Thoracoscopic lobectomy: Introduction of a new technique into a thoracic surgery training program

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Objective: Thoracoscopic lobectomy has been demonstrated to be safe and oncologically sound. However, few thoracic surgeons perform the operation. We hypothesized that use of a predetermined, stepwise plan for introduction of thoracoscopic lobectomy into a thoracic surgical training program would facilitate safe learning of the technique.

Methods: Databases from 2 affiliated institutions were queried to identify all lobectomies during a 4-year period. Our model for introduction of thoracoscopic lobectomy was established expertise in open lobectomy and video-assisted thoracoscopic surgery, participation in a formal thoracoscopic lobectomy course, stepwise introduction of specific techniques used in thoracoscopic lobectomy into the operative approach, proctoring of initial thoracoscopic lobectomies by partners, and teaching of the technique to other thoracic surgeons and residents.

Results: We performed 202 lobectomies: 97 open and 105 thoracoscopic. Mortality was 3.0%. The conversion rate from thoracoscopic to open thoracotomy was 13%. When divided into quartiles, the percentage of lobectomies performed thoracoscopically increased from 18% in the first quartile to 82% in the fourth quartile. With ongoing experience, the procedure was performed at higher frequency by new staff and trainees. Residents performed 0% of thoracoscopic lobectomies in the first quartile, increasing to 54% in the third quartile. In the fourth quartile residents and a new staff surgeon performed 76% of thoracoscopic lobectomies. A resident was the operating surgeon for 37 thoracoscopic lobectomies.

Conclusions: Introduction of thoracoscopic lobectomy into an academic thoracic surgical practice can be achieved safely if a stepwise transition is invoked. Training of thoracic surgical residents and additional staff can thus be effectively accomplished.

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Thoracoscopic lobectomy was first performed 13 years ago.¹ Worldwide, the procedure has been demonstrated to be safe,^{1–9} and its oncologic outcomes are at least equal to those achieved with thoracotomy.^{1,5,6,10–15} Thoracoscopic lobectomy can also offer several advantages, including decreased pain, faster return to functional status, and decreased inflammatory response. Despite the positive results with this minimally invasive technique, only 5% of the 40,000 lobectomies performed annually in the United States are done thoracoscopically.¹

With few thoracic surgeons performing thoracoscopic lobectomy, there has been inadequate opportunity for thoracic surgical trainees to receive sufficient training in this operation. Ng and Ryder¹⁶ demonstrated, in a series of 30 thoracoscopic

Abbreviations and Acronyms

CT = computed tomography

lobectomies, that a stepwise evolution toward a thoracoscopic approach can offer a safe approach for a trained thoracic surgeon. Ferguson and Walker¹⁷ suggested that thoracoscopic lobectomy can be safely taught to trainee thoracic surgeons, but that it should be coordinated at a national level. Others do not believe that this technique can be taught.¹⁷ Here we predicted that the use of a predetermined stepwise plan for introduction of thoracoscopic lobectomy into a thoracic surgical training program would facilitate safe learning and subsequent teaching of the technique.

Materials and Methods

Patients

Surgical databases from the Division of Thoracic Surgery at the University of Cincinnati College of Medicine and the Cincinnati VA Medical Center were queried to identify all pulmonary lobectomies performed during the 4-year period from July 1, 2002 through June 30, 2006. The study was approved by the University of Cincinnati Institutional Review Board.

Databases and patient records were reviewed for patient demographics, presenting symptoms, medical comorbidities, smoking history, previous cancer, pulmonary function tests, clinical staging by chest computed tomographic (CT) and positron emission tomographic scans, mediastinoscopic results, neoadjuvant therapy, attending surgeon, operating surgeon, operation performed (specific lobe, thoracoscopic or thoracotomy, and conversion), blood loss, operative time, pathologic stage, length of stay, chest tube duration, complications, and mortality.

Statistical Analysis

Operative mortality included all patients who died within 30 days of surgical intervention or within the same hospitalization. Thoracoscopy and thoracotomy groups were compared. Differences in categorical variables, including prolonged air leak, atrial fibrillation, and mortality, were determined by using continuity-adjusted χ^2 analysis. Ordinal variables, such as chest tube duration and hospital length of stay, were compared by using the nonparametric Wilcoxon rank sum test.

Procedure

Thoracoscopic lobectomy is defined as a video-assisted procedure using anatomic dissection with individual ligation of the vessels and bronchi. No rib spreaders are inserted. The technique of thoracoscopic lobectomy has been well described by others.¹ Briefly, single-lung ventilation is used, and the patient is placed in the lateral decubitus position. A 10-mm port is inserted in the eighth to ninth intercostal space at the anterior axillary line, and a 10-mm port is placed in the sixth intercostal space at the midclavicular line. A 4- to 8-cm utility incision is created in the axilla at the fourth (for upper lobectomy) or fifth (for middle or lower lobectomy) intercostal space. A 10-mm incision is frequently placed in the auscultatory

triangle in the sixth intercostal space, particularly when teaching the operation. This additional port allows the staff surgeon to assist more effectively, using retraction for improved exposure or for insertion of added instrumentation. The operating surgeon was defined as the individual who performed the majority of the hilar dissection. When converting to an open approach, the axillary utility incision was extended into a standard axillary thoracotomy.

All consecutive lobectomies were included. Prior thoracic surgery, neoadjuvant therapy, previous cancer, and medical comorbidities were not exclusion criteria. Sublobar resection, including wedge resections and segmentectomies, as well as bilobectomies, pneumonectomies, and sleeve lobectomies, were excluded. All cases were analyzed by using the intent-to-treat approach. Specifically, any planned thoracoscopic lobectomy, even if converted to a thoracotomy, was included in the thoracoscopic group. In one patient pneumonectomy was performed because of intraoperative bleeding. This patient, based on the intent-to-treat principle, was included in the thoracoscopic lobectomy cohort.

Model for Transition to Thoracoscopic Lobectomy

We used a predetermined model for introduction of thoracoscopic lobectomy. First, the attending surgeons are specialists in general thoracic surgery, with established expertise in open lobectomy and video-assisted thoracoscopic surgery.

Second, 2 attending surgeons participated in a formal thoracoscopic lobectomy course (Figure 1, time point 1).

Third, rather than immediately proceeding with transition to thoracoscopic lobectomy, a stepwise introduction of specific techniques was used. At first, in planned open lobectomies, we would begin thoracoscopically to gradually introduce the steps required in thoracoscopic lobectomy. For example, we initially took down the inferior pulmonary ligament thoracoscopically and then converted to a thoracotomy. We subsequently progressed to dissection

Figure 1. Cumulative number of cases performed open versus thoracoscopically. Time points: 1, attending surgeons participate in thoracoscopic lobectomy course; 2, first thoracoscopic lobectomy; 3, new attending thoracic surgeon begins; 4, attending surgeons first teach thoracoscopic lobectomy course. Arrows indicate mortalities. Solid line, Thoracoscopic lobectomy; dashed line, open lobectomy (thoracotomy).

and ligation of pulmonary veins and eventually to ligation of the arterial branches and bronchi, as well as mediastinal lymph node dissection.

Fourth, after using the stepwise introduction of the specific thoracoscopic techniques during open thoracotomy, we then progressed to complete thoracoscopic lobectomy (Figure 1, time point 2). In the initial thoracoscopic lobectomies the attending thoracic surgeons proctored each other.

Fifth, once the attending surgeons believed that they had acquired sufficient experience in thoracoscopic lobectomy, they began to teach others. Residents were transitioned from assistant to operating surgeon based on their demonstrated competence with advanced laparoscopy, video-assisted thoracoscopic surgery, and open lobectomy. They acquired the skills necessary for thoracoscopic lobectomy in a stepwise approach similar to the attending surgeons' strategy. Specifically, the residents first learned less advanced thoracoscopic procedures, such as wedge resection and pleural interventions. When they demonstrated competence in lesser procedures, they were allowed to begin thoracoscopic lobectomies. Initially, they would be taught to achieve exposure, take down the inferior pulmonary ligament, and expose the hilum. With demonstration of adequate technique in starting the operation, they would then advance to hilar dissection, progressing first to venous and bronchial dissection and finally to pulmonary arterial dissection. More recently, we have developed a quarterly resident course in which they are taught the procedure with cadavers. The attending surgeons also began teaching the technique to other thoracic surgeons in courses, both at the University of Cincinnati College of Medicine and as visiting proctors at other sites (Figure 1, time point 4).

Finally, with the recruitment of another attending thoracic surgeon, we used a similar stepwise approach to introducing the specific techniques of thoracoscopic lobectomy and proctored the surgeon for the initial cases (Figure 1, time point 3).

Results

Patient Characteristics

During the 4-year period from July 2002 through June 2006, we performed 202 consecutive lobectomies. In 97 lobectomies a thoracotomy was used, and 105 lobectomies were thoracoscopic (Table 1). Patient age, sex distribution, and smoking history were similar between the 2 groups. Additionally, preoperative pulmonary function was similar in the 2 groups. Because this was a consecutive series including all lobectomies, a significant portion of patients had prior malignancies, both intrathoracic and extrathoracic.

Choice of Procedure

Thoracoscopic lobectomy was used more frequently for patients with early-stage disease (Table 2). In particular, patients with clinical stage IA lung cancer were offered a thoracoscopic approach more often. Similarly, the mean tumor size was smaller in the thoracoscopic lobectomy group. The ideal patient for thoracoscopic lobectomy is one with a small peripheral lesion, at least early in a surgeon's learning curve. Thus as expected, a higher percentage of patients with

TABLE 1. Patient demographics

	Thoracoscopic	Thoracotomy
No.	105	97
Age (y), median (range)	66 (33–89)	64 (20–89)
Sex		
Male	58	63
Female	47	47
Tobacco use		
Current smokers	36 (34%)	40 (41%)
Former smokers	67 (64%)	46 (47%)
Never smokers	2 (2%)	10 (10%)
Pack-years	49 ± 31	52 ± 28
Previous cancer	23	22
Pulmonary function tests		
FVC (% predicted)	91.4 ± 17.4	83.3 ± 15.9
FEV ₁ (% predicted)	86.3 ± 23.4	74.0 ± 21.0
DLCO (% predicted)	74.2 ± 26.4	61.1 ± 21.3

FVC, Forced vital capacity; FEV₁, forced expiratory volume in 1 second; DLCO, diffusing capacity of lung for carbon monoxide.

adenocarcinoma were treated thoracoscopically because this histologic subtype is more commonly peripheral and therefore amenable to a thoracoscopic approach. Also, a higher percentage of patients with stage IB disease underwent open lobectomy, primarily because of large tumor size. Those with stage III disease usually had an open procedure for 2 main reasons: first, patients who had received neoadjuvant therapy were often managed with an open operation because of the potential technical challenges after radiation therapy, and second, a number of patients with occult N2

TABLE 2. Stage distribution

	Thoracoscopic	Thoracotomy
Clinical stage		
IA	77	41
IB	21	32
IIA/IIB	2	7
IIIA/IIIB	1	12
IV	3	3
Unknown	1	2
Pathologic stage		
IA	50	33
IB	32	30
IIA/IIB	14	14
IIIA/IIIB	6	13
IV	3	3
Complete response		4
Tumor size (cm)	2.5 ± 1.6	3.5 ± 2.4
Histology		
Adenocarcinoma	60	46
Squamous	37	36
Other	8	15

disease also had larger tumors that were not resected thoracoscopically. In the rare cases performed thoracoscopically after neoadjuvant therapy, the attending physician was the operating surgeon. Typically, 45 to 50 Gy had been used, although there was a range from 40 to 70 Gy.

Outcomes

The conversion rate from thoroscopic to open thoracotomy was 13% (14/105). There were 2, 4, 3, and 5 conversions in the first, second, third, and fourth quartiles, respectively. Ten of the 14 patients had evidence of prior histoplasmosis infection based on CT evidence of calcified pulmonary granulomas or lymph nodes, intraoperative observation of calcified nodes, or pathologic demonstration of calcified nodes. The specific indications for conversion were as follows: dense hilar inflammation or fibrosis (n = 4), hilar inflammation and bleeding (n = 4), pleural adhesions (n = 4), hilar adenopathy and bleeding (n = 1), and bleeding (n = 1). The causes of pleural adhesions were as follows: prior coronary artery bypass with left internal thoracic artery (n = 1), recent thoracic gunshot wound (n = 1), and “unknown” (n = 2). Of the 6 cases converted because of bleeding, one was in the first quartile, 3 were in the second quartile, 2 were in the third quartile, and none were in the fourth quartile. In 3 of these procedures, the resident was initially the operating surgeon. None of these patients had received neoadjuvant therapy. Thus in 4 of the 6 cases with pulmonary arterial bleeding requiring conversion, granulomatous nodal disease contributed to a difficult dissection.

Thirty-day mortality was 3.0% (6/202, Table 3). Two (2.1%) deaths occurred in the thoracotomy group, whereas 4 (3.8%) occurred in the thoracoscopic group. One patient died intraoperatively in the thoracoscopic lobectomy group of injury of the first branch of the left pulmonary artery during left upper lobe lobectomy. After conversion to thoracotomy, pulmonary artery repair was achieved, but the patient sustained a ventricular fibrillatory arrest and could not be resuscitated. One patient died postoperatively after planned

thoracoscopic right lower lobe lobectomy. During hilar dissection, granulomatous disease caused by histoplasmosis was encountered, and injury to the pulmonary artery required conversion to a thoracotomy with a subsequent right pneumonectomy. The patient died on the eighth postoperative day from adult respiratory distress syndrome. In the 2 deaths in which thoracoscopic lobectomy was converted to open lobectomy because of bleeding, one was with an attending physician as the operating surgeon and one was with a trainee as the operating surgeon. In the left upper lobectomy the same complication can occur in open procedures, and it is thus not certain that the injury would have been avoided with an open approach. In the right lower lobectomy, earlier conversion, when hilar fibrosis from histoplasmosis was encountered, might have prevented the complication. The other deaths were caused by adult respiratory distress syndrome (n = 2: one open lobectomy, died on postoperative day 59; one thoracoscopic lobectomy, died on postoperative day 7), pneumonia (n = 1: open lobectomy, died on postoperative day 22), and pneumonia with gastrointestinal bleed (n = 1: thoracoscopic lobectomy, died on postoperative day 20).

There was no apparent difference in mortality, prolonged air leak, or atrial fibrillation between the thoracoscopic and open groups (Table 3). The incidence of prolonged air leaks in the thoracoscopic and open groups was not different between cases performed earlier in the series and those occurring later in the series. However, length of stay and chest tube duration were shorter after thoracoscopic lobectomy compared with those after thoracotomy. The median length of stay was 4 days for thoracoscopic lobectomy and 5 days for thoracotomy. Median chest tube duration was 3 days for thoracoscopic and thoracotomy approaches, but the sum of scores (Wilcoxon rank sum analysis) was significantly higher for thoracotomy (Table 3).

Teaching Thoracoscopic Lobectomy

We used a stepwise approach to the incorporation of thoracoscopic lobectomy into our academic thoracic surgery practice. After a period of proctoring each other, the 2 attending surgeons then performed the procedure independently as operating surgeons. After the attending surgeons became confident in their ability to routinely perform the operation in a safe manner, we embarked on teaching trainees to perform the operation. The 202 lobectomies were divided into quartiles to determine changes in the accomplishment of thoracoscopic lobectomy and in the development of trainee experience. The percentage of lobectomies performed thoracoscopically increased from 18% (9/50) in the first quartile to 82% (42/51) in the fourth quartile (Figure 2).

With ongoing attending thoracic surgeon experience, the procedure was performed at higher frequency by trainees (Figure 3). Additionally, we recruited an attending surgeon who had just completed a thoracic surgical residency. We taught the procedure to the new surgeon in a stepwise

TABLE 3. Patient outcomes

	Thoracoscopic	Thoracotomy	P value
Length of stay (d)			.005
Median (range)	4 (2–17)	5 (2–61)	
Mean	4.9	7.4	
Chest tube duration (d)			.0191
Median (range)	3 (1–17)	3 (2–17)	
Mean	3.5	3.9	
Prolonged air leak (>7 d)	10	9	1.0
Atrial fibrillation	7	9	.67
30-d Mortality	4	2	.75

GTS

Figure 2. Number of lobectomies performed thoracoscopically versus open. The cases were divided into equal quartiles.

manner, and we then proctored the individual through the initial cases as the operating surgeon. There was a steady increase in the number of cases performed by trainees. In the first quartile residents performed 0% (0/9) of thoracoscopic lobectomies as the operating surgeon. This increased to 29% (7/24) in the second quartile and 54% (14/26) in the third quartile. In the fourth quartile residents performed 38% (16/42) of cases. However, during the fourth quartile, the new staff surgeon began performing thoracoscopic lobectomies, accounting for 38% (16/42) of cases (Figure 1). Thus, during the fourth quartile, residents and the new staff surgeon were both considered trainees in the procedure, and they collectively performed 76% (32/42) of thoracoscopic lobectomies. In total, a resident served as the operating surgeon for 37 of the 105 thoracoscopic lobectomies.

Discussion

Thoracoscopic lobectomy has been conclusively demonstrated to be a safe operation¹⁻⁹ without increased bleeding, morbidity, or cost.¹⁸⁻²¹ Many experienced thoracic surgeons have demonstrated several advantages of the minimally invasive technique, including decreased pain, shorter hospital stay, earlier return of functional status, improved postoperative pulmonary function, and decreased inflammatory response.^{20,22-25} Most importantly, it is equally effective as a cancer operation, with similar postoperative survival compared with that of the open approach. Lobectomy performed

thoracoscopically is the same operation as lobectomy performed through a thoracotomy, with individual ligation of the vessels and bronchi, as well as identical lymph node sampling or dissection.¹ Recently, the use of thoracoscopic lobectomy was shown to enable more effective administration of adjuvant chemotherapy than lobectomy by means of thoracotomy.²⁶ Despite these advantages, this minimally invasive technique is used for only a small minority of lobectomies.

There are few absolute contraindications to thoracoscopic lobectomy, and the approach has been used for higher-stage disease, sleeve lobectomy, and after neoadjuvant therapy. Yet the ideal patient for thoracoscopic lobectomy, particularly early in a surgeon's experience performing the operation, is one with a peripheral T1 or T2 lesion without nodal disease. Our experience demonstrates that adoption of this approach to patient selection is a safe strategy in the transition to routinely performing thoracoscopic lobectomy (Table 2).

Conversion to open lobectomy was not uncommon in our experience. A major reason for the conversion rate is that histoplasmosis is endemic in the Cincinnati area, often making hilar dissection challenging. Therefore careful review of the preoperative chest CT scan is essential, focusing on calcifications in the hilum, especially at the origin of the lobar bronchus that is to be divided. In this series a number of patients with stage IA or IB disease were not offered thoracoscopic lobectomy because of hilar calcification.

A significant limitation to greater application of thoracoscopic lobectomy appears to be the perceived difficulty in learning the operation.^{16,17} Accordingly, there is limited opportunity for thoracic surgical trainees to learn the operation. The learning curve appears to vary, both for residents and staff, depending on their experience with open lobectomy and with less complex thoracoscopic procedures. For experienced practitioners, the stepwise approach of introducing defined portions of the operation, rather than abruptly transitioning from an open to a thoracoscopic approach, allows the learning curve to be tailored to the individual surgeon. For example, experienced surgeons might require more cases during which the initial steps of exposure and thoracoscopic visualization are mastered, whereas later steps (eg, hilar dissection) require less time to learn. However, residents with significant experience in minimally invasive operations, but not open lobectomy, appear to have little difficulty with visualization and minimally invasive instrumentation but progress much slower through the later stages of the procedure while learning the anatomic details and technical challenges of hilar dissection. Future surgical training will certainly use novel simulation models and centralized training facilities. However, the well-established model of surgical attending physicians learning new techniques from others, mastering them, and then teaching the method to residents is rational and practical. Here we demonstrate that introduction of thoracoscopic lobectomy into an academic thoracic surgical practice can be achieved safely if a stepwise

Figure 3. Number of thoracoscopic lobectomies performed by attending surgeons compared with trainees. The cases were divided into equal quartiles.

transition is invoked. By using this approach, training of additional staff, as well as thoracic surgical residents, can be effectively accomplished.

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Discussion

Dr John D. Mitchell (Denver, Colo). Mike, I would like to congratulate you on a very nice presentation and, for that matter, a very smooth, well-written manuscript that I was able to review in advance of the meeting.

As you pointed out, despite its obvious advantages in selected patients, the technique of thorascopic lobectomy has been slow to gain acceptance by the general thoracic community. There are several reasons for this, including the perceived steep learning curve and the difficulties of incorporating the technique in thoracic training programs. The present study addresses this latter issue through a retrospective review over 4 years of 202 lobectomies in an academic training program. At the same time, the technique of thorascopic lobectomy was introduced in a stepwise fashion into the same training program. About half the lobectomies were done thorascopically, and over the 4-year period, increasing numbers of thorascopic procedures were performed both by the attending and resident staff.

I have 2 main questions for you. First, I would expect, particularly given the patients selected for thorascopic lobectomy, that the mortality rates for open and thorascopic procedures should be about the same. Even though not statistically different in the manuscript, the mortality rate for thorascopic lobectomy was a bit high at almost 4% and was almost double that for open lobectomy. At least some of the mortality was associated with intraoperative difficulties, such as pulmonary artery injury. I wonder whether you could comment on the mortality rate and whether the morbidity and mortality changed over the 4-year period of your study.

Dr Reed. That is an excellent question. First of all, this is a consecutive series, which I think is important. It is not selected for studies. It incorporated our entire learning curve. There was not an excess mortality in the early part of it, perhaps because we were carefully selecting the patients. Indeed, a few deaths occurred a little bit later on, perhaps suggesting that we were broadening our criteria for performing the operation and probably a little bit too much. I think when looking at what was related to the deaths, for example, bleeding, one of the issues that we learned was that in the setting of

histoplasmosis and thoracoscopic lobectomy, you have to be very suspicious about potential inflammation about the pulmonary artery. Clearly, there are some patients who have rock piles in the hilum and you are not going to do it thoracoscopically, but half of our patients in the area have at some point been exposed to histoplasmosis. Therefore we have to look carefully at the CT scan, particularly at the lobar bronchus, and going in have a very low threshold for conversion. We mentioned the 13% conversion rate. I would think that, if anything, it perhaps should have been a little bit higher. A number of those patients should have been converted earlier, and I think that is one of the teaching points that we gathered from looking back at this.

Dr Mitchell. Second, you conclude that thoracoscopic lobectomy can be safely introduced into an academic training program if a stepwise transition is invoked. Based on your experience and retrospective review, what advice would you give others trying to introduce the technique into their practice, and what changes would you make if you had to do it all over again?

Thank you. I enjoyed your paper very much.

Dr Reed. I think that first of all this should be done by surgeons who already have all of the building blocks so that they are experienced with thoracic surgical oncology and it is a reasonable portion of their practice.

Second, that the surgeons take a formal course is really important. Trying to embark on this without taking a formal course would have been crazy, at least in our experience. Learning from instructors who know it already and getting the tips from them is critical so that we do not make the same mistakes over and over again.

Next, I really think the stepwise approach, which is what was suggested to us by others who are far more experienced with this, is not something in which you take a course and the next day do it skin to skin, at least not in our hands. This gradual adoption is good for the patients. I think this is a safe way for us to do it without extending the operation unduly and without pushing the envelope initially.

Finally, in terms of teaching, which I think is an important part of this, the same principle that applied to the staff surgeon applied to the residents. You do not go in on the first day and hand them the instruments and say “go at it” just because you know how to do an open lobectomy. Proctoring each other or invited surgeons is also very important.

Dr John Benfield (*Los Angeles, Calif*). The issue of how one teaches new techniques in surgical intervention is extraordinarily important. It prompts me to recall when video-assisted thoracoscopic surgery using current techniques was first described. The Society of Thoracic Surgeons launched a number of courses. Some of those in the audience taught in those courses, and we taught and monitored one another. Thus how one teaches is important for our patients and for the profession.

One aspect that is important is the use of simulation. Paul Uhlig, when he was the chairman of the Education Committee for the Thoracic Surgery Foundation for Research Education, headed a task force to assess where and how the foundation should direct funding for thoracic surgical education. The use of simulation technology for teaching was among the top 3 recommendations, and arguably it was the priority. Accordingly, I would suggest that simulation technology should be used to teach practicing surgeons and residents rela-

tively new methods, such as video-assisted thoracoscopic surgery lobectomy.

Dr Reed. I think that is an excellent point, and it has clearly been proved in numerous settings that simulation really is the future of education. Unfortunately, I am not aware—and perhaps others can enlighten me—of good simulation programs for thoracoscopic lobectomy. We are currently in the process of setting one up for laparoscopic procedures. I have asked whether the software exists for thoracoscopic procedures, and I was told they did not have it for this company. I do not know which one it was.

Dr Benfield. Unfortunately, I cannot give you the details, but if you like, I would be happy to help you find the information.

Dr Reed. The way we have handled it is to give the residents some experience in the procedure on pigs, and we have also done some cadaver-based teaching courses.

Dr R. Thomas Temes (*Cleveland, Ohio*). I went through exactly the same process you did learning the video-assisted thoracoscopic surgery lobectomy, and the one problem that I had—and I would be interested in hearing about your approach—is the mediastinal node dissection because in the open technique I would do a routine dissection, but I found by the time I had done the video-assisted thoracoscopic surgery lobectomy the time was such that and the position of the incisions was such that it was not really practical to do the mediastinal node dissection. The way I handle this problem is that I routinely perform a mediastinoscopy now on every patient before the lobectomy, and I am curious how you handle the problem.

Dr Reed. First, we have a very low threshold for performing mediastinoscopy, essentially in all patients with T2 disease or greater or anything suspicious on positron emission tomographic scanning. Probably the only patients in whom we do not routinely perform it are those with peripheral T1 N0 disease, although that does not necessarily change what we are going to do. We routinely will perform a mediastinal lymph node dissection, again stressing from my point of view that it should be the same operation, open or thoracoscopic. The angles can be tough. I think that is to be taken into account in placing the ports, yet in some ways a visualization is superior because you can get the 30 degree camera angled so that you are looking right on the paratracheal region. I think in the subcarinal space the trick is the retraction, and that is, I think, a matter of just plugging away and getting used to it, but it is hard. I think the subcarinal, for me, is a little bit more challenging; however, I think that we have been doing the same procedure in terms of dissection, getting the same number of nodes when we look at the final pathology.

Doctor. Can you tell me roughly how long these procedures take?

Dr Reed. Including all the painful ones, and including all teaching, cases it is usually a little over 3 hours, and honestly, that is including many patients in whom we did a wedge resection and waited for a result. This is truly a consecutive series not on a trial. It includes those patients for whom you send off a lymph node, you are not quite sure whether it is positive, you might stop if it were positive. It includes the patients in whom we had difficulty and had to convert to an open lobectomy. They are still included in the video-assisted thoracoscopic surgery lobectomy group. Interestingly, it did not change a lot over time, probably because we were adopting teaching the residents.