Surgical Treatment of Bronchiectasis

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Directing attention to the fact that anatomists and pathologists had "entirely overlooked" the condition, Rene Laennec, in 1819, originally described the characteristic clinical and pathological features of bronchiectasis. During the century following his brilliant contribution little trenchant knowledge was added to the bewildering pathogenesis and the difficult management of this physically and psychologically debilitating disease. In distinct contrast is the remarkable and fairly recent progress that has been made in the diagnosis and treatment of bronchiectasis through the unified and assiduous efforts of physiologists, radiologists, bronchoscopists, anesthetists, and thoracic surgeons. Strikingly illustrative of this consequence of co-ordination is the spectacular improvement in the operative mortality which has dramatically fallen from over 50 per cent to less than 5 per cent. Thus, within the brief span of approximately two decades this once mystifying and seemingly hopeless chronic pulmonary affection now may be readily recognized clinically and effectively treated surgically.

In order to permit a better comprehension of the management of bronchiectasis and to establish the rationale of early surgical intervention, the insidious development, irreversible pathologic features, natural prognosis and morbidity, and the limitations of conservative therapy deserve consideration. Whereas the etiology and pathogenesis of bronchiectasis remain controversial considerable evidence has accumulated to indicate the pathogenic significance of bronchial obstruction. Undoubtedly this may be due to a number of mechanical influences but one of the most frequent forms seems to be an inflammatory bronchial stenosis associated with upper respiratory infections commonly manifested in childhood as repeated "attacks" of pneumonia but actually due to atelectasis consequent to retained and obstructing secretions. By correlating the progressive clinical and roentgenographic manifestations with the corresponding endoscopic features this "pre-bronchiectatic" stage has been demonstrated. Although there is evidence in some cases to indicate a congenital basis, in the majority a normal lung exists at birth and bronchial dilatations are acquired probably as a result of mechanical obstruction and infection. Previously the
acquired form has been considered a disease of middle age but more recent studies have clearly demonstrated the significant fact that its insidious development usually begins in early childhood. The importance of this realization lies in the fact that by its early recognition and the institution of appropriate measures the progressive development of the disease can be effectively controlled.

Whereas no attempt will be made to discuss the pathologic characteristics of bronchiectasis, some concept of this process will permit a better understanding of the rationale of surgical therapy. In addition to the bronchial dilatations the pathologic process includes destruction of the elastic fibers and muscle bundles of the bronchial wall with extensive fibrous tissue replacement, ulcerative atrophic and hyperplastic mucosal alterations, and varying degrees of chronic inflammatory changes, infiltration, and fibrosis in the surrounding peribronchial tissue and parenchyma. The irreversible character of this pathologic process is evident and it becomes obvious that no method of conservative therapy will restore normal bronchial and parenchymatous structures which have been replaced by fibrous tissue. Although it is agreed that considerable symptomatic improvement may be obtained by drainage of secretions and decreasing infection, the fundamental pathologic changes remain and can be removed only by extirpation.

A real concept of the natural prognosis and morbidity of bronchiectasis and the limitations of conservative therapy also permit a better comprehension of the rational basis of surgical therapy. The previous idea that bronchiectasis is spontaneously curable is no longer tenable and the grave natural prognosis and devastating morbidity of the disease have been conclusively demonstrated by numerous investigators. Of 12 patients observed by Findlay and Graham up to 12 years after onset, 9 had died and subsequent studies on 32 cases emphasized further the gravity of the disease. Of 101 patients with bronchiectasis treated conservatively and followed for a period of three to six years by Roles and Todd, 38 per cent terminated fatally. Of 49 cases treated medically approximately one-half were dead, 9 totally incapacitated and of the remainder only 4 were “dry” 5 years after diagnosis. The natural course of the disease was studied by Perry and King in 400 patients over a 12 year period, 1926 to 1938. Of these 200 were treated nonsurgically and 140 surgically. By January, 1939, only 55 per cent of the non-surgical group were known to be living, 19 per cent were untraced, and 26 per cent were known to be dead. Forty-one per cent of the fatal cases died within 5 years after onset and this was directly attributable to the disease in 78 per cent. Of even greater significance is the fact that of 96 patients in whom the disease
developed before the tenth year only 35 per cent lived more than 20 years after the onset and 9.4 per cent thirty years or more, strongly supporting their clinical impression that the patient in whom bronchiectasis develops before the age of 10 does not live beyond the age of forty. Of the 144 living and traced patients 123 continued to raise sputum and 33 had hemoptysis of varying degrees. Only 38 per cent of these were considered to have good working and living capacity. In a follow-up on 171 patients with untreated bronchiectasis admitted to the Jefferson Medical College Hospital between 1925 and 1935, Bradshaw, Putney and Clerf\(^8\) found that bronchiectasis or its complications resulted in a total mortality of 34.5 per cent and that in these fatal cases the average duration of life from onset of symptoms was 13.5 years. In a similar study of 85 patients with untreated and medically treated bronchiectasis Riggins\(^60\) found that 14.1 per cent died, 41.1 per cent were definitely worse, 46.6 per cent essentially unchanged, and only 13.3 per cent could be considered as improved. Whereas these figures indicate clearly the high mortality attending untreated and medically treated bronchiectasis, the progressive physical and psychological debility constituting the morbidity factor is not sufficiently realized. Considerable impairment in the physical development of these patients begins in childhood and chronic invalidism continues throughout life. Of equal or perhaps greater significance is the psychological handicap which has been emphasized particularly by Churchill.\(^13\) The social ostracism resulting from their unpleasant symptoms is soon manifest and eventually they develop psychological changes varying in degree from mild depressions to actual psychopathic personalities. Thus, it becomes apparent that untreated and medically treated bronchiectasis is attended with a high mortality, a relatively short life expectancy and a devastating morbidity, and that these undesirable consequences of the diseased lung can be eliminated effectively and permanently only by surgical extirpation.

The main objection to surgical therapy has been the prohibitively high mortality attending the early attempts at operation. As previously emphasized, this has unfortunately persisted as a stigma of surgical therapy. Actually the representative mortality of approximately 60 per cent in lobectomy for chronic pulmonary suppuration prior to the last decade should be considered in the light of pioneering spirit.\(^38\) Since the introduction of the single stage lobectomy by Brunn\(^10\) about a decade ago the mortality has steadily decreased and more recent refinements in preoperative preparation, anesthesia and operative technique have reduced it to less than 3 per cent. Over a ten year period, Edwards\(^18\) performed lobectomy in 168 cases with a total mortality of 12 per cent and in
the last 54 cases, the mortality was only 3.7 per cent. Even more significant is the fact that he had no deaths in the 38 patients between the ages of four and sixteen years. Churchill recently reported a series of 124 cases in which lobectomy was performed with a mortality of only 2.4 per cent. These and other recent reports16,22, 23,31,35,39,45 demonstrate clearly that surgical therapy, the only curative measure, may now be considered a relatively safe procedure.

As previously emphasized54 the indications for operation are frequently difficult to delineate and depend upon the age, general condition of the patient, extent of involvement, and character and degree of manifestations. Careful appraisal of these various factors is important and requires a thorough study of each case. Thus, the removal of the lower lobe only in a patient with involvement of the right middle lobe and lingula of the left upper lobe will not cure the patient. It becomes apparent, therefore, that the extent and distribution of the disease must be carefully determined by bronchographic "mapping" of the entire lung.2,30,57 This is best accomplished by lipiodolization64 of the individual lobes under fluoroscopic visualization followed by posterior-anterior, lateral, and oblique roentgenographic projections. By such a study the extent and distribution of the disease process in each lobe may be accurately determined permitting a precise assessment of the extent of operation necessary to produce a cure. Whereas bilateral involvement is not in itself a contraindication to operation it is obvious that such a process is a greater surgical risk than unilateral involvement limited to one lobe or to the right lower and middle lobes and to the left lower and lingula. That unilateral involvement of the entire lung and bilateral involvement of the lower lobes62 are not contraindications to operation is demonstrated by the fact that such cases have been subjected to successful surgical extirpation. Graham24 has reported a successful result in a patient requiring removal of the right lower and middle lobes and the left lower and lingula divisions of the upper lobe. The significance of age in determining operability is shown by the fact that the operative mortality is lowest in children and increases proportionately with age. Thus, Edwards18 observed a mortality rate of zero in 38 patients between the ages of 4 and 16 years, 9.5 per cent in 21 patients between 16 and 20 years, 14 per cent in 56 patients between 20 and 30, 15 per cent in the fourth decade and 31 per cent in the fifth decade. It is the consensus of most observers that operation is rarely indicated beyond the age of 45 which may be explained to a great extent by the fact that most patients do not survive this long unless the process is relatively mild and therefore do not require extensive surgical therapy, whereas those that do have such an extensive distribution that operative cure is precluded. Other factors
such as anemia and infection or their consequences do not necessarily constitute contraindications for they may be corrected by appropriate preoperative measures. Obviously, serious cardiovascular or renal disturbances or other severe complications are considered contraindications just as in any other major operation.

The preoperative preparation of the patient is extremely important and has contributed greatly toward the steady reduction of mortality. Since lobectomy is an elective procedure the necessary time and effort in getting the patient in the best possible physical condition for the operation are thoroughly justified. Every attempt should be made to eliminate sinus and focal infections and clear the bronchi of retained and infected secretions. The latter is accomplished preferably by postural drainage and repeated bronchoscopic aspirations. Immediately before and after the operation bronchoscopic aspiration is also performed routinely. Infection may also be combatted by the use of sulfonamides and neoarsphenamine. In the general rehabilitation of the patient a nutritious diet with vitamin supplements including particularly vitamins B and C is especially important. Appropriate therapeutic measures and even transfusions of whole blood are used to correct an associated anemia.

The significance of anesthesia in increasing the magnitude and safety of intrathoracic surgery is thoroughly realized by thoracic surgeons. The rapid advances and refinements in anesthesia have played an important role in the steady reduction of operative mortality in bronchiectasis. Detailed considerations of this subject have been presented in recent reviews. In a previous publication attention was directed to the important desiderata which are complete control of intrapulmonic pressure, adequate facilities for aspiration of secretions in the respiratory passages during the operation, the maintenance of quiet respirations and high oxygenation, the avoidance of distressing cough reflex, and the rapid return to consciousness following completion of the operation. Whereas the type of anesthesia and the choice of anesthetic agent appear to be matters of personal preference, all are agreed that the availability of a skillful and highly trained anesthetist is essential.

Although variations in the details of operative technique exist depending upon the personal preference and experience of the surgeon and upon the pathological process found at operation, the salient features are now fairly well standardized. The choice of several types of incisions depends upon the presence or absence of adhesions, the distribution and extent of the process, and the performance of pneumonectomy or lobectomy. As previously emphasized the incision should be performed on the basis of permitting adequate exposure, ready adaptability to encountered variations in the pathologic condition, minimal degree of trauma, and ease of
closure. In the authors' experience the most desirable incision for lower lobectomy consists of a postero-lateral approach with the incision beginning paravertebrally and extending forward along the seventh interspace to the anterior axillary line. The pleural cavity is entered through the seventh interspace and the paravertebral portions of the seventh and eighth ribs are divided permitting wider separation (Fig. 1). Occasionally it is more convenient to use an interspace higher or lower depending upon individual variations.

After entering the pleural cavity adhesions are divided by sharp dissection and, for lower lobectomy, the inferior pulmonary ligament severed as high as the inferior pulmonary vein, and the lobe mobilized down to the hilum by separation at the interlobar fissure. Several methods of excision of the diseased lung may be employed,

Fig. 1—Technique of lobectomy for bronchiectasis. (a) Position of patient for operation on left side. A cannula is placed in the saphenous vein immediately anterior to the medial malleolus for the purpose of administering whole blood, plasma, or other fluids during the operation. (b) The pleural cavity is entered through an interspace and greater exposure permitted by separating the rib above and below after their subperiosteal division paravertebrally. (c) The ribs are divided at a slight angle to permit better fixation when the wound closed.
namely, mass ligation, individual isolation and ligation of the intra-
hilar structures, and segmental pneumonectomy. The last proce-
dure may be employed in removal of the lingula and in excision of
the lower lobe with preservation of its large dorsal segment in cases
in which this part of the lower lobe is uninvolved. Pneumonectomy
is occasionally necessary and may be performed by mass ligation
with a tourniquet or individual isolation and ligation.

The advantage of the tourniquet technique of lobectomy lies in
the fact that it obviates tedious dissection and thus permits a more
rapid performance of the operation which may be especially desira-
ble in poor risk patients and it possibly decreases the danger
of accidental serious hemorrhage. Its obvious disadvantages are
due to the inherent results of mass ligation and the consequences
of devitalized infected tissue. The technique of tourniquet lobec-
tomy is relatively simple and consists essentially in mobilizing
the lobe down to the hilum, where the tourniquet is applied and
tightened, and severing the hilar structures just distal to the tourni-
quet. A series of deep interrupted sutures are placed in the hilar
stump until the bronchial and vascular structures are securely li-
gated following which the tourniquet may be released and removed.
A localized empyema invariably occurs and a bronchial fistula is
not infrequent. For this reason intercostal catheter drainage is
always instituted at the time of operation. The subsequent con-
traction by scar tissue results in healing of the fistula.

Whereas in some cases because of difficult accessibility of the
hilar region due to unusual inflammatory adhesions, enlarged
lymph nodes, and rudimentary fissures tourniquet lobectomy must
be employed, intrahilar lobectomy is considered preferable and the
growing tendency toward its wider adoption indicates its value.
It has the obvious advantage of permitting the application of better
surgical principles, complete removal of disease tissue and more
accurate bronchial closure with resultant decrease in postoperative
morbidity. As previously emphasized, however, its technical per-
formance necessitates a thorough concept of the anatomic pat-
terns and variations of the segmental division of the pulmonary
vessels and bronchi. This has been afforded by the recent surgical
anatomical studies of Nelson, Churchill and Belsey, and Blades
and Kent. Based upon the demonstration of four major broncho-
vascular segments these investigators suggest that each lung may
be considered as having four lobes: upper, middle, dorsal, and
lower. The apical portion of the lower lobe constitutes the dorsal
lobe and the lingula of the left upper lobe corresponds to the right
middle lobe. According to Churchill and Belsey, "Each lobe pos-
sesses an independent bronchus and blood supply and is separated
from the adjacent lobes by either a complete or partial fissure, or
Fig. 2—Technique of intrahilar lobectomy on left side. (a) The inferior pulmonary ligament is severed as high as the inferior pulmonary vein which is divided between ligatures and the lower lobe mobilized down to the hilum by separation at the interlobar fissure permitting exposure of (b) the pulmonary artery to the lower lobe with its lingula branch. In cases in which the lingula is also involved and requires extirpation the technique of segmental pneumonectomy as described by Churchill and Belsey may be followed. (c) The inferior pulmonary artery including the lingula division is divided between double ligatures and transfixation sutures and the lower lobe bronchus with its lingula branch exposed. Both of these structures are divided between clamps and the proximal ends closed by the technique shown in Fig. 3g. (d) Clamps are applied across the lung substance between the atelectatic lingula and the remaining portion of the upper lobe in a T-shaped fashion as shown in (e) and the lingula removed by severance distal to these clamps. (f) The defects are closed by a running of atraumatic chromic 0 catgut. (g) The structures of the hilar stump are covered with a pleural flap.
by an avascular plane of cleavage across which no vascular communications are encountered until the hilum is approached." These authors have directed attention to the clinical and surgical significance of the lingula segment of the left upper lobe. They found that "the lingula is also involved sufficiently to demand resection in at least 80 per cent of the cases of bronchiectasis of the left lower lobe." It was also observed that in such cases "commonly the posteromedial bronchi of the lingula bronchus alone is diseased and only rarely are both branches involved." They found anatomically that the lingula bronchus arises from the inferior aspect of the left upper lobe bronchus about one to two cm. from its origin and extends downward and forward to terminate in anterolateral and posteromedial divisions. In cases in which the bronchiec-tatic process involves the left lower lobe and the lingula, the latter is resected following the intrahilar lobectomy by the technique of segmental pneumonectomy described by Churchill and Belsey.15 This consists essentially of individual isolation and ligation of the hilar structures of the lingula and severance of lung substance between clamps applied along the cleavage plane between the lingula and the remaining upper lobe (Fig. 2). This is facilitated by delineating the lingula as the atelectatic segment following first deflation of the upper lobe, temporary occlusion of the lingula bronchus, and then reinflation of the upper lobe.

On the right side in addition to the lower lobe the middle lobe is not infrequently involved by the bronchietatic process.6-43 For this reason the bronchographic delineation of these structures prior to operation is essential. Obviously in such cases extirpation of both lower and middle lobes is necessary for a successful result. However, in cases in which only the lower lobe is involved and requires removal care must be exercised in the intrahilar division of the lower lobe bronchus in order to avoid the inadvertent occlusion of the middle lobe bronchus. The possibility of this accident has been demonstrated by the anatomical dissections of Blades and Kent.7 These investigators found that in a "very appreciable number of instances . . . the point of origin of the dorsal lobe bronchus is either virtually opposite or even above the level of the middle lobe bronchus." Accordingly in cases in which only the lower lobe is to be removed and in order to avoid encroachment upon the orifice of the middle lobe bronchus the dissection must be carried down "along the bronchus until it is possible to divide the dorsal lobe bronchus and the main trunk to the lower lobe at a point distal to the bifurcation which yields the dorsal lobe bronchus"7 (Fig. 3c). Advance knowledge of these anatomic variations may be obtained by careful preoperative bronchoscopic and bronchographic studies. It becomes evident from these considerations that successful technical per-
Fig. 3—Technique of intrahilar lobectomy on the right side. (a) After mobilizing the lower and middle lobes by separation of the interlobar fissure the pleura over the hilum is opened and the inferior pulmonary artery with its middle lobe branch exposed. (b) The artery is then divided between double ligatures and transfixation sutures. (c) The lower lobe bronchus is then exposed, care being taken to recognize the middle lobe bronchus and the bronchus to the dorsal lobe division of the lower lobe. In some cases it may be necessary to divide the dorsal lobe and lower lobe bronchi individually to prevent encroachment on the opening of the middle lobe bronchus. The bronchus is divided between clamps and the proximal end closed as shown in (g). (d) The inferior pulmonary vein is then exposed and its branch from the middle lobe recognized. The vein is divided between double ligatures distal to the branch from the middle lobe. Obviously in cases in which the middle lobe is involved and must be removed the bronchus and vessels of the middle lobe are similarly ligated and divided. (e) The stump of the lower lobe or the lower and middle lobes is covered with a flap of pleura as shown in (f). (g) The technique of closing the bronchial stump consists of placing proximal to the clamp a first row of mattress sutures which are tied after removal of the clamp and a second row of interrupted sutures placed just distal to the first row and tied over the ends of the bronchus.
formance of intrahilar lobectomy depends upon an accurate knowl-
edge and a thorough concept of the anatomic relationship and the
possible variations of the bronchovascular structures.

Following the isolation of the intrahilar structures the vessels
are preferably ligated individually by double ligatures and trans-
fixation sutures of cotton\(^5\) (Fig. 3). The bronchial stump is closed
with simple interrupted sutures over its end and proximal mattress
sutures of cotton (Fig. 3g). The ends of these structures are cov-
ered with a small flap of visceral or mediastinal pleura (Fig. 3f).
Drainage of the pleural cavity is provided by an intercostal catheter
and the wound is closed (Fig. 4). The local application of a sul-
fonamide and its preoperative and postoperative administration to
establish an effective concentration in the blood have been em-

\[\text{Fig. 4—Technique of wound closure. Fixation of ends of divided ribs during}
\text{closure of wound. A small hole is drilled through the ends of each rib a short}
\text{distance from the line of division and a fine stainless steel wire is threaded}
\text{through the holes. The ends of the ribs are held together as the wire is tightened}
\text{and tied. It should be observed that the ribs have been divided at a slight angle}
\text{to permit better fixation. As the rib immediately above and below the incision}
\text{are pulled and held together with hooks paracostal sutures are applied and tied}
\text{as shown in the inset. Thus the edges of the parietal pleura and intercostal}
\text{muscles are approximated and the incision into the pleural cavity closed by}
\text{stabilization of the ribs rather than by attempting to suture the friable parietal}
\text{pleura and intercostal muscles.} \]
ployed as indicated by recent clinical and experimental studies.\textsuperscript{3,11,32}

Pneumonectomy is only occasionally necessary in bronchiectasis as shown by the fact that in 133 pulmonary resections for bronchiectasis Churchill\textsuperscript{14} performed pneumonectomy in only 9 (6.7 per cent). The procedure may be performed in one or more stages and by the tourniquet technique or intrahilar dissection. In the authors' experience the procedure of choice is individual isolation and ligation of the intrahilar structures in one stage. The technical details of this procedure have been described and illustrated in previous publications.\textsuperscript{52,53}

Bronchoscopic aspiration immediately following the operation is routinely performed. The decreased postoperative morbidity resulting from the removal of viscid mucopurulent secretions by this means has convincingly demonstrated its value. Meticulous attention to postoperative care is important especially during the first few hours and days. Precautions taken to combat shock during the operation are continued postoperatively. Thus, routinely before operation a cannula is inserted preferably into the saphenous vein immediately anterior to the medial malleolus\textsuperscript{33} through which a solution of 5 per cent glucose and physiologic saline may be administered slowly during the operation. Compatible whole blood or plasma is always available in the operating room for immediate transfusion in case of serious hemorrhage or evidence of impending shock and such measures are continued for the first few days postoperatively. Oxygen is administered routinely for the first twenty-four or forty-eight hours. Although immediately postoperatively it is considered preferable to keep the patient on his back or on the operative side, later changes in position are encouraged as well as coughing and deep breathing exercises. Vitamin supplements especially B\textsubscript{1} and C are given parenterally until the patient can resume oral feedings. Negative pressure is applied to the catheter which is inspected frequently to assure efficient function. It is allowed to remain from two to four days in cases with minimal contamination and longer in tourniquet lobectomy cases. In uncomplicated cases the patients are permitted to be out of bed within ten days.

**SUMMARY**

1) The rationale of surgical therapy in bronchiectasis is based upon a thorough comprehension of the pathogenesis, irreversible pathologic features, natural prognosis and morbidity, and the limitations of conservative therapy. These features of the disease are briefly considered.

2) During the last two decades the rapid advances and refinements in preoperative preparation, anesthesia, and operative tech-
nique have resulted in a steady reduction in mortality until it has now reached the amazingly low level of 3 per cent.

3) The indications for operation are briefly discussed and the significance of an accurate study of the distribution of the disease process in each lobe in permitting a precise assessment of the extent of operation necessary to produce a cure is emphasized.

4) Appropriate measures in the preoperative preparation and postoperative management of the patient are indicated and their importance stressed.

5) The various methods that may be employed in the surgical extirpation of the diseased lung, namely, mass ligation, individual isolation and ligation of the intrahilar structures, and segmental pneumonectomy are briefly described and their advantages, disadvantages, and indications are discussed. Wherever feasible intrahilar lobectomy is considered the most preferable procedure.

RESUMEN
TRATAMIENTO QUIRURGICO DE LAS BRONQUIECTASIAS

La terapeutica quirurgica racional en las bronquitectasias esta basada en la total comprension de la patogenia, de los caracteres patologicos irreversibles, del pronostico natural, de la morbilidad y de las limitaciones del tratamiento conservador. Estas caracteristicas de la enfermedad son brevemente consideradas.

Durante las ultimas dos decadas el rapido avance y perfeccionamiento del pre-operatorio, anestesia y tecnica quirurgica ha dado como resultado una considerable reduccion en la mortalidad que ha descendido a la admirable cifra de 3%.

Las indicaciones operatorias son brevemente discutidas y se destaca la importancia de un prolijo estudio de la distribucion del proceso en cada lóbulo, lo que permitira establecer la indicacion quirurgica precisa para producir la cura.

Se indican las medidas necesarias en la preparacion pre-operatoria y en el postoperatorio del paciente y se destaca su importancia.

Son brevemente descriptos los diversos metodos que pueden ser empleados en la extirpacion quirurgica del pulmon enfermo, especialmente la ligadura en masa, el aislamiento individual y la ligadura de los elementos intrahiliares, y la neumectomia segmentaria, discutiendose sus ventajas, inconvenientes e indicaciones. Siempre que sea factible la lobectomia intrahilar es considerada el procedimiento de eleccion.

REFERENCES
2 Adams, Ralph, and Davenport, Lawrey F.: "The Technic of Bron-


