Multiple Segmental Resection in the Treatment of Bronchiectasis

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Chest specialists now recognize that bronchiectasis is a disease which in most cases is best treated by surgery. Many reports, especially those of Perry and King,7 and Bradshaw, Putney and Clerf,2 have emphasized the seriousness of bronchiectasis untreated by excision. They have shown that on the average patients having symptoms since early childhood do not live much beyond the age of 30 and that life expectancy after the development of symptoms is only 13.5 years in the fatal cases. Bradshaw, et al12 further found that in the fatal cases the duration from diagnosis to death was only 1.8 years. This came as a surprise to many physicians, who, although they recognized that the patient with bronchiectasis had his “ups and downs,” assumed that most of them went on for an indefinite time without very much change in their condition. An appreciation of the fallacy of this assumption has provided an impetus to the perfection of surgical treatment. Furthermore, the introduction of chemotherapy and the antibiotic drugs has increased rather than decreased the need for excisional therapy. Many patients who would have otherwise succumbed to acute exacerbations are now reconverted to the chronic form of the disease. The chest specialist, therefore, is faced with a problem of caring for more patients who live and suffer longer with the disease.

The changes that have taken place in the surgery of bronchiectasis during the past few years have been outstanding. There

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is little resemblance between the precise dissection and excision of pulmonary tissue as carried out today and the comparatively crude lobectomy by the tourniquet method of a few years past. Gone is the two-stage operation and the prolonged periods of hospitalization. Postoperative bronchial fistulae and empyema instead of being common sequelae are rarely encountered. Formerly one expected a few days to a week of rather profound prostration and critical illness. Now the postoperative course is short, benign, and, surprisingly, not very uncomfortable. What are the factors responsible for these gratifying changes? What are the prospects for further improvement and refinement in the surgical treatment of this disease? Recent experiences and developments which answer these questions will be presented.

In the beginning it was essential that a technique be developed which would result in an acceptable mortality for resection of the simplest units of excision,—a pulmonary lobe or a lung. The dissection technique used in dissecting the hilum of the lobe, now in almost universal practice, has proved to be highly successful. First reports of a reduction to a 3 or 4 per cent mortality have been superseded by others of sizable groups of cases (100 or over) with no mortality or a mortality as low as 1 per cent. Such figures, however, apply mainly to uncomplicated cases with well-localized disease since surgical treatment has been limited in its application by and large to patients suffering from unilateral disease.

It is well known, however, that bronchiectasis is not necessarily a lobar disease. Churchill and Belsey have called attention to the frequency with which the lingular segment of the left upper lobe is involved in cases of bronchiectasis. They also pointed out that frequently the superior segment of the lower lobe is free of disease when basal segments are involved. Blades,1 and Clagett and Deterling have also emphasized the fact that bronchiectasis may involve only segments and have described a clamp and suture method for removing portions of lung of less magnitude than a pulmonary lobe. In our own previously reported experience with bronchiectasis, it was found that in only 15 per cent of the cases was an entire lobe involved. In the majority of cases the disease was found to be multi-segmental. In approximately 30 per cent the involvement was bilateral.

Segmental Localization

Roentgenography and bronchography are the basis of accurate pulmonary localization. The value of fluoroscopy and a study of roentgenograms taken in various projections is well known. An appreciation of the necessity for complete bronchographic study of all bronchopulmonary segments is of more recent development.
For the bronchectasis patient, an intelligent plan of treatment cannot be outlined without accurate knowledge of the condition of all the segmental bronchi. Simply injecting the opaque medium and positioning the patient is not sufficient as frequently some segments will not fill adequately by such a method. We believe a preferable plan is to do the actual injection of the contrast material under fluoroscopic control in order that the segments can be visualized and filled with certainty. The bronchi of both lungs may be mapped out at the same time if roentgenograms in the oblique projections are taken. The oblique position separates the bronchi and prevents overlapping of their images.

A number of acceptable and workable systems of nomenclature for the bronchopulmonary segments have been devised. Jackson and Huber have named the ten basic bronchopulmonary segments of each lung according to their position within the lobe. We have chosen to use their nomenclature (Figure 1). The right and left lungs do not differ greatly. The lingular segment of the left upper lobe is homologous to the right middle lobe. Other changes in the pattern of the segments in the left upper and lower lobes on the left result from a combining of two segments of the upper (apico-posterior) and two segments of the lower lobe (antero-medial).

The main advantage of any of these newer systems of nomenclature is the ability thereby to discuss more accurately anatomical divisions of less than lobal area. With the availability of a precise method of definition, more detailed study and appraisal

**Broncho-Pulmonary Segments**

**Jackson-Huber Nomenclature**

1. Apical
2. Posterior
3. Anterior
4. Lateral
5. Medial
6. Superior
7. Medial Basal
8. Ant. Basal
9. Lat. Basal
10. Post. Basal

**FIGURE 1**: Diagram of the 18 bronchopulmonary segments and their names suggested by Jackson and Huber. This nomenclature is based upon the position of the segment within each lobe. On the left side there are eight instead of ten segments. The left apical and posterior segments have a common trunk. Likewise the anterior and medial basal segments are best considered as one surgical unit because of a common origin of their segmental bronchi.
of disease processes has resulted. It has been generally appreciated for some time that pulmonary absceses, for instance, are frequently situated in the upper posterior part of the lower lobe (superior segment) or in the anterior portion of the upper lobe (anterior segment). The explanation for this is obvious when one appreciates the anatomy of the segmental bronchi supplying these areas. When a patient is in the supine position, the superior divisional bronchus of the lower lobe is directly dependent. The same is true of the anterior segmental bronchus of the upper lobe with the patient in the lateral decubitus position. Thus material from the naso-pharynx or other segments of the lung will find its way into these dependent areas by gravity.

Bronchiectasis likewise shows a predilection for certain segments. Most frequently involved are the basal segments of the lower lobes, the left more often than the right.6 Quite commonly
the lingular portion of the left upper lobe is affected, occasionally by itself but usually in conjunction with the basal segment of the left lower lobe. On the right side the homologous areas are most generally involved, that is, the basal segment of the lower lobe and the middle lobe (Figure 2). Only rarely are other portions of the lung the seat of bronchiectatic changes except when associated with, or as sequelae of, preceding infectious processes. For instance, one occasionally sees bronchiectasis limited to the superior division of the lower lobe following a lung abscess in the same location.

The knowledge that bronchiectasis is usually segmental, rather than lobar, in its distribution stimulated our interest and that of others in the pulmonary segment as a possible unit of excision.

FIGURE 3: Diagrams of the lateral surface of the lungs with the segmental surface areas outlined. Diagrams "A" and "B" show small remaining areas if lobes are used as the units of excision in bilateral bronchiectasis. See Figure 2 for illustration of the most common distribution of bilateral disease. Diagrams "C" and "D" show relative areas conserved by using the segment as the unit of excision in bilateral disease.
Much credit should go to Churchill and Belsey,3 to Blades,1 and to Clagett and Deterling4 for their concept of the problem and for their contributions in the development of the technique of segmental resection. One of the goals in excisional therapy is to eradicate all the disease without sacrificing any normal tissue. If this goal is to be approached in bronchiectasis, segments rather

FIGURE 4: Diagrams of the lateral surface of the left lung illustrating the advantage of employing the segment rather than the lobe in bronchiectasis in adults. Diagram "A" shows the relative size of the segments in a case of bronchiectasis of the lingular and basal segments. The three remaining healthy segments have hypertrophied because the patient developed bronchiectasis early in childhood. As the disease contracted the involved segments, the upper segments of each lobe grew to form abnormally large segments. If surgical treatment is carried out after puberty, any further expansion will take place by a process of simple over-stretching. Diagram "B" shows the over-expansion of the remaining two segments if the entire lower lobe is removed together with the lingula. The resulting emphysema may be pathological. Diagram "C" shows the lateral surface of the left lung after segmental resection for basal and lingular bronchiectasis. The previously hypertrophied superior segment of the lower lobe has been preserved. Its presence greatly lessens the need of the remaining two segments of the upper lobe of undergoing over-expansion.
than lobes become the excisional units for most cases. Furthermore, the conservation of all healthy pulmonary tissue becomes a necessity in treating many patients with extensive bilateral disease (Figures 3 and 4). The marked pulmonary insufficiency of the patient following removal of both lower lobes, the right middle lobe, and the lingula of the left upper may be just as incapacitating as the original disease itself.

Pre-operative Preparation

There seems little doubt but that the use of the antibiotic penicillin pre-operatively has contributed to a safer, smoother postoperative course. Its use after operation is likewise important. Penicillin aerosol and/or penicillin intramuscularly effectively decreases the amount of expectoration and liquefies the material, thus permitting easier and more effective expectoration. These procedures, together with postural drainage, allow the patient to go through operation with a decreased hazard of postoperative atelectasis or pneumonitis from dissemination of the bronchial secretions.

Position During Operation

The contralateral spill-over of secretions during operation has been recognized as a distinct hazard when the patient is operated upon in the side position. To obviate this risk the patient is placed in the face-down position. This new operative positioning has been employed for all types of intrathoracic surgery for the past three years. With the patient suspended by the pelvis, shoulders, and face, the head can be kept lower than the remainder of the body, thus causing secretions to flow toward the patient's mouth without the tendency to contralateral contamination that occurs with the patient in the side position. This face-down position, although developed originally for resection in tuberculous cases, has been very beneficial for resection in cases of bronchiectasis because of the frequently large volume of bronchial secretion.

Patients in the prone position appear to withstand an open pneumothorax better than when lying on the side as the good lung is not encumbered by the weight of the heart and mediastinum, and there appears to be less tendency to mediastinal shift with respiration.

We also believe that the use of procaine anesthesia with endotracheal intubation under cocaine topical anesthesia, rather than the use of a general anesthetic, promotes a smoother convalescence and lessens postoperative pulmonary complications. The cough reflex is not completely inhibited during operation and becomes active immediately afterwards for the patient is conscious enough to cooperate.
Technique of Segmental Resection

Each bronchopulmonary segment has its own bronchus, arterial blood supply, and venous return. Bronchus and artery penetrate through the hilum into the substance of the segments. The venous channels return along the surface of the segments. It is possible to apply the principles of individual ligation technique, as used in lobectomy and pneumonectomy, to the bronchopulmonary segments. After the artery, bronchus, and vein to a segment have been ligated and divided, it is then possible by gentle blunt dissection to separate the diseased from the normal segments. Before this separation is started, the normal segments are inflated by raising the intrabronchial pressure. The line of demarcation then stands out clearly and facilitates separation. The plane is comparatively avascular, and the actual splitting of the lobe is done by blunt dissection mainly by the thumb and forefinger. After the bronchus, artery, and vein to the segment have been divided, the only structure holding the segments together that needs to be separated by sharp dissection is the visceral pleura. This may be divided before the actual splitting of the lobe or afterward. We prefer to do this step last as it is occasionally difficult to accurately define the intersegmental pleural line until the segments are separated. The surface of the remaining segment may bubble slightly, but this usually stops after a moist cottonoid pad has been applied for a few moments. The use of clamps on the lung tissue is avoided and considered hazardous. It is impossible to place the clamps precisely in the intersegmental plane. Either too little or too much tissue will then be excised. No attempt is made to suture over the edges of the remaining segment as it has been found to be not only unnecessary but unwise. Suturing traumatizes the normal remaining tissue and reduces its volume.

Postoperative Care

The after care of the patient following segmental resection is similar to that following a routine lobectomy. Attention is directed toward the maintenance of a free airway and re-expansion of the remaining pulmonary tissue. As a rule two intrapleural catheters are left in the chest—one posteriorly and one anteriorly—and both are connected to under-water drainage with moderate negative pressure of 4 to 8 centimeters of water. The drainage tubes are usually withdrawn 48 to 72 hours after operation provided there is roentgenographic evidence that the pleural space has become obliterated and the lung expanded. In some instances it is necessary for the tube to remain longer if there is still evidence of leakage of air from the pulmonary surface.

Oxygen is not ordinarily required postoperatively. It is felt that
in the absence of definite indication for its use, the deeper breathing that takes place in a normal atmosphere is advantageous in that it encourages more rapid re-expansion. Patients are urged to cough and raise voluntarily, and their position is changed frequently. Any evidence of retained secretions or atelectasis calls for prompt transnasal tracheo-bronchial aspiration or the more positive removal by bronchoscopy. An uneventful postoperative course is largely dependent on the maintenance of a free airway and prompt, complete pulmonary expansion.

Results

The technique of segmental resection has been applied to all segments of all lobes for various conditions. This report, however, is limited to patients with bronchiectasis in whom segments of two or more lobes, or a lobe and one or more segments, were so removed. In the beginning segmental resection was employed only in patients with multi-segmental and bilateral disease. For the patient with unilobar involvement, lobectomy may still be preferable as conservation of all healthy pulmonary tissue is not as imperative.

In our series of patients with bronchiectasis, a total of 53 cases have been treated by one or more segmental resections. Inasmuch as we believe at present the procedure is primarily indicated in multilobar disease, this report has been confined to the 39 patients that have had multilobar resection.

Figure 5 shows the location of the various segments removed. We have found it usually more practical to remove all the basal segments of the lower lobes (3 on the left side and 4 on the right) as a single unit. It is possible to remove individual basal segments, but in bronchiectasis all three left and four right basal segments are commonly involved and therefore the basal group will usually require their group removal. In one bilateral case the individual posterior basal segment was removed and the other three healthy basal segments were preserved.

The discrepancy between Figures 1 and 2 in the number of patients and the number of operations is due to two factors. First, many of these patients have bilateral processes requiring bilateral operations. Often a period of 3 to 6 months or more may elapse between stages. Twelve patients with bilateral disease have not yet had the contralateral lesions excised, but for completeness all the cases have been included. Second, it is our practice to do the most involved side first. Some of these patients are so greatly improved that the minimal symptoms from the contralateral side have not as yet warranted the second operation.

The preponderance of resections of the basal segments of the
left lower lobe and the lingular segments of the left upper lobe is
due to this combination being most frequent in our multilobar
group, and to our practice of generally operating on the left side
first when the lesion is about equally distributed between the
two sides. As mentioned before, the uncompleted bilateral cases
thus weight the figures in this group.

Fourteen patients have had bilateral operations completed. As
a group they are strikingly better than the patients with bilateral
disease treated by bi or trilobar resection. The pulmonary reserve
of most is practically as good as before operation as no normal-
functioning pulmonary parenchyma has been sacrificed.

There was one fatal case in the 39. This one has been reported
elsewhere. The death was not related to the type of resection
performed.

Morbidity and hospitalization for the segmental cases is length-
ened on the average by 4 to 7 days. This is due in part to an
occasional persistent air leak from the pulmonary surface and
also to a desire to keep these patients under observation a little
longer than the patients following a routine lobectomy. We be-
lieve the increased morbidity is not significant when the final
result is so much superior. When the morbidity has been reduced

**FIGURE 5**: Diagram illustrating the various segments that have been removed
for bronchiectasis. There were 39 patients, 26 of whom had bilateral disease.
Upon these patients 53 operations have been completed.
to that of simple lobectomy, then segmental resection should be extended to include the patient with unilobar disease.

SUMMARY

Bronchiectasis is usually a segmental rather than a lobar disease process. Surgical therapy should, ideally, remove all the involved segments without sacrificing any normal pulmonary tissue. Refinements and advances in diagnosis, localization, and surgical therapy now make such a goal attainable.

Fifty-three operations in 39 patients, with one death, are reported. All had at least two segments, or a lobe and a segment, excised. There are 26 cases with bilateral bronchiectasis in which bilateral operations have been completed on 14.

Segmental resection is especially applicable to patients with multilobar involvement where conservation of all normal pulmonary tissue is essential.

RESUMEN

Por lo general la bronquiectasia es un proceso morboso segmentario más bien que lobular. Lo ideal es que la terapia quirúrgica extirpe todos los segmentos invadidos, sin sacrificar ningún tejido pulmonar normal. Los refinamientos y adelantos en el diagnóstico, la localización y la terapia quirúrgica permiten ahora que se pueda alcanzar este objeto.

Se informa sobre 53 operaciones en 39 enfermos, uno de los cuales murió. En todos ellos se extirparon por lo menos dos segmentos, o un lóbulo y un segmento. Hay 26 casos con bronquiectasia bilateral, en 14 de los cuales se han completado operaciones bilaterales.

La resección segmentaria es aplicable especialmente a enfermos con afección multilobular, en los que es esencial que se conserve todo el tejido pulmonar normal.

REFERENCES