GENERAL THORACIC SURGERY

TREATMENT STRATEGIES FOR BRONCHOPLEURAL FISTULA

Successful management of chronic postoperative bronchopleural fistula remains a challenge for thoracic surgeons. Forty-two patients (33 referred from other institutions) were treated for major postoperative bronchopleural fistula since 1978. Factors associated with bronchopleural fistula included right pneumonectomy ($n = 23$), left pneumonectomy ($n = 8$), long bronchial stump ($n = 16$), pneumonia ($n = 13$), radiation therapy ($n = 12$), stapled bronchial closure ($n = 8$), prolonged mechanical ventilation ($n = 7$), recurrent carcinoma ($n = 6$), and tuberculosis ($n = 2$). Patients had undergone an average of 3.3 surgical procedures to correct their bronchopleural fistulas during a mean interval of 24 months before our treatment. Bronchopleural fistulas were located in the right main bronchial stump ($n = 23$), left main bronchial stump ($n = 8$), right lobar bronchial stumps ($n = 10$), and tracheobronchial anastomosis ($n = 1$). Thirty-five patients were treated by suture closure of the bronchial stump, buttressed with vascularized pedicle flaps of omentum ($n = 19$), muscle ($n = 13$), or pleura ($n = 2$). In seven cases, direct suture closure was not possible, and omental ($n = 6$) or muscle ($n = 1$) flaps were sutured over the bronchopleural fistula. Suture closure without pedicle coverage was performed successfully in one case. Initial repair of the fistula was successful in 23 of 25 patients treated with omentum, in nine of 14 patients treated with muscle and in neither of two patients treated with pleural flaps. In nine patients with persistent or recurrent bronchopleural fistula after our initial repair, four underwent a second procedure (three successful) and five were managed with drainage only. The fistula was successfully closed in 11 of 12 patients who had received high-dose radiation therapy (nine with omentum). Overall, successful closure of bronchopleural fistula was achieved in 36 of 42 patients (86%). Four in-hospital deaths resulted from pneumonia and sepsis, two in patients with recurrent bronchopleural fistula after pleural flap closure. In 16 patients the empyema cavity was obliterated during definitive repair of the fistula. The cavity resolved with drainage in four others, nine had draining cavities at follow-up, and one was lost to follow-up. Ten patients required a total of 17 Clagett procedures and one had a delayed myoplasty. Direct surgical repair of chronic bronchopleural fistula may be achieved in most patients after adequate pleural drainage by suture closure and aggressive transposition of vascularized pedicle flaps. Omentum is particularly effective in buttressing the closure of bronchopleural fistulas. (*J THORAC CARDIOVASC SURG* 1995;109:989-96)

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Successful management of postresection bronchopleural fistula (BPF) has historically been a major challenge for thoracic surgeons^{1,2} and remains so today.³⁻⁶ In the early antimicrobial era, pneumonectomy for tuberculosis carried a risk of BPF as high as 28%.⁷ The best way to manage postoperative BPF is to prevent the problem at the time of pulmonary resection. Every attempt should

be made to avoid disruption of the bronchial blood supply, rough handling of the bronchial mucosa, excessive suture tension, and steroid administration. It has been our practice to use absorbable sutures and to cover all bronchial stumps with pedicled pleura, pericardial fat pads, or even pedicled intercostal muscle in high-risk situations. A recent multivariate analysis by Asamura and associates⁸ of risk factors for BPF in 1360 pulmonary resections for lung cancer identified right-sided resection, pneumonectomy (especially right pneumonectomy), mediastinal lymph node dissection, high-dose preoperative radiation therapy, and residual/recurrent carcinoma at the bronchial stump as technical factors predisposing to BPF. Nonoperative predisposing conditions included diabetes mellitus, hypoalbuminemia, hepatic cirrhosis, and steroid administration.⁸ Despite widespread understanding of these principles, the modern reported incidence of major BPF after pulmonary resection varies from 2.1% to almost 10%.^{3, 8-11}

The initial management of patients with BPF must include thorough drainage of the infected pleural space, antibiotics to treat the infection, protection, and adequate clearance of secretions from the remaining lung. Drainage may be either closed or open so long as it is dependent and complete. Once the infection has been brought under control, the challenge remains to close the fistula and manage the residual space. A vast array of techniques have been used to accomplish these goals, ranging from thoracoplasty,¹² myoplasty,¹³ omentoplasty,¹⁴ and completion pneumonectomy¹⁵ to aggressive combinations of these procedures.⁴ Biologic glues have been applied bronchoscopically to achieve endobronchial closure of BPF in several case reports.^{16, 17} Despite these various measures, postresection BPF carries a mortality ranging from 16.4%⁹ to 71.2%.^{3, 8} Successful treatment of postresection BPF requires adherence to the principles of management, aggressive control of infection, and an individualized approach to each patient. We sought to review our own experience with this dreaded complication to clarify treatment strategies for BPF.

Methods

We reviewed the records of all patients who had been treated for postoperative BPF at the Massachusetts General Hospital from 1978 through 1993. Follow-up was by office records, a written questionnaire, and telephone interviews. Follow-up was complete for 40 of 42 patients for a mean of 37.8 months (range 1 to 153 months).

The details of the original operation and subsequent

treatment were carefully reviewed for each patient. Particular attention was paid to the technique of the initial surgical resection, performance of lymphadenectomy, method of bronchial closure, and prior radiation therapy. Most patients had a chest x-ray film and chest computed tomographic scan to assess the status of the fistula, residual space, and remaining lung. A bronchoscopic examination was routinely performed to assess the location and size of the BPF. Thoracoscopy via the drainage tract was done to assess the size of the cavity, degree of contamination, and adequacy of drainage. Ventilation scintillation scanning with inhaled radionuclides was performed in two patients to confirm the presence of pinpoint BPFs undetected by other methods.

Surgical technique. The technique of muscle flap mobilization and transposition has been well described elsewhere.^{4, 13, 18} We¹⁹ have previously described the technique of omental mobilization/pedicle advancement. The omentum derives its blood supply from the right and left gastroepiploic vessels, which form a vascular arcade within the omentum. Das²⁰ determined that detaching the omentum from the transverse colon provides sufficient length to reach nipple level in 75% of patients. Division of the left gastroepiploic vessels and detachment of the gastroepiploic arch from the greater curvature of the stomach creates a large omental pedicle based on intact right gastroepiploic vessels, which allows the mobilized omentum to reach the base of the neck in 88% and the axilla in 70% of patients. Most commonly, the omentum is transposed to the thoracic cavity for closure of a BPF via a substernal route. It can be placed initially in the substernal tunnel and the abdomen can be closed. The omentum can then be passed through an opening in the mediastinal pleura if it is to be used in an infected area of the thoracic cavity. This precaution may lessen the theoretical risk of intraabdominal sepsis. Alternatively, the omentum may be passed through an opening in the diaphragm directly into either the left or right thoracic cavity. The opening in the diaphragm should be fashioned to avoid compression of the omental vessels and yet not allow intestinal herniation.

Results

Original operations. Nine patients had undergone their original pulmonary resections at the Massachusetts General Hospital; 33 patients were referred to our institution for management of their BPF. There were 33 men and 9 women, with a mean age of 58.7 ± 9.8 years (range 31 to 73 years). Original pulmonary resections resulting in BPF were performed for carcinoma ($n = 32$), tuberculosis ($n = 4$), aspergillosis ($n = 2$), postpneumonic abscess ($n = 1$), posttraumatic abscess ($n = 2$), and destruction of main-stem bronchus by thoracic aortic aneurysm ($n = 1$).

Associated factors. Factors associated with BPF included right pneumonectomy ($n = 23$), left pneumonectomy ($n = 8$), bronchial stump 2 cm or larger ($n = 16$), pneumonia ($n = 13$), radiation therapy

($n = 12$), stapled bronchial closure ($n = 8$), prolonged mechanical ventilation ($n = 7$), recurrent carcinoma ($n = 6$), and tuberculosis ($n = 2$). Patients who had received prior irradiation had been treated with between 4000 and 6800 cGy, from 1 month to 10 years before closure of the BPF.

Prior treatment. Patients referred from other institutions for management of BPF had undergone an average of 3.3 surgical procedures to treat their BPFs (range 1 to 19). The mean interval was 24 months between diagnosis of BPF and referral. These surgical procedures had almost universally included attempts at tube thoracostomy or open drainage and often had included various attempts at suture closure of the BPF, with or without thoracoplasty, or myoplasty (Table I).

Location of BPFs. BPFs were located in the right main bronchial stump ($n = 23$), right lobar bronchial stumps ($n = 10$), left main bronchial stump ($n = 8$), and tracheobronchial anastomosis ($n = 1$). Nineteen BPFs were greater than 1 cm in diameter. Thirteen patients had bronchopleurocutaneous fistulas that were plainly audible through open draining cavities on physical examination.

Initial management of empyema space. Thorough drainage of any remaining empyema space is a sine qua non of successful management of postoperative BPF and was achieved for all patients. Irrigations of the space (most frequently with sterile saline but occasionally with dilute povidone-iodine [Betadine], Dakin's, or antibiotic solution) were performed, usually three times daily. Whenever feasible, patients with large BPFs and large open thoracostomies were treated with debriding dressing changes. If necessary, patients were discharged home for daily irrigations and dressing changes by visiting nurses. Great care was taken to avoid contamination of the patient's remaining lung with empyema fluid or irrigation solution. Any infection of the contralateral lung was vigorously treated with intravenous antibiotics guided by cultures of sputum and empyema fluid. Thoracostomy drainage (either via tube or open window) and irrigations/dressings were continued until the space was rendered clean—as determined by thoracoscopic inspection. Only after these conditions were achieved was definitive surgical repair of the BPF considered. The interval between drainage of empyema and repair of BPF varied from 2 days to several weeks, depending on the degree of contamination and the rate of cleansing of the pleural space. During this interval each patient's nutritional status was maximized. This

Table I. Prior treatment of BPF in 33 patients

Tube drainage	48
Open drainage	39
Suture closure	12
Thoracoplasty	2
Intercostal muscle flap	2
Pectoralis flap	2
Pleural flap	1
Completion pneumonectomy	1
Endobronchial glue	1

sometimes necessitated placement of enteral feeding tubes or parenteral hyperalimentation catheters. The pleural space was cultured before surgical repair to guide selection of antibiotics.

Surgical repair. In our 42 primary repairs of BPF, thoracotomy was performed on the same side as the previous pulmonary resection in 36 cases (30 right, 7 left). Right thoracotomy was performed for a right main-stem bronchial BPF in one patient who had undergone transsternal right upper lobe sleeve resection and in one patient who had a right lower lobe BPF caused by cavitary tuberculosis. A right thoracotomy was done to resect the open left main-stem bronchial stump after previous left pneumonectomy in one patient. Early in our experience, a transsternal/transpericardial approach to the right main-stem bronchus was chosen in two patients with bronchial stumps greater than 2 cm. In four reoperations for persistent or recurrent BPFs, three right thoracotomies were redone twice and one patient had a right thoracotomy to resect the left main-stem bronchial stump after failed repair of a left main-stem bronchial BPF after left pneumonectomy.

Sixteen patients whose bronchial stumps were 2 cm in length or more had resection of the bronchus before suture closure. Primary suture closure (with 3-0 or 4-0 Vicryl suture; Ethicon, Inc., Somerville, N.J.) of the bronchial stump was possible in 35 cases. The closure was buttressed with vascularized pedicle flaps of omentum ($n = 19$), muscle ($n = 13$), or pleura ($n = 2$). In seven cases, direct suture closure was not possible, and omental ($n = 6$) or muscle ($n = 1$) flaps were carefully sutured over the BPF, achieving an airtight seal. Suture closure without pedicle coverage was performed successfully in one case. In the four reexplorations for persistent/recurrent BPF, secondary repairs were buttressed with omentum ($n = 2$) and muscle ($n = 2$).

A total of 21 patients had muscle flaps to buttress primary closure of BPF ($n = 14$), to fill a residual pleural space after omental closure of BPF ($n = 6$),

Table II. Muscle pedicles used in 21 patients

Intercostal muscle	8
Serratus anterior	8
Latissimus dorsi	7
Bilateral latissimus dorsi	1
Pectoralis major	5
Sternohyoid	2
Thoracoplasty $\geq$ 3 ribs	5

or in a secondary repair of a failed omental closure ($n = 1$). The various muscle flaps used in our patients are presented in Table II.

Mortality. Four postoperative deaths occurred (9.5%). All deaths were related to pulmonary sepsis. Two patients had early recurrent BPF after suture closure and pleural flap coverage. The other two patients died of pneumonia and multisystem organ failure with closed BPFs.

Management of pleural space. Management of the residual pleural space was variable. In 16 patients, the empyema cavity was successfully obliterated at the time of repair of the BPF. In five of the 25 patients treated with omentum, myoplasty with or without limited thoracoplasty was performed concomitantly in an effort to fill the pleural cavity. Six cavities were successfully obliterated by omentum only and three by a combination of omentum, muscle flaps, thoracoplasty, or a combination thereof. Seven cavities were obliterated with muscle flaps alone. Remaining cavities resolved with drainage in five cases. Nine patients had draining cavities at most recent follow-up and one patient with a draining cavity was lost to follow-up. One patient underwent delayed myoplasty after successful omental closure of BPF.

The Clagett procedure²¹ was performed in 10 patients to manage a residual pleural cavity after successful closure of BPF. Antibiotics were selected on the basis of pleural cultures. In six patients a single Clagett procedure was curative (60% initial success rate). Four patients underwent multiple procedures (range two to five procedures per patient). Success was achieved in two patients, one patient died, and the fourth has a stable draining cavity. The overall success rate for the Clagett procedure was 80% (8/10).

Fate of the BPF. Initial closure was successful in 33 of 42 patients (78.6%). Omental buttressing was successful in 23 of 25 patients (92%), muscle in nine of 14 patients (64%), and no success was achieved in those BPFs buttressed with pleura (0/2). Successful closure was achieved in one patient treated by

simple suture closure without buttress after left pneumonectomy.

Nine patients had either persistent or recurrent BPF after our initial repair. Four of these patients underwent a second procedure (three successful) and five were managed with drainage only. One patient who had completion right pneumonectomy and muscle flap buttress for radiation necrosis of the right upper lobe bronchus had a recurrent BPF and was successfully treated with a second suture closure and omental buttress, followed by a delayed Clagett procedure. The second patient initially had suture closure of the right upper lobe bronchus with muscle flap buttress and thoracoplasty; recurrent BPF was successfully treated with a second suture closure and omental buttress. The third patient initially had an omental onlay closure of a left main-stem BPF; recurrent BPF was successfully managed by reexcision of the left main-stem bronchus with intercostal muscle buttress via a right thoracotomy. The fourth patient had an unsuccessful intercostal muscle onlay closure of a right main-stem BPF and had a second muscle onlay and subsequent Clagett procedure; a recurrence of BPF 9 months later resulted in sepsis and death.

BPF was successfully closed in 11 of 12 patients who had received prior irradiation (4000 to 6800 cGy), nine with omentum and two with muscle. Initial repair of BPF was successful in 28 of 35 (80%) patients treated by direct suture closure and vascularized pedicle buttress. In five of seven (71%) patients in whom direct bronchial closure was not possible, the BPF was successfully closed by our initial repair. Overall, successful closure of BPF was achieved after primary and secondary procedures in 36 of 42 patients (86%).

Discussion

BPF is best managed by avoiding the complication altogether. Postoperative BPF has become less prevalent with advances in surgical technique based on several principles, including gentle handling of tissues, precise placement of sutures, bronchial closure without tension, avoidance of long bronchial stump and excessive dissection, assurance of disease-free bronchial margin, preoperative control of infection, and aggressive nutritional support of the patient.²² We also believe that use of absorbable simple sutures (4-0 Vicryl sutures) and routine coverage of all bronchial stumps with a vascularized flap contribute to a reduced rate of BPF. Coverage has been accomplished most commonly with the

pedicled pericardial fat pad whenever feasible, because it has been shown both experimentally and clinically to reduce the prevalence of BPF.^{22,23} When this is not feasible, a pleural flap or intercostal muscle pedicle is used. The pleural flap has little bulk and vascularity and may not be optimal for coverage of pneumonectomy stumps.

During the 15-year period of this study, only nine BPFs occurred in 1661 pulmonary resections at the Massachusetts General Hospital (a rate of 0.5%). Eight of these patients had pneumonectomies and one had a right upper lobectomy. Four of these bronchial stumps had been covered with pleural flaps in our early experience, three with pericardial fat, one with an azygos vein pedicle, and one with an intercostal muscle flap.

Risk factors associated with BPF in the present series are consistent with the findings of Asamura and associates.⁸ Of special concern are patients who undergo right pneumonectomy after preoperative irradiation in excess of 5000 cGy. If diabetes, malnutrition, advanced age, steroid administration, or a combination of these are concomitant factors, the risk of BPF is increased. Under these circumstances use of an intercostal muscle flap or even an omental pedicle reinforcement of the bronchial closure should be considered prophylactically at the time of pneumonectomy. This measure has been effective in reconstruction of the previously irradiated trachea and bronchus.²⁴

When a BPF occurs it is most important to ensure proper drainage of the pleural space and control of infection in the remaining lung. Definitive repair should be delayed until the patient is in optimal condition and the cavity is clean. This ensures the greatest chance for success. We prefer a direct transthoracic approach on the same side as the fistula in most cases, regardless of the length of the bronchial stump. We have found this approach suitable even for patients previously treated with high-dose irradiation. For long bronchial stumps the median sternotomy transpericardial approach is an alternative approach. However, it provides less exposure, may present difficulties in removing the bronchial stump, and always necessitates a second procedure to close the pleural cavity. The fistula can always be identified by ventilating above the level of the affected bronchus. A dense thick peel is encountered, making dissection tedious and difficult, but with care and patience the fistula can be unroofed until normal bronchus is encountered. Dissection should be kept on the bronchus at all times to avoid

nearby vascular structures including the divided end of the pulmonary artery. Long bronchial stumps should be resected to healthy tissue and closed with absorbable sutures. This procedure achieves two benefits: pooling of infected secretions is prevented and fresh bronchial tissue is used in the closure, promoting healing. Retention of residual distal stumps, such as after a transsternal approach with bronchial division or stapling only, may lead to recurrent empyema.²⁵ When the stump is too short or rigid or the fistula too large to allow direct closure, the chosen vascularized flap (muscle or omentum) is carefully sewn to the edges of the fistula as if for an anastomosis to achieve an airtight seal. We have preferred interrupted fine absorbable sutures for this. Each patient must be treated individually and the best approach chosen on the basis of the unique set of circumstances presented.

We prefer to buttress all fistula repairs with vascularized tissue. We believe that the omentum is superior to muscle or pleural flaps as evidenced by the 92% success rate for omentum versus 64% for muscle. Three unique properties of omentum make it an ideal pedicle flap for treating BPF. The ability of omentum to induce angiogenesis and neovascularity may be its most important property. Goldsmith and associates²⁶ have demonstrated an angiogenesis factor in omental fat. Morgan and colleagues²⁷ showed that totally ischemic bronchial tissue may be revascularized within 4 days after omental wrapping. Bronchial omentopexy has been shown to reduce the frequency of bronchial anastomotic complications in canine lung autotransplantation²⁸ and allotransplantation.²⁹ Omentum has been shown to revascularize other ischemic organs including brain, heart, and extremities^{30,31} and to relieve chronic lymphedema.³² A second important property of omentum is its ability to function in the presence of established infection. It not only survives, but aids in the elimination of infection.³² This property is often demonstrated in the omentum's natural role as "policeman of the abdomen." Third, the bulk and amorphous shape of the omentum allow it be intimately apposed to the bronchial stump and to fill any irregular cavity.³³ For these reasons we use the omentum preferentially to buttress the repair of BPF. Muscle flaps are reserved for those cases in which omentum is unavailable or single-stage obliteration of the cavity is planned.

The successful closure of major postoperative BPFs in 11 of 12 patients who had received 4000 to 6800 cGy of preoperative radiation therapy was

particularly gratifying. As a general rule, if radiation therapy is over 4000 to 4500 cGy and is given more than 1 year before the operation, healing may be seriously impaired because of depressed proliferation of capillaries and fibroblasts.³⁴ In this situation, the special angiogenetic properties of the omentum are vital to successful repair of BPF. Omental pedicles were used in nine primary and one secondary repair of BPF after radiation therapy. Successful closure and healing were achieved in nine of these 10 cases, despite the longstanding duration of BPF in this subgroup (mean 4.3 years, range 1 month to 10 years).

Reluctance to use the omental flap to control BPF because of fear of intraabdominal sepsis or herniation is unjustified. No episode of intraabdominal sepsis or herniation of abdominal contents occurred in any of the 25 patients treated with omental pedicle flaps.

Management of the residual pleural cavity can be accomplished in a variety of ways. In small, contracted cavities, little space remains after the omentum or muscle has been transposed, and nothing further need be done other than simple drainage. This was true for 16 patients in our series. Simple drainage may result in closure of the space over time if the cavity is kept clean. The length of time needed depends on the size of the cavity and the nutritional state of the patient. A large space can be closed at the time of BPF repair by muscle transposition or thoracoplasty or both. This eliminates the need for a second-stage operation and the inconvenience of prolonged drainage of the cavity. When this approach is chosen, we prefer muscle transposition over major thoracoplasty for cosmetic reasons.

Residual pleural spaces may also be managed in a delayed fashion by muscle transposition or the Clagett procedure.²¹ The cavity must be kept clean and drained during the interval. If a Clagett procedure is chosen the cavity must be essentially sterile and the fistula successfully closed. Compromise on either of these conditions will doom the Clagett procedure to failure. We prefer the Clagett procedure as the least disfiguring, least morbid method of managing a clean residual pleural space. The overall success rate for the Clagett procedure in our series was 80% (8/10). This compares favorably with other reported success rates with the Clagett procedure.³⁵ This gratifying result is likely due to careful patient selection and preparation based on principles of thorough pleural drainage and disinfection and successful prior closure of the BPF, preferably with omental buttressing. It is interesting that seven of

the eight patients successfully treated by delayed Clagett procedure had prior BPF closure with omentum. This may be another demonstration of the effectiveness of omentum in fighting infection.

Conclusions

Optimal results are obtained in patients with BPF by a two-stage approach. First, the pleural cavity is thoroughly drained by closed or open thoracostomy and vigorously disinfected. Second, suture closure of BPF is buttressed by a vascularized pedicle of omentum or muscle. A pleural flap alone is never used to buttress the closure of BPF. The pleural cavity may be simultaneously obliterated, either by the bulk of the omentum or by some combination of myoplasty and thoracoplasty. A less morbid alternative is a delayed Clagett procedure, after successful closure of BPF with omental transposition and thorough cleansing of the pleural space. It cannot be overemphasized that attempted closure of BPF in the presence of suppurative infection is unlikely to succeed. Similarly, instillation of antibiotic solution and chest closure in the presence of infection or open BPF is doomed to failure.

Management of postresectional BPF remains a major challenge. Successful outcome demands strict attention to technical details, optimization of the patient's general condition, and a clean pleural cavity. The method of closure should be individualized for each patient. Direct surgical repair of chronic BPF may be achieved in most patients after adequate pleural drainage by suture closure and aggressive transposition of vascularized pedicle flaps. Omentum is particularly effective in buttressing the closure of BPF.

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Discussion

Dr. Willard A. Fry (*Evanston, Ill.*). I would like to ask you a few questions. First, what are the advantages of omentum over muscle? Second, with the downstaging neoadjuvant programs coming on now with preoperative chemotherapy and radiation, particularly when both models are used, from a preventative point of view, what are your procedures for reinforcing the bronchial closure, particularly with pneumonectomy? Third, in no instance here did you perform an operation that has attracted some attention, and that is the transsternal Perelman approach. I would like you to comment on that.

Dr. Puskas. The advantages that we have seen to the omentum are several, in particular, its natural angiogen-

esis. Goldsmith identified in 1984 a lipid-soluble angiogenic factor isolated from omentum. Morgan in 1982 proved that an autotransplanted bronchial stump wrapped in omentum was revascularized in 4 days, as documented by a celiac angiogram. DuBois and Lima in 1983 and 1984 demonstrated that bronchial anastomotic complications in canine allotransplantation and autotransplantation, respectively, were markedly reduced if the bronchial anastomosis was wrapped with omentum. Those studies were performed in Dr. Cooper's laboratory in Toronto.

The second benefit or natural property of omentum that provides an advantage in buttressing a BPF closure is its bulk and amorphous shape. It can be mobilized from the abdomen, as I mentioned, to reach the apex of the chest in a vast majority of patients, it can be fashioned to fill any residual cavity, and it can be intimately opposed to a bronchial stump over its entire length. Finally, the omentum's natural design by God is to fight infection. It is the policeman of the abdomen, and it performs that role very well, better than any other organ in the body or any other tissue pedicle. Because the major problems with BPFs are ischemia and infection, the natural angiogenic factor of omentum and its ability to fight infection make it a natural choice for a pedicle.

The risk of BPF can be formidable, particularly in patients with downstaged IIIA disease undergoing pneumonectomy, particularly in patients undergoing a right pneumonectomy after irradiation. This risk is further increased in elderly or diabetic patients receiving steroids. Under those circumstances the thoracic unit at the Massachusetts General Hospital would probably buttress that right main-stem bronchial stump with omentum at the time of original pneumonectomy. An alternative would be a vascularized muscle flap, but the prejudice at the Massachusetts General Hospital has been in favor of omentum.

The Perelman approach was used in two patients in our series of 42. The transthoracic/transpericardial approach

was tried briefly in 1980 and 1981 and abandoned thereafter. Dr. Perelman himself has abandoned the procedure for repair of BPF. The Perelman approach through the sternum and transpericardial dissection offers limited exposure, it is technically difficult to perform, and it is probably contraindicated in patients who have had irradiation. To be of any benefit at all, it requires that the stump be long. The purpose of the transpericardial approach, of course, is to staple the bronchial stump and leave it in place. Leaving the bronchial stump in place predisposes to recurrent empyema and to recurrent BPF. Alternatively, approaching the bronchial stump through the thorax allows the bronchial stump to be excised and removed and allows the option of closing or obliterating the pleural cavity at the time of the original repair, accomplishing a one-stage treatment for the BPF. We have found little or no indication for the Perelman procedure in the past 14 years.

Dr. Douglas J. Mathisen. I would like to clarify one point concerning the question that Dr. Fry asked about those patients whose disease has been downstaged with preoperative therapy. In general we have used pericardial fat pad flaps or intercostal muscles in a preventive sense and have used omentum sparingly, but on occasion, in that group of patients. We have used the omentum almost religiously whenever the dose has been in excess of 4000 rads and the duration between the interval when the radiation was given and when we see them is greater than a year. In that case we use the omentum exclusively.

Dr. Fry. In conclusion, is the take-home message that you would reinforce the stump with pericardial fat after a right pneumonectomy in a patient who had had chemotherapeutic downstaging?

Dr. Mathisen. I would probably use intercostal muscle. Many of us have also used the fat pad and would routinely do that in those patients who have had preoperative radiotherapy.