, degree of reperfusion injury, postoperative cytolytic therapy, and postoperative acute rejection.⁶⁻⁹ Previous study populations have represented a combination of these diverse influences.

To minimize the effect of many of these variables on bronchial anastomotic healing, we selected a relatively

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homogeneous group of patients with pulmonary emphysema who underwent single lung transplantation at our institution. The purpose of the study was to assess the influence of surgical technique on the incidence of bronchial anastomotic complications in this selected population.

Methods

Study population. Eighty-two adult patients underwent single lung transplantation for advanced pulmonary emphysema at our institution between 1990 and 1999. Six (7.3%) transplant recipients died within 30 days after the operation of causes unrelated to bronchial anastomotic healing and were excluded from analysis. The records of the remaining 76 patients were analyzed retrospectively. A bronchoscopic description in 23 patients has been previously reported.¹⁴

Operative technique. Two types of surgical technique were used for construction of bronchial anastomoses. The first (n = 44 patients) was a simple end-to-end anastomosis carried out with running polydioxanone 4-0 suture (PDS; Ethicon, Inc, Somerville, NJ) on the posterior membranous portion of the bronchus followed by interrupted sutures to reapproximate the cartilaginous portion of the bronchus. Neither pericardial nor omental wrapping was routinely used. The second technique (n = 32 patients) was a telescoped anastomosis.³ In this technique, the donor bronchus was invaginated into the recipient bronchus by 1 to 2 cartilaginous rings and then sewn with running sutures posteriorly and interrupted sutures anteriorly. Choice of anastomotic technique was determined by individual surgeon preference. The end-to-end anastomosis was used continuously over the course of the 10-year review. The telescoped anastomosis became more popular in our institution after 1994 because of initial favorable reports in the literature. No bronchial revascularization procedures were used. Cardiopulmonary bypass was not required except briefly (20 minutes) for 1 patient for transient hemodynamic instability.

Therapeutic regimen. Standard immune suppression consisted of prednisone, cyclosporine (INN: ciclosporin), and azathioprine. After 1996, mycophenolate was substituted for azathioprine. Prednisone 1 mg/kg per day was begun immediately after the operation and tapered to 0.1 to 0.15 mg/kg per day by 3 months after the operation. Episodes of rejection were treated with intravenous infusion of methylprednisolone (1 g per day) for 3 days. No patients received perioperative cytolytic therapy. All patients received perioperative antibiotics consisting of vancomycin and aztreonam or gentamicin for 72 hours after the operation. Subsequent antibiotics were adjusted on the basis of operative cultures and clinical course. Prophylaxis against *Pneumocystis carinii* pneumonia was administered to all patients. Antiviral prophylaxis was modified according to the cytomegalovirus (CMV) serologic status of the donor and recipient.¹⁵

Clinical follow-up. After the operation, patients underwent intensive postoperative surveillance in the hospital, followed

by regular, frequent visits in the outpatient department. Complete physical examinations, pulmonary function testing, chest radiography, and blood tests were performed weekly for the first 2 months, biweekly for the next 2 months, and then at monthly intervals thereafter indefinitely. Mean follow-up time for all patients was 2.9 ± 2.4 years (range 0.1-8.8 years). No patient was lost to follow-up.

Bronchoscopic examination. Patients were routinely examined with a fiberoptic bronchoscope in the immediate postoperative period to assess bronchial anastomotic sites and lower airways, as well as to suction respiratory secretions for culture. Bronchoscopic examination was repeated whenever clinically necessary for reinspection of bronchial anastomoses, suctioning of secretions, or clinical-radiographic signs of infection or rejection.¹⁵ In the absence of symptoms or abnormalities on the chest radiograph, surveillance bronchoscopic examination including transbronchial biopsy was performed 3 weeks postoperatively and then every 3 months during the first postoperative year. During the second postoperative year, surveillance bronchoscopy was performed every 4 months and thereafter every 6 months. Bronchoalveolar lavage and transbronchial biopsies were performed according to standard techniques.¹⁵

Diagnostic criteria. For purposes of this study, *anastomotic ischemia* was defined as black, necrotic exudate covering more than 50% of the anastomotic circumference as viewed through the bronchoscope. *Anastomotic dehiscence* was defined as disruption of more than 25% of the circumferential suture line as observed through the bronchoscope. *Severe stenosis* was defined as narrowing of the bronchial lumen to less than 4.9 mm in diameter (the outer diameter of the bronchoscope).

Comparison between bronchial anastomotic groups. Variables applied in statistical analysis were grouped in 5 broad categories:

1. Preoperative donor variables: donor age, sex, race, smoking, Gram stain, HLA type, CMV status
2. Preoperative recipient variables: recipient age, sex, race, preoperative corticosteroids, HLA type, CMV status
3. Preoperative donor-recipient matching: age, sex, race, HLA type, CMV status
4. Intraoperative variables: ischemic time, right lung versus left lung transplant, cardiopulmonary bypass, surgeon
5. Postoperative complications: ischemia-reperfusion injury, postoperative pneumonia, diaphragmatic paralysis, CMV pneumonitis

Ischemia-reperfusion was assessed by hypoxemia (arterial oxygen tension/inspired oxygen fraction) and lung injury scores.¹⁶ The diagnosis of postoperative pneumonia was based on the presence of a new intrathoracic opacity (other than atelectasis) within 30 days after transplantation and (1) culture, serologic, cytologic, or histopathologic evidence of a specific organism or organisms or (2) a clinical course in which pulmonary infection appeared highly likely in association with response to antimicrobial therapy.¹⁵

Statistical methods. Survival statistics were calculated by the method of Kaplan and Meier. Observed proportions were compared by means of the Fisher exact test. Calculated means were compared by the Student *t* test.

Table I. Comparison of preoperative variables between patients receiving telescoped anastomoses versus end-to-end anastomoses

Variable	T anastomoses (n = 32 patients)	EE anastomoses (n = 44 patients)	P value: T vs EE
Mean age (y)	56 ± 8	55 ± 7	NS
Female	20 (63%)	27 (61%)	NS
Right lung transplant	15 (47%)	22 (50%)	NS
Long-term corticosteroid therapy	20 (63%)	26 (59%)	NS

T, Telescoped; EE, end-to-end; NS, not significant.

Results

Comparison of preoperative variables between patients receiving telescoped anastomoses versus end-to-end anastomoses. No significant preoperative differences were observed between the group receiving telescoped anastomoses versus end-to-end anastomoses in any measured variable (Table I). In the telescoped group (n = 32 patients), mean age at the time of the operation was 56 ± 8 years (range 41-67 years). Twenty (63%) transplant recipients were women and 12 (37%) were men. Fifteen patients received a right single lung transplant (47%), and 17 received a left single lung transplant (53%). Twenty (63%) patients were receiving long-term corticosteroid therapy at the time of the operation. In the end-to-end group (n = 44 patients), mean age at the time of the operation was 55 ± 7 years (range 41-64 years). Twenty-seven (61%) transplant recipients were women, and 17 (39%) were men. Twenty-two patients received a right single lung transplant (50%), and 22 received a left single lung transplant (50%). Twenty-six (59%) were receiving long-term corticosteroid therapy.

Bronchial anastomotic complications. The 3 major complications, ischemia, dehiscence, and severe stenosis, were observed in 11 (34%), 8 (25%), and 11 (34%), respectively, of 32 telescoped bronchial anastomoses (Table II; Figs 1 and 2). In contrast, ischemia, dehiscence, and severe stenosis occurred in only 4 (9%), 1 (2%), and 2 (5%) of 44 end-to-end anastomoses, respectively. These differences were statistically significant for the occurrence of all 3 anastomotic complications (see Table II). The relative risk of ischemia, dehiscence, and severe stenosis in telescoped anastomoses was 2.1, 2.5, and 2.5, respectively, compared with end-to-end anastomoses. Five (13%) telescoped anastomoses required stent placement as compared with only 2 (5%) end-to-end anastomoses ($P = .1244$).

Comparison of postoperative variables between patients receiving telescoped anastomoses versus end-to-end anastomoses. No significant postoperative differences existed between the bronchial anastomotic groups with regard to ischemic time or other immediate postoperative variables such as hypoxemia score, lung injury

score, median ventilator days, and median stay in the intensive care unit (Table III). The only difference between the two groups was a higher incidence of postoperative pneumonia in the telescoped anastomosis group (56%) as compared with the end-to-end group (32%) ($P = .0380$). Later events such as CMV pneumonia, time to acute rejection, severity or frequency of acute rejection episodes, and time to chronic rejection were not significantly different between the two groups (Table III).

There was no relation between the side of bronchial anastomosis (right vs left) and the incidence of anastomotic complications. Similarly, there was no relation between doses of preoperative or postoperative corticosteroids and the incidence of anastomotic complications.

Effect of anastomotic complications on survival. Survival tended to be shorter in the telescoped anastomosis group (mean survival 1046 ± 145 days) than in the end-to-end group (mean survival 1289 ± 156 days), but these differences did not achieve statistical significance ($P = .2410$; Table III). Two deaths were directly related to an anastomotic complication. Both patients had locally invasive *Aspergillus* infection at the site of a necrotic telescoped anastomosis, followed in 1 patient by fatal disseminated *Aspergillus* infection. In the second patient, local erosion of the bronchus into an adjacent pulmonary artery caused massive fatal hemoptysis.

Discussion

The results of the present study demonstrate a high incidence of anastomotic complications associated with the telescoping technique in patients who underwent single lung transplantation for pulmonary emphysema. The incidence of bronchial anastomotic complications in the telescoped group (ischemia 34%, dehiscence 25%, severe stenosis 34%) was significantly higher than the incidence of anastomotic complications in the end-to-end group (ischemia 9%, dehiscence 2%, severe stenosis 5%). Other than anastomotic technique, no differences could be identified between the two groups to account for the different rates of bronchial anastomotic complications.

Fig 1. Telescoped right bronchial anastomosis in a 53-year-old man 4 weeks after single lung transplantation for pulmonary emphysema. There was persistent exudate and necrosis of the medial flange (arrow) of the telescoped anastomosis. The patient had recurrent episodes of bacterial pneumonia.

Fig 2. Telescoped right bronchial anastomosis in a 55-year-old woman 3 months after single lung transplantation for emphysema. There was narrowing at the anastomotic site and recurrent pooling of yellow-black secretions (arrow) in the cul de sac formed by the redundant edge of donor bronchus and recipient bronchus. Removal of the accumulated secretions revealed clumps of *Aspergillus* hyphae.

Table II. Incidence of anastomotic complications in 76 patients after single lung transplantation for pulmonary emphysema

Complication	T anastomoses (n = 32 patients)	EE anastomoses (n = 44 patients)	P value (T vs EE)	Relative risk: T vs EE (95% CI)
Ischemia	11 (34%)	4 (9%)	.0087	2.1 (1.3, 3.4)
Dehiscence	8 (25%)	1 (2%)	.0034	2.5 (1.6, 3.7)
Stenosis	11 (34%)	2 (5%)	.0012	2.5 (1.7, 3.9)
Stent	5 (13%)	2 (5%)	.1244	1.8 (1.0, 3.2)

EE, End-to-end; T, telescoped; CI, confidence intervals.

The results of this study are not strictly comparable with previously reported series.³⁻¹³ The earliest reports in the transplant literature described end-to-end anastomoses, usually buttressed with a viable tissue pedicle flap such as omentum.^{4,6} Subsequently, the “telescoped” anastomosis was introduced to provide increased security to the cartilaginous airway and to obviate the need for routine omentopexy.³ After Calhoun and associates³ reported *no* complications with the telescoped anastomosis, several transplant centers switched to this technique and observed fewer anastomotic complications compared with the end-to-end anastomosis.¹⁻⁷ Other centers, however, observed very high rates of stenosis associated with the telescoped anastomosis^{8,9,13} and low rates of complications with the end-to-end anastomosis.^{8,9,11,13} Some of the improvement associated with switching from the end-to-end anastomosis to the telescoped anastomosis may have reflected increased surgical experience and

improved methods of suturing the telescoped anastomosis.^{1,7} Centers that continued to use the end-to-end technique attributed improved results to abandoning the omental wrap^{8,11} or using pericardial or other tissue wrap instead.⁹ The result of all of these studies is a bewildering series of reports in the transplant literature describing widely divergent bronchial anastomotic complication rates ranging from 0% to 48% for telescoped anastomoses^{3,5,9,11} and from 0% to 32% for end-to-end anastomoses.^{4-8,10,11}

Comparison of bronchial anastomotic complication rates between transplant centers is restricted by 3 major limitations. First, no system of classifying airway damage after lung transplantation has been universally accepted.² Two classification systems have been proposed, but neither has gained widespread acceptance.^{2,17} The system of Couraud and associates¹⁷ provides an assessment of early anastomotic healing. The system of Shennib and Massard² was expanded to include late air-

Table III. Comparison of postoperative variables between patients receiving telescoped anastomoses versus end-to-end anastomoses

Variable	T anastomoses (n = 32 patients)	EE anastomoses (n = 44 patients)	P value: T vs EE
Ischemic time (min)	210 ± 49	213 ± 50	NS
Day 1 hypoxemia score	255 ± 100	281 ± 115	NS
Lung injury score	0.9 ± 0.8	0.9 ± 0.7	NS
Median ventilator support (d)	2	2	NS
Median ICU stay (d)	5	5	NS
Median hospital stay (d)	31	29	NS
Postoperative pneumonia	18 (56%)	14 (32%)	.038
CMV pneumonia	12 (38%)	15 (34%)	NS
Mean time to acute rejection (d)	138 ± 27	156 ± 35	NS
Chronic rejection at 3 y (%)	38	26	NS
Mean survival (d)	1045 ± 145	1289 ± 156	.241

T, Telescoped; EE, end-to-end; NS, not significant; ICU, intensive care unit; CMV, cytomegalovirus.

way complications as well. The system used in the present study was far less complex than those described by these 2 classification systems and included only the most severe degrees of ischemia, dehiscence, and stenosis, corresponding to Couraud grade 3 and Shennib grades 4b and 5b.^{2,17} The purpose of including only the most severe degrees of ischemia, dehiscence, and stenosis in the present study was to guarantee inclusion of only clinically significant complications.

Second, the rate of reported bronchial anastomotic complications depends on how vigorously such complications are sought and how uniformly such complications are defined. In the present series, we maintained a high level of vigilance in detecting anastomotic complications by performing routine surveillance bronchoscopic examination in the immediate postoperative period and then 3 weeks after the operation. In addition, we adhered to uniform bronchoscopic criteria to guarantee homogeneous recording of observations and inclusion of only clinically significant endoscopic findings.

Third, bronchial anastomotic healing may be strongly affected by heterogeneity of the transplant population being studied, as well as by differences in preoperative and postoperative variables. Previously published reports combined a mixture of patients with cystic fibrosis and other lung diseases,⁷ single lung and bilateral lung transplants,⁸ patients who did and did not require cardiopulmonary bypass,⁸ and patients who did and did not receive cytolytic therapy.^{4,8} Similarly, many previously published reports did not assess the degree of reperfusion lung injury, postoperative hypoxemia, pneumonia, and acute rejection.

We believe that a large component of the disparity of bronchial anastomotic complication rates between transplant centers relates to lack of uniform diagnostic

criteria, differences in the vigilance of evaluating airways postoperatively, and heterogeneity of study populations. To minimize many of these variables, we selected a relatively homogeneous group of patients with pulmonary emphysema who underwent single lung transplantation. Since this was a retrospective review, however, some degree of heterogeneity still persisted, such as use of preoperative corticosteroids and right versus left lung transplant procedure. Fortunately, data analysis revealed no identifiable preoperative or perioperative differences between the telescoped and the end-to-end anastomosis groups to account for the different rates of bronchial anastomotic complications (Tables I and III).

The only differences between the two groups of bronchial anastomoses were a higher incidence of postoperative pneumonia and a trend toward shorter survival time after lung transplantation in patients who received telescoped anastomoses (Table III). Anastomotic ischemia and dehiscence foster bacterial and fungal overgrowth and restrict clearance of lower respiratory tract secretions² (Fig 1). In the telescoped anastomosis, there is often an obstructing flange of cartilage or nonuniform invagination of the donor bronchus into the wall of the recipient bronchus, which also impairs clearance of secretions⁶ (Fig 2). Severe stenosis further impairs clearance of lower airway secretions.¹¹ Presumably, a combination of these factors contributed to the higher incidence of postoperative pneumonia and possibly to the trend to shorter survival after lung transplantation associated with the telescoped anastomoses. It is possible that postoperative pneumonia may have been the cause rather than the consequence of poor anastomotic healing. However, we do not believe that postoperative pneumonia was more common in the telescoped group as a result of

reperfusion lung injury, graft ischemic time, stay in the intensive care unit, or duration of ventilatory assistance, because these variables were comparable between the two groups (Table III).

The data from the present study support the conclusion that in our institution, telescoped anastomoses were associated with a higher incidence of bronchial anastomotic complications than end-to-end anastomoses in patients who underwent single lung transplantation for pulmonary emphysema. Telescoped anastomoses also had a deleterious effect on postoperative pneumonia and possibly survival. We recommend that each transplant center critically review its own bronchial anastomotic data with these considerations in mind.

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