Anatomic Lung Resection for Nontuberculous Mycobacterial Disease

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Background. **Chronic lung infections involving nontuberculous mycobacteria are often inadequately treated owing to concomitant lung parenchymal damage, leading to persistence of the offending organisms. Little is known about the results of surgical therapy as part of a multimodality approach to these infections.**

Methods. **A retrospective review was conducted of 236 consecutive patients who underwent anatomic lung resection for nontuberculous mycobacteria disease at our institution as part of a multimodality treatment program.**

Results. **In all, 236 patients underwent 265 operations. The average age was 54 years (range, 23 to 77). Fifty-three patients had prior thoracic procedures. All patients had in-vitro sensitivity testing of cultured organisms, and had several months of guided antibiotic therapy. Special emphasis was placed on nutritional status. Eighty percent of patients had *Mycobacterium avium* complex disease. Anatomic lung resection was performed in all patients, with 126 lobectomies, 55 segmentectomies, 44 pneumonectomies, and 40 mixed procedures. Sixty-seven patients had either muscle or omental transposition. Mortality rate was 2.6%. The major morbidity rate was 11.7%. Average length of stay was 6.5 days. Presence on postoperative bronchopleural fistula was associated with positive sputum at operation and right pneumonectomy, particularly right completion pneumonectomy.**

Conclusions. **This series represents the largest cohort of patients in the literature to date who underwent operation for nontuberculous mycobacteria infection. Surgery for nontuberculous mycobacteria disease may be accomplished with minimal morbidity and mortality. A multidisciplinary approach including targeted antimicrobial therapy and complete anatomic resection is the key to success.**

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Although most clinicians are familiar with the bacterium *Mycobacterium tuberculosis* and the significant lung disease it can cause, other forms of mycobacteria have become increasingly recognized over the last 2 decades as important causes of pulmonary infection. These organisms, the so-called "nontuberculous" mycobacteria (NTM), have been referred to in the past as "atypical" mycobacteria as well as a name coined by our own group: "mycobacteria other than tuberculosis" (MOTT). They are ubiquitous within the environment, found in ground and tap water, soils, food, and on inanimate objects [1]. In contrast to *M tuberculosis* (TB), they are not obligate pathogens and are not spread by person-to-person contact. Rather, they are opportunistic organisms that can cause infection in areas of preexisting lung injury and in those with impaired host defenses. In many affected persons, the exact nature of the host impairment remains obscure. They are resistant to chlorination and other sterilization processes, and thus may remain after standard disinfection.

There are more than 100 types of nontuberculous mycobacteria, yet only a few are important pathogens in terms of human lung disease (Table 1) [2]. *Mycobacterium avium* complex, which includes the avium and intracellulare species, is the most common cause of lung infection. *Mycobacterium kansasii* is another slow-growing mycobacteria usually associated with cavitary upper lobe disease reminiscent of TB. The so-called "rapid growing" mycobacteria [3], named for their rapid identification in vitro, include the species *M abscessus*. These organisms are often resistant to many standard antimicrobial drugs and can be notoriously difficult to treat.

Patients with pulmonary mycobacterial disease present with symptoms consistent with a chronic pulmonary process. Because these organisms are ubiquitous

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Table 1. Nontuberculous Mycobacteria Causing Lung Disease

Slow-growing mycobacteria
Mycobacterium avium complex
M kansasii
M xenopi
M simiae
Rapid-growing mycobacteria
M abscessus
M fortuitum
M chelonae

within the environment, the distinction between contamination, colonization, and true infection can be difficult. The diagnosis usually requires the presence of symptoms, characteristic radiologic findings, and as many as three positive sputum cultures or acid-fast bacilli smears within the last 12 months, after malignancy and other forms of infection are ruled out. Once the diagnosis is confirmed, medical therapy using a three- or four-drug regimen is begun. The treatment failure rate is high, though, when significant lung parenchymal damage is present, either in the form of cylindrical or varicose bronchiectasis (Fig 1), cavitation (Fig 2), or both. At times, the destructive process can progress to liquefaction of the lung parenchyma (Fig 3). The antimicrobial therapy penetrates poorly into these areas of lung damage, which then tend to act as a microbe reservoir to seed relapse at a later date.

The addition of surgery to the treatment regimen, to remove and "debulk" the areas of damaged lung tissue that lead to treatment failure, has been infrequently studied in the past. Little is known regarding the feasibility, optimal technique, morbidity, and mortality regarding these potentially complex procedures. To better understand these factors, we retrospectively reviewed our experience with anatomic lung resection in patients with pulmonary nontuberculous mycobacterial disease.

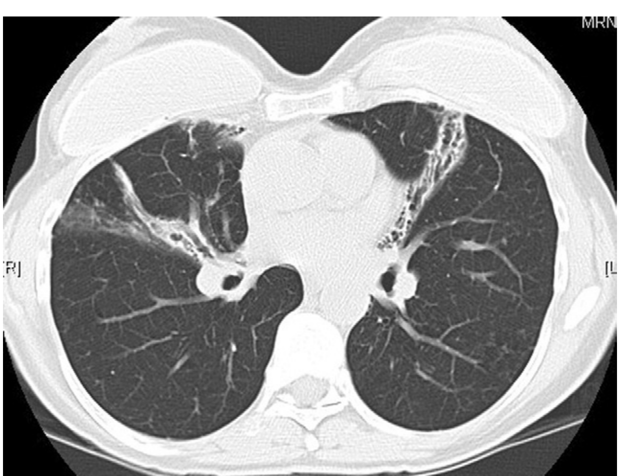

Fig 1. This computed tomography scan demonstrates focal bronchiectasis of the right middle lobe and lingula characteristic of elderly women who present with nontuberculous Mycobacteria infection. (L = left; R = right.)

Fig 2. This scan demonstrates a thick-walled cavity in a patient with Mycobacterium avium complex infection. (L = left; R = right.)

Patients and Methods

We reviewed the hospital records of 236 consecutive patients who underwent anatomic lung resection for nontuberculous lung disease at our institution between November 1983 and December 2006. The study was approved with the need for patient consent waived by the University of Colorado Hospital's Institutional Review Board.

Preoperative Assessment

Patients initially underwent an extensive evaluation at the National Jewish Medical and Research Center in Denver, Colorado, including sputum analysis and radiologic and physiologic testing. Bronchoscopy was performed when appropriate, primarily for diagnostic purposes and to rule out concomitant endobronchial

Fig 3. The pulmonary parenchymal damage can progress in some patients to complete lung destruction, as in this patient with Mycobacterium avium complex disease. (L = left; R = right.)

pathology. Confirmation of the presence of NTM disease was made in accordance with the guidelines published by the American Thoracic Society [4]. Evaluation of culture results included in-vitro susceptibility testing appropriate for the cultured mycobacterial organism. Patients were then typically initiated on three- or four-drug oral antimicrobial therapy, often combined with intravenous antibiotics as indicated. Revisions to the planned therapy were occasionally made owing to intolerance to the initial regimen. The duration of the preoperative antibiotic therapy varied, but typically lasted 2 to 6 months.

A complete nutritional assessment was made at the time of initial presentation, and dietary supplementation was initiated when indicated. In a few patients, this included the use of nasogastric or gastrostomy feeding tubes to ensure adequate intake under the supervision of a nutritional specialist. Rarely, in patients with advanced pulmonary infectious disease (eg, destroyed lung), it proved difficult in our experience to reverse the chronic catabolic state despite our aggressive approach.

Surgery for NTM pulmonary disease is employed only as part of a multimodality treatment approach, and patients appropriate for surgical therapy were discussed at a weekly multidisciplinary conference attended by surgeons, pulmonologists, and infectious disease clinicians with specialization in mycobacterial disease. Indications for surgery included the presence of focal, persistent lung damage (bronchiectasis, cavitation, consolidation, and destroyed lung) amenable to complete anatomic resection after initiation of appropriate antimicrobial therapy. Consideration of surgical therapy occurred for many patients at the initial consultation, when evidence of irreversible, focal parenchymal injury was noted on the radiologic evaluation. In others, surgery was offered after the lung damage failed to improve or even progressed despite adequate therapy.

After the planned duration of preoperative antibiotic therapy, patients returned for repeat clinical and radiologic evaluation before surgery. Computed tomography scanning confirmed the presence of focal disease amenable to surgical resection. Assessment of pulmonary function was made to ensure adequate postoperative pulmonary reserve in view of the planned resection. Nutritional status was evaluated and consultation with nutritional specialists was obtained as indicated. Careful attention was paid to other known or potential comorbidities in this patient population and addressed as needed.

Surgical Technique

Epidural catheters were offered to all patients undergoing an open procedure. Surgical resection was performed with the patient under general anesthesia with a double-lumen endobronchial tube or a standard endotracheal tube with a bronchial blocker. The majority of operations were performed through a lateral thoracotomy incision, with harvest of the latissimus dorsi muscle or intercostal muscle if planned. The previous incision was used in the case of reoperation. For cases of completion or extrapleural pneumonectomy where extensive extrapleural dissection would be used, the fifth or sixth rib was usually removed to facilitate exposure and help define the extrapleural plane. Our techniques used in completion pneumonectomy have been previously described [5].

Adhesions were often encountered throughout the opened hemithorax, particularly involving the diseased lung segment. These adhesions are divided with blunt or sharp dissection, or with the cautery, taking care to identify and preserve vital structures. The planned anatomic resection was then carried out using standard techniques. The pulmonary vessels were ligated either with suture or with a vascular stapling device. The bronchi were closed with either an Endo-GIA stapler (Auto Suture Company, United States Surgical Corp, Norwalk, Connecticut) or with interrupted absorbable suture. The fissures and lines of parenchymal division for segmentectomy were completed using the Endo-GIA stapler, edging or "cheating" a bit to the side of uninvolved lung. We believe this latter point is an important technical feature that ensures complete excision of the infected, diseased lung tissue.

The removed specimens were "double cultured" with samples sent to two separate microbiology laboratories to minimize sampling error. After placement of chest drains, routine techniques were used to close the incision. Blood loss was usually minimal except in cases of totally destroyed lung, extensive extrapleural dissection or in the reoperative setting.

In patients with mycobacterial infection, the residual lung is often poorly compliant and fails to "fill" the remaining space within the ipsilateral hemithorax. If the residual space is considerable, we occasionally employed autologous tissue or limited thoracoplasty, or both, to reduce it. Indications for muscle transposition included not only issues of residual space, but also to buttress the bronchial closure. This latter approach was utilized frequently (although not routinely) in cases of pneumonectomy or particularly poorly controlled infection at the time of operation. Latissimus dorsi or intercostal muscle was used for this purpose. Use of the serratus anterior muscle was poorly tolerated in this characteristically thin patient population, owing to the resulting winged scapula that results from the muscle harvest. In a few cases late in the series, an omental pedicle was used to buttress the bronchial closure after pneumonectomy. The omental harvest was performed by the same thoracic team, and completed through limited upper midline abdominal incision just before the thoracotomy. The technique of omental transposition has been previously reported [5].

Later in the series, a video-assisted thoracoscopic approach was used to perform anatomic lobectomy and segmentectomy in selected patients. Two 10-mm ports and a 5-cm "utility" incision in the anterior axillary line were used to complete the procedure. No rib spreading was used. The resection was otherwise carried out in an identical fashion to the open approach. An Endobag (Auto Suture Company, United States Surgical Corp, Norwalk, Connecticut) was used to remove the specimen

Table 2. Anatomic Lung Resection for Nontuberculous Mycobacteria Disease

Type of Resection	Number
Lobectomy	126
Right upper lobe	27
Right middle lobe	71
Right lower lobe	8
Left upper lobe	10
Left lower lob	10
Segmentectomy	55
Lingulectomy	46
Other	9
Pneumonectomy	44
Right simple	16
Right completion	8
Right extrapleural	3
Left simple	8
Left completion	8
Left extrapleural	1
Mixed procedures	40
Bilobectomy	18
Bisegmentectomy	2
Lobe plus segment	20
Total number of cases	265

from the hemithorax, taking care to avoid contamination of the port sites.

Postoperative Care

All antimycobacterial antibiotics were continued according to the previously established schedule throughout the patient's perioperative course. Intravenous cefazolin was given at the time of the procedure and continued for 24 hours. Routine postoperative care was utilized, with emphasis on pulmonary toilet, pain control, and early patient mobilization. Ongoing nutritional supplementation to standard oral intake was given when indicated.

After discharge, patients received follow up both by our service and at National Jewish Medical and Research Center. Interpretation of intraoperative tissue culture results allowed for further tailoring of antimicrobial therapy, including some assessment regarding duration of treatment. Patients who presented with bilateral disease underwent staged procedures, with the second procedure usually planned for 6 to 12 weeks later.

Results

Over a 23-year period from November 1983 to December 2006, 236 patients underwent 265 anatomic lung resections for NTM disease at our institution. Twenty-seven patients had two (bilateral, staged) procedures, and 1 patient had three operations. The mean age was 54.8 years (range, 23 to 77). The patient cohort was predominately female (83%) and Caucasian (94%). A history of prior thoracic surgery was noted in 53 patients (20%). Reflecting the chronicity and difficulties in treating this disease, these patients had, on average, been treated with three different antimicrobial regimens before referral for surgical intervention.

Mycobacterium avium complex disease was seen in189 patients (80%), followed by *M abscessus* (32 patients,14%), *M chelonae* (13 patients, 5.5%), *M kansasii* (9 patients, 3.8%), *M xenopi* (4 patients), *M simae* (4 patients), *M fortuitum* (3 patients), *M flavescens* (2 patients), and *M bovis* (1 patient). Twenty-one patients had a mixed infection with two or more mycobacterial organisms present. Thirty other patients had a mixed infection with other bacterial or fungal infection, including 15 patients with *Pseudomonas aeruginosa*, and 10 with aspergillis. Despite months of targeted antimicrobial therapy, only 57% were sputum or tissue culture negative at operation.

The most common pattern of focal parenchymal lung disease was bronchiectasis, seen in 55% of patients. Cavitary lung disease was noted in 29%, and a mixed pattern was seen in 9%. Several cases of completely destroyed lung were assigned to the cavitary pattern, although mixed areas of cavitation and bronchiectasis might have coexisted at one time. In 7% of cases, the pattern of disease could not be determined.

The operations performed are listed in Table 2. Segmentectomies other than lingulectomy included the superior segment of either the right or left lower lobe, the posterior segment of the right upper lobe, the anterior segment of the right upper lobe, and the nonlingular segments of the left upper lobe. In this report, the term bisegmentectomy was reserved for cases where segments were removed from two different lobes. A video-assisted thoracoscopic approach was used in 68 cases for anatomic lobectomy and segmentectomy.

Table 3. Morbidity and Mortality After Anatomic Lung Resection for Nontuberculous Mycobacteria Disease

Complication	Number	Percent
Operative mortality	7	2.6%
Respiratory failure/pneumonia/ ARDS	4	
Bronchopleural fistula	2	
Myocardial infarction	1	
Operative morbidity	49	18.5%
Major complications	31	11.7%
Bronchopleural fistulae	11	4.2%
Respiratory failure/pneumonia	9	3.4%
Reoperation for bleeding	4	
Pneumothorax requiring intervention	3	
Wound infection/dehiscence	2	
ARDS	2	
Myocardial infarction	1	
Minor complications	18	6.8%
Atrial fibrillation	9	
Prolonged air leak	7	
Atelectasis	2	

ARDS = adult respiratory distress syndrome.

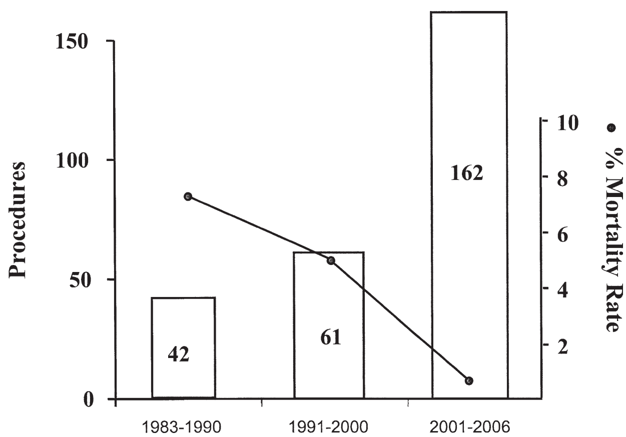

Fig 4. Case volume and operative mortality, 1983 to 2006, by era.

Muscle transposition was used in 65 patients, and omental transposition in 4 patients. Additional procedures included limited thoracoplasty in 6 cases, and creation of an "eloesser flap" or open thoracostomy in 2. The latter procedure was added in these patients after spillage during the lung resection resulted in a contaminated pleural space. One patient presented with severe gastroesophageal reflux in addition to a destroyed right middle lobe due to bronchiectasis, and underwent an uneventful combined thoracoscopic lobectomy and laparoscopic Nissen procedure.

The observed operative mortality and morbidity are detailed in Table 3. We defined operative mortality as any death which could be directly related to the result of the initial operation, even if months later. Seven patients died as a result of the procedure (2.6%), with respiratory failure/pneumonia the predominate cause of death. Postresection bronchopleural fistulae were associated with 2 deaths. The mortality rate has declined steadily from 7.1% in the 1980s, to 4.8% in the 1990s, to the current 0.6% this century for the last 162 patients (Fig 4). Forty-nine patients had complications, for an overall rate of 18.5%, and in 31 patients (11.7%), the complications were serious in nature. Eleven patients had a bronchopleural fistula (BPF) develop, for a rate of 4.2%. Nine patients had respiratory failure or pneumonia, or both, and 4 patients were reexplored for bleeding, including 1 from the muscle transposition harvest site.

Of the 11 patients in who BPF developed, almost all (10 of 11) had positive sputum at the time of surgery, and 82% (9 of 11) of the BPFs occurred after right pneumonectomy. Fully one third of all patients who underwent right pneumonectomy of some type (9 of 27) had a BPF, including 50% of the patients (4 of 8) who underwent a right completion pneumonectomy. In contrast, none of the patients who underwent a left pneumonectomy of any type had a BPF develop.

In the setting of right pneumonectomy, the use of transposed muscle to buttress the bronchial stump closure was associated with a relatively lower rate of BPF formation (5 of 19, 26%) than when transposed muscle was omitted (4 of 8, 50%). A bronchopleural fistula did not develop in the few patients who underwent omental transposition.

Comment

In this report, we describe our experience with pulmonary resection for nontuberculous lung disease. Patients underwent targeted anatomic resection to remove diseased, damaged lung parenchyma as part of a multimodality treatment program. We sought to better define the optimal techniques, morbidity, and mortality for this type of lung resection in this difficult patient population. This study is the largest report to date regarding the early outcomes for patients with resectable pulmonary NTM disease. Our operative mortality rate of 2.6%, which includes both early and late mortality, compares favorably with other reports in the literature. The major morbidity rate of 11.7%, with an overall bronchopleural fistula rate of 4.2%, is also acceptable. However, we were troubled with our BPF rate in this series after right pneumonectomy (33%), and particularly right completion pneumonectomy (50%), despite bronchial stump coverage with autologous tissue in the majority of patients. Although these results are consistent with other studies in the literature, this observation has led us to change our operative strategy after right pneumonectomy. Beyond the perioperative results, we are now investigating the long-term outcomes in these patients to assess the benefits of resectional therapy for patients with NTM pulmonary disease.

Nontuberculous mycobacterial infection is not a reportable disease in the United States, and thus the true incidence and prevalence of NTM disease is unknown. Most experts agree the prevalence exceeds that seen currently with *M tuberculosis* in the United States [6]. Also poorly understood are the mechanisms that lead to clinical infection in some, but not others after clinical exposure to the organism. Certainly, patients with impaired immune defenses, such as those with HIV (human immunodeficiency virus), are at considerable risk, although in the setting of HIV the infection is usually disseminated and not amenable to a surgical approach. In this series, only 1 of 236 patients had HIV. Other groups of patients with impaired pulmonary defenses, such as those with cystic fibrosis or immotile cilia syndrome, are also at risk. In the case of cystic fibrosis, increasing recognition of NTM infection has emerged as improvements in care lead to longer survival for this group of patients.

Patients with preexisting structural lung damage are also at risk of NTM infection. For example, bronchiectasis is both a consequence of and a risk factor for NTM disease. The presence of cavitary disease, including that seen with chronic obstructive lung disease, old granulomatous infection (including TB), and carcinoma can also predispose to superinfection with mycobacterial organisms [7]. Many pneumoconiosis including silicosis also render the affected patient at increased risk [8].

Other reports have sporadically addressed the topic of lung resection for NTM disease over the last three decades. In 1981, Corpe [9] described results with excisional surgery combined with antimicrobial therapy for patients with *M avium* complex disease, reporting a operative mortality rate of 6.9% and a BPF rate of 5.3%. 93% of surviving patients became sputum negative, with a long-term relapse rate of 5%. In 1991, Pomerantz and colleagues [10] detailed our early experience with anatomic lung resection for NTM infection. In that study, 41 procedures were completed in 38 patients, with an operative mortality of 2.4%. The sole death was due to adult respiratory distress syndrome. The presence of BPF, which occurred in 19.5%, was related to right pneumonectomy, positive sputum at operation, a history of prior thoracic surgery, and evidence of polymicrobial superinfection in a destroyed lung before surgery. The results from these early reports in the premacrolide era demonstrated the perioperative difficulties surrounding antimicrobial therapy in this complex group of patients.

In 1998, Nelson and coworkers [11] reported their experience with anatomic lung resection for NTM disease in the postmacrolide era. Twenty-eight patients underwent resection with an operative mortality of 7.1%, and a BPF rate of 3.6%. Eighty-eight percent of surviving patients became sputum negative within 1 month of operation. Similar results were obtained by Shiraishi and colleagues [12] in 21 patients with *M avium* complex infection who had resectional therapy combined with multidrug preoperative therapy. In this study, there was no operative mortality, and the BPF rate was 2 of 21, or 9.5%. Both BPFs occurred after right pneumonectomy. All patients were rendered sputum negative after operation. The high sputum conversion rate is indicative of the synergistic effect of resectional therapy combined with improved antimicrobial therapy.

The need for right pneumonectomy in the setting for NTM disease, particularly in the reoperative setting, remains a daunting surgical procedure. Shiraishi and coworkers [13] reported a BPF rate of 27% in 11 patients after pneumonectomy for NTM infection, all after right pneumonectomy. The presence of bronchial stump coverage with autologous transposed muscle did not reduce the risk. In an earlier report [5], we found an identical BPF rate of 27% in a similar population with severe mycobacterial pulmonary disease requiring completion pneumonectomy. These data combined with our current experience have led us to consider omental transposition for bronchial stump coverage after right pneumonectomy of any type, which in limited experience has reduced our incidence of this troubling complication. The higher rate of BPF after right (versus left) pneumonectomy mirrors the experience after pneumonectomy for other causes, and is likely due to similar factors, perhaps exacerbated by the high incidence of positive sputum seen in our patient population.

In summary, anatomic lung resection for pulmonary nontuberculous mycobacterial disease is both feasible and safe, and can be accomplished with acceptable morbidity and mortality. Careful patient selection combined with a multimodality treatment program utilizing the talents of a broad variety of interested clinicians remain the keys to success. In cases of NTM infection for which right pneumonectomy is planned, the risk of bronchopleural fistula is high and consideration should be given to measures such as omental transposition to mitigate this risk.

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DISCUSSION

DR SCOTT J. SWANSON (New York, NY): Is it pretty obvious to you, John, when to operate on these patients? I mean is it pretty clear or is it hard to tell sometimes?

DR MITCHELL: Most of the time it is, Scott. They tend to fall into two main categories: people with very focal lesions that come, get treated with appropriate antimicrobial therapy for a while, and then come back and undergo debulking or resection of the focal segments of damaged lung; and the other patients have severely damaged lung, like the gentleman with completely destroyed lung, and in whom it's obvious that an intervention is required.

DR JOHN A. ODELL (Jacksonville, FL): I appreciated this talk very much. I worked and trained in South Africa where 25% of my patients were there because of pulmonary tuberculosis. Our incidence of bronchopleural fistula even in patients with positive disease was very much lower than what you have indicated. I just wonder whether you would go into a little bit more detail on your technique. We used to keep all our lymph nodes and other tissue surrounding the bronchus and used it to cover the bronchus. In this country, where lung cancer is the predominant reason for pulmonary resection, surgeons are ingrained to remove those lymph nodes, whereas I think, particularly in patients with inflammatory lung disease, these lymph nodes and surrounding tissue should be retained to surround and cover the bronchus.

DR MITCHELL: Well, a couple of comments. Number one, I think you're talking about a slightly different set of patients. Comparing individuals with "true" tuberculosis versus those with nontuberculous mycobacterial disease—they are not quite the same thing—including their clinical presentation and treatment.

Secondly, I agree with you that the surrounding tissue around the bronchus should be preserved. It's a different sort of operation than when you operate for people with lung cancer. Almost all of our bronchopleural fistulas occurred after right pneumonectomy, and it has been shown in the literature that in other series of pneumonectomy in patients with nontuberculous mycobacterial disease they have had the same sort of problems. I would agree that we need to come up with a better solution to deal with it. We recently have become more aggressive about using omentum, to bring that up to help buttress the closure. We feel that provides better protection than a simple intercostal muscle flap or a latissimus flap.

DR HENNING A. GAISSERT (Boston, MA): John, I congratulate you on your results and on your presentation. You spoke and your abstract speaks about the importance of the nutritional status. What precisely is your nutritional program? How often do you defer resection to improve on the nutritional status?

DR MITCHELL: I would say not often enough, Henning. We try to push nutritional supplementation and we have become increasingly aggressive over this time period in trying to do so. In some patients that means placement of a gastrostomy tube or some similar device to make sure that enough nutrition gets in, but many of these patients are so catabolic at the time of their operation or presentation that even in trying to improve it we have had limited success.

DR NASSER K. ALTORKI (New York, NY): Can you elaborate a little bit on whether or not you demand that patients are sputum-negative before you operate on them, and how long before elective surgery would you require that they remain on antimicrobial therapy?

DR MITCHELL: That's a good question. Despite all the antimicrobial therapy in the world, some of the patients will never be sputum-negative. That patient I showed you with the CT scan of the entirely destroyed left lung, he was never going to be rendered culture-negative. So what we were trying to do in that operation, for example, is to remove the source of infection and try to spare his right lung from becoming similarly involved. So it is optimal to try to render the patients sputum-negative, but it's not always possible.

DR RICARDO S. SANTOS (Pittsburgh, PA): My initial training was in Brazil and, unfortunately, we still have a lot of cases of tuberculosis. Therefore, the Brazilian group has a significant experience in this subject. I would like to make one more comment about the technique for bronchial closure to avoid bronchial pleural fistula.

Our teachers always emphasized the technique for bronchial closure; and they were always using manual suture, not the stapler, because it is still too expensive for the most public academic hospitals in South America. I remember lessons from Dr Frazatto and Dr Forte in São Paulo; and those are the same lessons learned from Dr Craaford in Sweden or Dr Overholt in Boston. They emphasized to close the posterior membrane towards the anterior cartilaginous wall, leaving extra membranous tissue. When you close it laterally, you have too much tension. After that, two pursue strings were made to reinforce the suture and reduce the tension. As we know, those precautions decreased enormously the incidence of bronchopleural fistula.

Well, I don't know if the position that you put the staplers is contributing with the higher incidence of BPF. Other authors (eg, Bazzocchi R, Bini A, Grazia M, Petrella F. Bronchopleural fistula prevention after major pulmonary resection for primary lung cancer. Eur J Cardiothorac Surg 2002;22:160) also suggested using simple interrupted stitches to minimize the bronchial tension. I would like to hear your comments about positioning the stapler device, and the way you close the bronchial stump. Thank you. Congratulations on your presentation.

DR MITCHELL: Well, we could debate the proper closure of a bronchus all day long, and even in our group, we vary somewhat on how to do that, particularly when it comes to right pneumonectomy. So I can tell you that I favor manually suturing the bronchus closed in the setting of right pneumonectomy with leaving an extra tag of membranous wall that you can then bring up and basically close it under zero tension.

DR JOSEPH B. SHRAGER (Philadelphia, PA): John, how many had intercostal versus larger muscle flaps? Obviously it's a lot quicker and easier to take down an intercostal. Is that enough in this situation?

DR MITCHELL: Joe, I did not specifically divide out and count the number of latissimus flaps versus intercostal muscle flaps, although I can tell you that there is a great preponderance of latissimus flaps. By the way, the reason for using muscle flap in this series partly had to do with bronchial stump closure, but some of the time was used to take up space within the hemithorax, in which case, obviously, latissimus is a much better option.