Native lung volume reduction surgery relieves functional graft compression after single-lung transplantation for chronic obstructive pulmonary disease

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Objective: Single-lung transplantation is an accepted treatment for end-stage lung disease caused by chronic obstructive pulmonary disease. A complication unique to single-lung transplantation for chronic obstructive pulmonary disease is graft dysfunction due to compression caused by native lung hyperinflation. We hypothesized that patients with functional compromise from native lung hyperinflation would benefit from native lung volume reduction surgery.

Methods: The charts of all patients undergoing single-lung transplantation for chronic obstructive pulmonary disease were reviewed for lung volume reduction surgery of their native lung. Data regarding length of stay, surgical morbidity and mortality, overall survival, type of lung volume reduction surgery, and pulmonary function were recorded to evaluate the effect of lung volume reduction surgery.

Results: Between February 1992 and May 2007, 206 single-lung transplantations were performed for chronic obstructive pulmonary disease. Ten (5%) patients had clinically significant graft compression from native lung hyperinflation. After excluding other causes for functional decline, these patients underwent a modified lung volume reduction surgery between 12 and 142 months after single-lung transplantation (mean, 50 months). Lung volume reduction surgery consisted of anatomic resection. Two (20%) of 10 patients died during their hospitalization. Of the remaining 8 patients, 7 (87.5%) have demonstrated functional improvement on the basis of forced expiratory volume in 1 second improving from 12% to 200% (mean improvement, 57%). Within 6 months of lung volume reduction surgery, mean 6-minute walk values improved significantly (866 to 1055 feet), whereas desaturation with exertion decreased significantly.

Conclusions: Lung volume reduction surgery by means of formal lobectomy in patients with native lung hyperinflation undergoing single-lung transplantation and significant graft compression appears feasible. Additionally, improvements in forced expiratory volume in 1 second can be accomplished in nearly all properly selected patients. Lung volume reduction surgery should be considered in patients with decreasing graft function caused by graft compression from native lung hyperinflation.

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Single-lung transplantation (SLT) is an accepted treatment for end-stage lung disease caused by chronic obstructive pulmonary disease (COPD). SLT for COPD has accounted for almost 40% of lung transplantations according to

Abbreviations and Acronyms

BOS	= bronchiolitis obliterans syndrome
COPD	= chronic obstructive pulmonary disease
CT	= computed tomography
FEV ₁	= forced expiratory volume in 1 second
LVRs	= lung volume reduction surgery
NLH	= native lung hyperinflation
SLT	= single-lung transplantation

the most recent report from the International Society for Heart and Lung Transplantation Registry.¹ Moreover, from 1995 through 2005, more than 67% of lung transplantations for COPD were single-lung rather than double-lung transplantations.

A complication unique to SLT for COPD is graft dysfunction due to compression caused by native lung hyperinflation (NLH).² Clinically relevant graft compression is characterized by a decrease in clinical function as measured by a decrease in forced expiratory volume in 1 second (FEV₁), exercise tolerance, and increased oxygen requirements in the setting of radiographic evidence of graft compression. Lung volume reduction surgery (LVRs) has been proposed as a method of treatment for this phenomenon.³⁻⁷ Table 1 summarizes the most comprehensive reports in the literature on lung volume reduction surgery after single lung transplants for COPD.

The purpose of this study was to determine whether native lung resection improves overall lung function in the setting of transplant graft compression caused by NLH. We hypothesized that patients with graft compromise caused by NLH would benefit from LVRs of the native lung. This study reports our experience in 10 patients undergoing LVRs for NLH and graft compression after SLT for COPD.

Materials and Methods

Approval of this study was obtained from the Colorado Multiple Institutional Review Board. The charts of all patients undergoing SLT for COPD at our institution between February 1992 and May

2007 were reviewed to capture those patients undergoing LVRs for SLT graft compression. Functional decline was defined primarily as a decrease in FEV₁, but a decrease in 6-minute walk values and an increase in the need for supplemental oxygen also contributed to this determination. Graft compression was suspected with chest radiographic findings of progressive mediastinal shift (Figure 1). Chest computed tomography (CT) was used to confirm mediastinal shift in the setting of an incremental decrease in transplanted lung volume. Other CT findings included evidence of compression of the intragraft vasculature or a large bronchus. Patients underwent bronchoscopy with transbronchial biopsy to rule out airway stenoses or bronchomalacia or acute or chronic rejection. A careful evaluation was performed to rule out other causes of decreased allograft function, as shown in Figure 2. The modified LVRs consisted of anatomic resections, both lobectomy and segmentectomy, rather than the more traditional extensive buttressed wedge resections.

Data were recorded regarding outcomes of LVRs, including length of hospital stay, perioperative morbidity, and mortality. Date and timing of both the original transplantation and the LVRs were noted. Furthermore, the patient's overall survival and specific LVRs procedure were reviewed. Most importantly, pulmonary function test results were recorded from evaluation for transplantation to the present. The patients' FEV₁, 6-minute walk values, and oxygen requirements were used as objective markers to determine the overall effect of LVRs procedure by comparing them at their peak after transplantation, before LVRs, and postoperatively after LVRs.

Statistical comparisons were performed by an independent statistician using repeated-measures analysis of variance, and differences were confirmed with Tukey HSD multiple-comparison analysis.

Results

From 404 lung transplantations, 206 SLTs were performed for COPD. Ten (5%) patients experienced significant functional graft compression and underwent LVRs. All patients underwent a modified LVRs consisting primarily of anatomic resections, as follows: 3 lower lobectomies, 5 upper lobectomies, a bilobectomy, and a lower lobe segmentectomy with upper lobe wedge resection. Three of the 10 patients also underwent intercostal muscle flap reinforcement of the bronchus. All LVRs were performed by one of 3 surgical staff whose practice consists solely of thoracic surgery.

TABLE 1. Reported literature on native lung volume reduction surgery after single-lung transplantation

Author	Year	n	Indication	Procedure	Showing functional improvement (%)	Survival >1 y after LVRs
Kroshus and coworkers ⁶	1996	3	NLH	LVRs	100%	1/3
Anderson and coworkers ³	1997	3	NLH	LVRs	100%	Not reported
Schulman and coworkers ¹²	1999	7	BOOP	LVRs	86%	3/7
Fitton and coworkers ¹¹	2003	5	NLH	LVRs	NA	2/4
Current study	2007	10	NLH	Lobectomy	70%	8/10

Most reports are small, demonstrating at least early functional improvement. These studies include all reports with more than 1 patient. The larger studies show that longer-term outcomes can be mixed, which stresses the importance of patient selection for this procedure. LVRs, Traditional lung volume reduction surgery with extended, buttressed wedge resection of the native lung; NLH, native lung hyperinflation; BOOP, bronchiolitis obliterans organizing pneumonia.

Figure 1. Evolution of graft compression on chest radiographic analysis. These plain films show the progression of graft compression with increased right lung volume and mediastinal shift from after transplantation to before lung volume reduction surgery (LVRS). The last film demonstrates resolution of the compression after LVRS.

The mean time between transplantation and LVRS was 50 months (range, 12–142 months). The decrease in FEV₁ between SLT and LVRS was 40% (range, 11%–70%) from transplantation to consideration for LVRS. Two patients died in the perioperative period at 17 and 34 days, respectively, after the operation. One death stemmed from bronchial stump complications, whereas the other patient was ultimately found to have bronchiolitis obliterans syndrome (BOS) on autopsy. Two other patients required reintubation during their hospital course. Three patients had postoperative pneumonia, 2 cases of which resulted in hospital deaths. Five had prolonged air leak of greater than 7 days. One patient had acute renal failure requiring hemodialysis. The intensive care unit stay averaged 13 days (range, 4–34 days). Hospital stay averaged 18 days (range, 8–34 days) after LVRS.

Follow-up of the survivors from LVRS averaged 21 months (range, 9–71 months). After discharge, all patients except 1 were still alive, with the 1 late death being a result of complications from posttransplantation lymphoproliferative disease. Of the 8 patients who left the hospital, 7 (87.5%) demonstrated significant functional recovery, as shown by improvement of FEV₁ to the previous baseline value (Figure 3). FEV₁ improvement averaged 57% (range, 12%–200%). Improvement in FEV₁ surpassed the previous posttransplantation peak in 1 patient. Among hospital survivors, 7 of 8 patients desaturated with exertion (decrease of 4% or to <90%) before LVRS, but none of the 8 decreased their oxygen saturation with exercise at their peak after transplantation. After LVRS, only 2 of 8 patients desaturated with exertion. Additionally, the impaired 6-minute walk values of these patients demonstrated a significant reduction from their

peak after transplantation to the time of LVRS, with a return to baseline around 6 months after LVRS. Finally, mean oxygen saturation was 94.5% at rest after transplantation. This decreased significantly to 90% before LVRS, with significant

Figure 2. Algorithm for lung volume reduction surgery (LVRS) after single-lung transplantation for chronic obstructive pulmonary disease. The steps for working up a decrease in pulmonary function in single-lung transplantation for chronic obstructive pulmonary disease are shown. native lung hyperinflation (NLH) is a diagnosis of exclusion, and therefore every attempt is made to exclude infection, acute rejection, and bronchiolitis obliterans syndrome (BOS). The workup, in bold, includes findings and reasons for the test. FEV₁, Forced expiratory volume in 1 second; CXR, chest radiography; VQ, ventilation/perfusion.

Figure 3. Changes in forced expiratory volume in 1 second (FEV_1). The graft depicts individual changes in FEV_1 from after transplantation to after LVRS by each patient. On average, there was significant improvement, and all but 1 of the hospital survivors demonstrated benefit on the basis of FEV_1 from the procedure. The mean FEV_1 at each point is depicted by the thick gray line with the diamond markers. *Significant change from after transplantation and after lung volume reduction surgery (LVRS; $P < .01$).

recovery to 93.4% after LVRS. The results of the 6-minute walk and resting peripheral oxygen saturation measurements are depicted in Figure 4. The specific procedures and outcomes of each patient are summarized in Table 2.

Discussion

Although the optimal approach to end-stage COPD is argued, the International Society for Heart and Lung Transplantation Registry demonstrates that SLT for COPD has been the most

common lung transplantation procedure performed.¹ The native lung in these patients can continue to overinflate, which does not usually affect overall pulmonary function. However, a small subset of these patients has compromised function of the transplanted lung as a result of compression by the native lung. This transplant lung compression can manifest with increased oxygen requirements, deterioration in pulmonary function tests, and significant reduction in exercise capacity. The algorithm used for evaluating these patients for LVRS is depicted in Figure 2. Although all patients are followed with serial chest radiography, chest CT scans can facilitate diagnosis in these patients, with demonstration of increasing native lung expansion at the cost of allograft volume. Other CT findings included evidence of compression of the intragraft vasculature or a large bronchus. Patients underwent bronchoscopy to rule out airway stenoses or bronchomalacia and transbronchial biopsies to evaluate for acute or chronic rejection. It is critical that chronic rejection or BOS is ruled out before LVRS because patients with BOS do very poorly with lung surgery. This might not always be possible, but the lack of a mosaic pattern or air trapping on CT scanning or patchy perfusion defects on perfusion scintigraphic analysis suggest the absence of BOS.^{8,9}

The National Emphysema Treatment Trial showed that resection of focal areas of emphysematous lung can benefit select patients with COPD.¹⁰ LVRS is intended to relieve compression of more normal areas of lung through resection of the most diseased, least functional areas of the lung. This was shown to be most effective in patients with relatively focal disease (upper lobe predominant). In regard to the current study, all the patients have focal COPD limited to their native lung but were not believed to be LVRS candidates before transplantation. Similar to traditional LVRS, the most

Figure 4. Changes in pulmonary function: A, changes in 6-minute walk values; B, changes in room air oxygen saturation. These 2 graphs show the respective changes in mean distance during 6-minute walks and room air oxygen from after transplantation through the clinical native lung hyperinflation to after lung volume reduction surgery (LVRS). Both markers of clinical pulmonary function showed a decrease from peak after transplantation, which was recovered to baseline in the majority of patients within 6 months of LVRS. *Significant change from after transplantation and after LVRS, $P < .01$.

TABLE 2. Specific patient outcomes

Age at SLT (y)	Sex	SLT to LVRS (mo)	Dx	Operation	LOS (d)	Complications	Δ FEV ₁	Δ 6-min walk	Survival (mo)
47*	F	108	COPD	RLL	17	Prolonged air leak, pneumonia, death	NA	NA	0.5
49	F	45	COPD	RUL	21	Prolonged air leak	+30%	+14%	8
50*	F	12	α ₁ -Antitrypsin	LLL	34	MSOF, death	NA	NA	1
54	F	37	COPD	RUL, RML	16	Pneumonia, ileus	+200%	+66%	16
54	M	142	COPD	RUL	26	Prolonged air leak, reintubation	+100%	+18%	14
55	F	23	COPD	LUL	10	None	+12%	+30%	9
55	M	41	COPD	RUL bleb, RLL segment	11	Pain control	+50%	−10%	18
59	F	54	COPD	RLL	11	Prolonged air leak	+33%	+50%	70
61	M	37	COPD	LUL	26	ARF, reintubation	−30%	+32%	11
61†	M	22	COPD	LUL	8	Prolonged air leak	+57%	+33%	18

Specific patient outcomes after lung volume reduction surgery for native lung hyperinflation causing transplant graft compression in patients with single-lung transplantation for chronic obstructive pulmonary disease are shown. *SLT*, Single-lung transplantation; *LVRS*, lung volume reduction surgery; *Dx*, diagnosis; *LOS*, length of hospital stay; *FEV₁*, forced expiratory volume in 1 second; *COPD*, chronic obstructive pulmonary disease; *RLL*, right lower lobectomy; *RUL*, right upper lobectomy; *LLL*, left lower lobectomy; *NA*, not applicable; *MSOF*, multiple systems organ failure; *RML*, right middle lobectomy; *LUL*, left upper lobectomy; *Bleb*, blebectomy; *ARF*, acute renal failure. *Hospital death. †Late death.

hyperinflated lobe or lobes of the native lung were targeted for resection in the present study.

Lung resections in patients undergoing lung transplantation are considered high risk for almost all patients. Pulmonary resection for these patients might be at even higher risk given the combination of immunosuppression and an extremely abnormal native lung. However, there is a growing body of literature documenting the feasibility of operating on these patients. Fitton and colleagues¹¹ published a series of 12 lung resections performed on lung transplant recipients for various indications, including graft compression, infection, and neoplasm. Overall, their high-risk cohort did relatively well, with 85% surviving a month. Of note, the subgroup undergoing wedge resection did notably worse. A proposed mechanism is that these patients would have difficulty healing the long suture line of a wedge resection. They conclude that with medical optimization, lung resections in lung transplant recipients is high risk but can be undertaken with acceptable morbidity and chance for success. Other reports in the literature substantiate the feasibility of lung resections after lung transplantation.^{3,4}

Several smaller series of LVRS in patients undergoing lung transplantation have been published, but they include limited data regarding outcome beyond a year of follow-up.³⁻⁷ Case reports of lung resections for NLH can be found back to 1996. These reports include both lobectomies and wedge resections. Schulman and associates¹² reported using LVRS with disabling BOS. They performed a more traditional LVRS with native lung wedge resection. In their study the majority of patients showed some improvement in pulmonary function with relief of allograft compression. Although they found native lung LVRS for BOS salvaged some respi-

ratory function, the benefits were concluded to be limited in magnitude and duration by the severity of the chronic rejection. They reported that 3 of 7 reported patients died within a year of their procedure after LVRS, despite documented early improvements in pulmonary function. Fitton and colleagues¹¹ reported 4 native lung reductions for NLH in their report on lung resections in patients undergoing lung transplantation. Of the remaining 2 patients, one lived for more than 3 years after LVRS, and the other was still alive more than a year out at the time of their publication. These studies demonstrate that LVRS is feasible in patients undergoing lung transplantation but that patient selection, in particular avoiding operations in patients with BOS, and timing of surgical intervention are probably the most important determinants of longer-term postoperative outcomes for these patients.

The present series represents the largest series of native lung LVRS in SLT for COPD found in the literature. The development of NLH leading to clinically significant allograft compression has been uncommon, with 10 patients undergoing native lung LVRS among 206 SLTs for COPD. Overall, patients undergoing LVRS for NLH fared well in our study. Two patients died during their hospital course, which is consistent with the National Emphysema Treatment Trial mortality rate for LVRS in nonimmunosuppressed patients.² The development of pneumonia was a difficult problem for these patients to overcome because the 2 deaths both included pneumonia. One of these 2 patients with pneumonia was found later to have BOS, which complicated the pulmonary course. One patient who had pneumonia during the hospital course left the hospital. Seventy percent of the patients enjoyed functional improvement on the basis of

FEV₁ or 6-minute walk values after LVRS. By using the algorithm depicted in Figure 2, patients can be well selected for LVRS to possibly reset the baseline of their pulmonary function to their peak after transplantation. This reestablishment of baseline lung function has been demonstrated by improved 6-minute walk values, oxygen requirements, room air saturations at rest, and FEV₁.

Given the less-than-optimal reports of both wedge resections and traditional LVRS in the SLT literature, anatomic resections were chosen in an effort to facilitate pulmonary healing. This strategy appears to have been successful, but prolonged air leak still occurred in half of the patients and significantly extended hospital stays. The extended hospital stays and incidence of complications demonstrate the level of care needed for these patients. Although intense pulmonary rehabilitation was required for recovery from their lung resections, 7 of 8 patients discharged from the hospital saw improved pulmonary function, as demonstrated by their improved FEV₁. In terms of late follow-up, 7 of 8 hospital survivors are alive at a mean of 20 months after LVRS.

These data demonstrate that LVRS by means of formal anatomic resection in patients undergoing SLT with significant graft compression from NLH is feasible. Although hospital stay and pulmonary rehabilitation can be intensive, improvements in lung function can be accomplished in nearly all properly selected patients, with excellent long-term survival. In conclusion, LVRS should be considered in patients with decreasing graft function caused by graft compression from NLH.

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Discussion

Dr Patricia Thistlethwaite (*San Diego, Calif*). I would like to congratulate Dr Reece and his colleagues at the University of Colorado for an excellent presentation and a well-written article. This is indeed a difficult set of patients to manage, those with overinflation of a native lung compromising transplant allograft function. It is nice to see that your surgical approach, first described by our group at the University of California at San Diego in 1996 in the SLT patient population with emphysema, is still being effectively used to this day. I think many of us would agree that LVRS after lung transplantation is performed as a last resort, when allograft deterioration occurs and the CT scan shows compression of the transplant lung. This is reflected by the high-risk stakes of doing this operation seen by the fact that you had a 20% perioperative mortality and that most patients had long intensive care unit and hospital stays. I am surprised that you chose thoracotomy over thoracoscopy in this immunocompromised and pulmonary compromised set of patients. Newer technologies, such as the use of 1-way endobronchial valves and the trend of performing double-lung transplantations in patients with COPD and α_1 -antitrypsin disease, might eliminate the need for LVRS in these subsets of patients who have transplantations in the future. I have several questions.

First, most cases of SLT for emphysema show some degree of hyperinflation of the native lung from the beginning with the first postoperative chest radiograph. What is your threshold for surgical intervention, and are there specific CT scan measurements of mediastinal shift that you could retrospectively identify as being useful to determine who would benefit from this operation and when intervention should occur?

Dr Reece. We have not applied any kind of volumetric analysis at this point. We have not been able to apply the technology, and our patients do not generally get a CT scan repeatedly unless there is a problem. Chest radiography is the way that we most commonly follow them, and unfortunately, the CT scans that we order are usually because of another problem, such as infection or concern about bronchiolitis; therefore it has been hard to define any CT criteria alone that would push us to do an LVRS.

Dr Thistlethwaite. Thank you. Most of your patients underwent LVRS in a time frame when chronic rejection is common. When do you decide that symptoms are due to allograft compression rather than rejection? We know that there is no reliable CT scan finding that is pathognomonic for chronic rejection. There is also well-documented sampling error and pathologic grading variability in the diagnosis of chronic rejection that might obscure why these patients have progressive shortness of breath. Were they empirically treated for chronic rejection before LVRS? (end cassette side)

Dr Reece. ... from reviewing their charts. None of these patients were treated preoperatively. We hope that our algorithm rules out the majority of the patients who are having chronic rejection or having other problems besides NLH. As shown by one of our 2 deaths, we actually missed it in that patient. I think it is a difficult call to make, but given all of the clinical information, we have been able thus far to make a good judgment of who has bronchiolitis and who does not. It is definitely a problem that we have seen clinically and something that we try to avoid and have not been able to eliminate completely.

Dr Thistlethwaite. Yes, in our group it seems to almost always be a concurrent problem.

Finally, and probably most importantly, in your cohort of patients, did LVRS result in permanent relief from NLH, or was it temporary? If so, for how long?

Dr Reece. It looks like the patients take around 6 months or so to recover to a peak after their LVRS, but they do have some gradual decrease that we see in all of the patients undergoing lung transplantation. We do think that we reset their baseline, but it is not a cure-all for future deterioration. It seems to be something that can reset their baseline and allow them to get back to a point where they are feeling good and doing the things that they need to and continue along with their lives.

Dr Thistlethwaite. Thank you very much, and I would like to thank the Association for the privilege of the floor.

Dr Michael Mulligan (*Seattle, Wash*). I applaud your desire to weigh in with this population. This is a topic that has been discussed by revered colleagues who have condemned it as being fairly useless and inappropriate. Your data are very encouraging, even though the mortality and morbidity appear to be quite high. My question to you is this: Who pays for this? The overwhelming majority of payers will not reimburse unilateral LVRS, yet you are here telling us that this is indeed LVRS. A bullectomy can be reimbursed as a unilateral procedure, but for patients about whom we have made ongoing solicitations to try and get reimbursement, we have been shut down. Who is paying for it, and how are you coding it to get it paid for?

Dr Reece. I am not certain about that. I have no idea about the coding or reimbursement at this point, but I will look into it and get back to you.

Dr Robert Cerfolio (*Birmingham, Ala*). We are coding it as bullectomy. That is a very important point. That is how we list it, and that is what I think it really is, not LVRS. We have done several of these at Birmingham, and I want you to take me on your cognitive leap from doing a large wedge resection to doing a lobectomy. I think one of the deaths was from a bronchopulmonary fistula, which you could have avoided. Second, your main problem was prolonged air leaks. No matter whether you do a fissureless lobectomy like most of us do, where one staples the fissure last and takes all of the vessels and bronchus first, or not, it is the large space that helps prevent sealing of the leaks. There is a lack of parietal to visceral pleural apposition. Therefore why perform an anatomic operation for a problem that does not require one and leads to a larger space deficit? Why not do a wedge resection, like we do in bullectomy surgery or in LVRS? Thus I have done all these with LVRS-type techniques, using pericardially buttressed staple lines, pleural tents, and just wedges. I would not do a lobectomy, where a stump is at risk, especially in an immunocompromised patient. Therefore tell me again why I should follow your cognitive leap of doing a lobectomy instead of just a large wedge resection.

Dr Reece. I think there are some data, although I would have to acknowledge that they are few, that patients with lung transplantations who get wedge resections—which LVRS is going to be an extended wedge resection—do worse. I mean, there is nothing to validate that, but we believe that if we have a small staple line of a bronchus and hopefully a smaller one of less tissue within the fissure itself, we would decrease the amount of air leaks from the lung parenchyma itself.

Dr Ross Bremner (*Phoenix, Ariz*). Most of your patients, or all of your patients, have chronic problems. I wonder with your experience now what your guidelines are for doing this in an acute setting in which you get one lung only offered, and when the lung comes to you, it is a little smaller than you had hoped for, or in the setting in which in the first couple of days after the operation you are having a lot of trouble with NLH on the vent.

Dr Reece. We have actually published on NLH in the acute setting, and with thoughtful management, we were able to get beyond this, so that it does not cause an increase in mortality and it does not cause an increase in morbidity, but I think this is a completely different subject from the chronic NLH that we are dealing with here. There are reports in the literature of surgeons doing bullectomies or lobectomies at the same time that they are doing the opposite lung transplantation, but that would subject many patients to a superfluous procedure for a process that would be unlikely to lead to an eventual compromise in pulmonary function. In our opinion, the low incidence of significant NLH does not justify prophylactic contralateral resection.

Dr Richard Whyte (*Stanford, Calif*). I enjoyed your article, and I think it is very nice to have some data on what happens with these patients because many of us who have been involved with lung transplantations have been asked to do this operation in patients over the years, and now we kind of know what happens. Interestingly, you can use the results to justify whichever approach, whether you want to do it or not.

My question relates to how you exclude bronchiolitis obliterans, which is actually a diagnosis of exclusion itself, yet you seem to be able to eradicate or eliminate those that you think have bronchiolitis obliterans. In fact, with your deaths, you had a 50% error rate. How do you eliminate a diagnosis of exclusion?

Dr Reece. That is a good question. I would have to lean on our pulmonary colleagues, as well as the pathologists, and all come together with a conclusion of whether we all believe that they have bronchiolitis. I do not know whether I can quantify how we say they do not at this point, but we have been fairly lucky and successful in avoiding it in all but 1 patient.

Dr Thistlethwaite. Dr Reece, I have one last question. Do you have a similar cohort of patients in whom you have actually chosen to do a contralateral retransplantation instead of lung reduction? Do you have any comparisons between the 2 groups? If one looks at this, all of these patients would likely be candidates for retransplantation of the contralateral native lung, and when you see the morbidity and mortality of LVRS, one could argue that the morbidity and mortality of retransplantation would potentially be less, with potentially more benefit. Have you tried that, and do you have any comparison data to tell us about?

Dr Reece. I have not looked at that, but that would definitely be something I would like to look at in the future.