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Surgical treatment of pulmonary tuberculosis

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SENIOR THESIS

SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

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THE UNIVERSITY OF NEBRASKA

by

HENRY W. WALTERS

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SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

The operative management of pulmonary tuberculosis is the most important advance in surgery in the twentieth century. This offers to a large group of people a chance to escape certain death and to become permanently well. It also allows these individuals an opportunity to earn a living and to return to their families and communities. The majority of cases operated upon, are those who have shown no improvement by other methods and would surely have died of tuberculosis. The writer takes great interest in the subject having spent three months in the National Methodist Tuberculosis Sanatorium in Colorado Springs, Colorado, and having seen the work of Dr. M. Shivers, a close friend of John Alexander, one of the foremost thoracic surgeons of America. To show the value of surgery on the chest it is necessary to quote a few figures. Of all cases reported we find 37% have been cured, 24% were decidedly improved, 5% were unimproved or worse, 1.5% immediate mortality, 12% died six weeks after the operation, and 19% died of tuberculosis elsewhere.

The history² of the subject is a very interesting one. Brunner states in the 18th century tuberculous cavities in the lung were at times incised upon the general principle of the evacuation of abscesses. Unsuccessfully! In 1873 von Mosler injected potassium permanganate, carbolic acid, and tincture of iodine into cavities. Towards the end of last century a few attempts were made to remove portions of the tuberculous lung, and, in so far as the operation was concerned, one finds a few successes reported (Tuffier, Doyen, Stretton). At the international Medical Congress in 1913, in London, Macewen of Glasgow showed a patient in whom, nineteen years before, he had removed in several sittings the whole of one lung. This has remained an isolated case. The classical hygienic treatment inaugurated by Brehmer

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about the middle of last century rendered unnecessary so serious an operation in the incipient and moderately advanced cases, while no one, when faced with the therapeutic problem involved in the very advanced unilateral chronic lesions, has had the courage to imitate the celebrated Glasgow surgeon.

But in the case of patients with moderately or even far advanced disease, the procedure of artificial pneumothorax, devised in the early eighties by Forlanini, came by gradually to be recognized, because of its relative safety and its remarkable efficiency, as marking an epoch in the treatment of many forms of the disease. This therapeutic measure has been accepted for the last twenty years as standard under special circumstances. It was clearly suitable only to patients in whom the disease was chiefly unilateral, and the pleural space free. If the pleural space were blocked by adhesions, air could not be introduced, or if part of the pleural space were free, that part was apt to overlie the relatively healthy portions of the lung, usually the lower lobe, while the upper lobe, the site of chief disease, remained uncompressed. And, inasmuch as it was well recognized that the principle of this treatment, lay in the putting at rest and the compression of the diseased lung, it followed that some other method in such cases had to be found which might satisfy this principle. This other method lay but a short step ahead. In 1888 Quincke perceived it, though only in part. He saw that tuberculous cavities could not be healed by incision because the surrounding tissue was hard and fibrous and the cavity could not collapse of itself. Release from this tension was necessary; and he, therefore, advised the resection of several ribs including the periosteum overlying the cavity, and he looked for a falling in of the lung and an indrawn scar. Carl Spengler, in 1890, independently of Quincke, took a further step. He was the first to recognize the necessity of a free mobilization of the chest wall, and he proposed the resection of the third to the seventh ribs

posteriorly, and to this operation gave the name, which it still retains, of extrapleural thoracoplasty. Turban, in 1899, and Landerer, in 1902, supported the contention of Spengler and published encouraging case reports. It was Brauer who first realized fully that the extraordinarily good effect of a successful pneumothorax could be practically equalled by rib resection, provided that such resection was a more extensive one than that proposed by his predecessors. He postulated the hypothesis, since abundantly confirmed, that a complete removal of the ribs of one side of the chest would bring about a collapse and compression of the lung as a whole, almost, if not quite equal to that resulting from a total pneumothorax. Calling to his aid the Marburg surgeon, Friedrich, he was able in 1908 to report eight cases of this operation---that is, a complete removal of the second to tenth ribs inclusive, from the transverse processes around to the junction of the cartilages. Of these cases, six yielded a satisfactory result, while two died of the operation. In a later series he had to admit an operative mortality of 28 per cent. This was prohibitive. Parenthetically, the first patient operated on by Archibald in 1912, according to the Brauer-Friedrich technique, even though the operation was divided into stages, died on the sixth day of mediastinal flapping and cardiac failure. The operation simply had to be made safer. It was realized that the other lung and the heart could not stand the removal of so great an extent of rib support. Wilms, to offset this danger proposed his "columnar resection." He removed only 3 to 4 cm. of the first to the eighth ribs inclusive, posteriorly, and if necessary a similar small resection in front from the rib cartilages (1911). To Sauerbruch, however, belongs the chief credit for establishing the operation upon a relatively safe basis. Gradually he worked out the type of operation which holds the field today, as the best for the majority of cases. He called it a paravertebral extrapleural thoracoplasty. The principles of his method

lay in this (he maintained), that the whole structure of the thorax can fall in properly only when all supports, including in particular the first rib and the tenth and eleventh ribs, are removed. Boiddin had already shown, in his work on chronic empyema, that this falling in of the chest wall was best accomplished when the extreme posterior ends of the ribs were removed, so that Sauerbruch's method insisted, as a rule, upon the resection of 4 to 8 cm. of all the ribs save the twelfth, from their attachment to the transverse processes forward. In 1913 Sauerbruch was able to publish a series of 43 cases, with a comparatively low mortality and a gratifying measure of success. By the year 1920 his series had risen to 381 patients and in 1927 it was over 700.

The best clinical work depends on exact pathological knowledge, therefore we believe a short statement of the pathological processes of pulmonary tuberculosis with which the surgeon should be familiar before he undertakes to operate may not come amiss.

The Germans, particularly Ranke, Frankel, and Albrecht and Aschoff and Nicol, have classified the pathology into main types, the exudative and the productive. The histological reaction in the exudative form, which is always a more or less acute process, consists in the collection of a fibrin-containing fluid in the lung parenchyma, together with the usual cellular elements, represented by lymphocytes, polynuclears, red cells, and cells exfoliated from the alveolar walls. The amount of fluid thrown out, in and around the foci of bacillary irritation, approximates the condition to that of lobular or even lobar pneumonia. When one considers the fate of such a tuberculous exudate, one must keep in mind, as has been convincingly demonstrated by the XRay work of recent years, that resorption of the exudate, within the space even of a few months, may be almost complete. An exudative tuberculosis may disappear almost like an ordinary lobar pneumonia. Yet such, of

course, is not the usual result. Caseation begins in the middle of the cell exudate, progresses, and involves the alveolar wall and the surrounding lung parenchyma with the stroma. A restoration to normal is then impossible. Failing further progression, the caseous focus, with its surrounding granulation tissue, may dry up, and may be turned into scar and with a surrounding ring or capsule of fibrous and hyaline tissue, in which calcification may ultimately appear. On the other hand, the caseous focus may break down, the end result being cavitation. If the resistance is strong, the exudative acute form may turn into the chronic productive type. If not it goes on to bronchopneumonic, or pneumonic phthisis.

The productive form is characterized by a relative absence of fluid exudate. It leads rather to the formation of the typical tubercle and tuberculous granulation tissue, such as we are accustomed to see depicted in textbooks. The tubercle, in its early stages, is composed of endothelial cells, which in places fuse and form giant cells; these are surrounded by lymphocytes, alveolar cells, and proliferated cells from the stroma and vessel walls. The number of giant cells, the relative isolation of the tubercle, and the lack of surrounding fluid exudate are considered as a measure of the productive type of reaction. Such a tubercle is apt to destroy the tissue of the host more or less completely in its own microscopic field, and in particular the elastic fibers. Restoration is impossible; but in revenge, the defensive forces of the host play here a stronger role than is usual in the acute exudative form. While caseation of the center of the tubercle, with sloughing out, expectoration, and the formation of small cavities, frequently occurs, it is perhaps no less frequent to observe a hyaline and fibrous transformation of the whole tubercle into a solid scar; or at least the formation of a dense fibrous capsule around a minute, inert, caseous mass. The exudative form is generally held to represent an acute process, and

to be the result of a massive or highly virulent infection; the productive type to be the result of infection by a few bacilli, to which is opposed a strong defense. In general the latter tends toward healing, the former toward breaking down. The one is nodular, the other is pneumonic or bronchopneumonic in type.

Each patient must be scrutinized however, not only as to the condition of the lung at the time of operation, but also as to the general clinical course of the disease from its onset. Resistance is the keynote to prognosis, and it must be said with all possible emphasis that in respect to surgical operations upon the tuberculous patient some evidence of resistance must be demanded. The evidence of resistance is scar formation, the fibrosis ending in scar formation and the scar tissue contracts which can be discovered in physical examination and by XRay.

The surgeon is concerned only with pulmonary tuberculosis as seen in late adolescence and in the adult, and not that of childhood. The most favorable type is that of a "good chronic". These fill the greater part of the surgical field. They show the evidence of scar contraction. Cavity formation, though usually present is not excessive. The lung may be honey combed over a small area with small cavities, or there may be a single cavity in the apex, which is at times as large as an egg; but the general condition is good. Such a patient has been watched for months or years; his disease seems to have come to a standstill, but he is troubled with persistent cough and a moderate amount of sputum, containing bacilli, and he is practically condemned to spend the rest of his life in a sanatorium, or at any rate away from his home. He is a constant danger to his community if his sputum contains bacilli. As to his future, the outlook in the course of the next few years is not really good. He has to fear a gradual progression of the disease and ultimate invasion of his good lung or of the other organs. He lives in that fear. He is exposed meanwhile to the dangers

of hemorrhage, of flare-ups, of bouts of fever. He is unable to work; or if able to work, there is constant danger risk of excessive fatigue and consequent activation. This class constitutes the best type for thoracoplasty.

Secondly there are the chronics who are showing signs of "slipping". There is going on a quiet but steady progression of the disease and enlargement of cavities even under bed rest. They are apt to run for long periods of time a fever of 99° to 100° F., with a pulse of 80 or 90. They have in the past shown good resistance, fibrotic contraction is evident, but this resistance is now failing, though slowly.

There are still others, the "bad chronics," who represent a further stage in the progress of the disease. Here we find persistent fever and well marked rise of pulse rate, with steady loss of weight; and in the lung considerable and increasing cavitation. If in these less favorable cases we still discover the evidence of previous resistance in contraction, if the disease is still chiefly unilateral, and if destruction has not gone on so far as to excavate a large part of the lung, operation may still be justifiable, though carrying with it a greater risk, inasmuch as sometimes its effects are quite extraordinary.

On the other hand, if in these chronic cases it is clear that there has occurred lately an acute exudative process, a fresh invasion of other parts of the lung, with appearances in the XRay films suggesting a bronchopneumonic process, then we must regard the patient as being in a negative phase and as likely to stand operation badly. In all such circumstances the therapeutic plan should lean very much towards a continuation of rigid bed rest together with, possibly, the establishment of an artificial pneumothorax. Recently active lesions may be influenced in a particularly favourable way by pneumothorax,

which effectively puts the lung at rest; but thoracoplasty, which does the same, represents a much more formidable interference, and should be reserved for some later period when the patient, through these measures, has recovered his resistance and has perhaps cleared away the recent acute exudate.

The right choice of cases is undoubtedly the greatest factor influencing the success of operative procedures. Alexander gives as his indications¹, "those patients having moderately or far advanced chronic tuberculosis, with or without hemoptysis whose lesions are of fibro-ulcerative type, with or without cavitation or empyema, and are principally confined to one lung, whose general condition, heart, and individual resistance to tuberculosis are fairly good and in whom all other treatment including a sufficiently long sanatorium regime and attempted pneumothorax, have failed, are chosen for operation." He also states that:

1. There must be close cooperation between the tuberculosis specialist and the surgeon;
2. Ten percent of tuberculous patients need compression, about one half being benefited by pneumothorax, less than one half requiring thoracoplasty.
3. In regards to the time for operation, it should not be attempted until artificial pneumothorax has failed and not until the patient has "cured" for many months and has lost ground steadily, operation at present is a last resort.
4. He gives a chart illustrating the importance of selecting the patients with the productive type of lesion. He classifies the patients into three groups.

Group I. Having clinically unilateral lesions with cirrhotic productive lesions.

Group II. Predominantly productive but some exudative lesions,

sub-febrile, the better lung being involved.

Group III. Rapidly progressive coarse, predominantly exudative lesions, febrile, poor general condition.

	Early death	Late death	Worse and unchanged	Better	Free of T B Bacilli	Cured
I.	3%	3%	3%	17%	34%	4%
II.	5%	9%	12%	32%	28%	14%
III.	25%	29 %	18%	15%	13%	0%

5. The general condition of the patient is an important factor. Even very sick patients stand the operation well. The operative shock is slight if done in two stages and a good anaesthetic given. He considers the following as poor risks.

- a. Emaciated cachectic individuals.
- b. Stout people poorer risks than the lean.
- c. Persons of abnormally poor resistance and having a bad family history
- d. Those having high fever, dyspnoea, and rapid heart.
- e. Those individuals above 15 years of age and below 45.
- f. Sex has no effect upon the prognosis.
- g. Right sided involvement are poorer risks than left. Of 100 cases reported:
 1. 57 were left sided---40.4% were cured 17.5% deaths
 2. 43 were right sided---32.5% were cured 32.5% Deaths
- h. Worse lung of acute caseous exudative type rather than chronic fibrous, exudative.

Archibald and Alexander agree as to the contra-indications which are as follows:

1. Disease in other organs as acute nephritis, diabetes, serious cardiac lesions, etc.;
2. Exudative lesions or active lesions in good lung;
3. Intestinal tuberculosis----use XRay;

4. Bilateral kidney involvement---unilateral involvement is not;
5. Laryngeal tuberculosis is not a contra-indication on the other hand it usually shows improvement;
6. The location of the disease is not a big a factor as the resistance of the individual whether it be in the intestine, joints, or larynx;
7. In case of pregnancy an abortion should first be done.

Hedblom³ gives the following as indications for a two or three stage operation-----extrapleural thoracoplasty:

1. Chronic unilateral fibroid phthisis;
2. Adhesions preventing artificial pneumothorax of the diseased portion of the lung, not sufficiently collapsed by phrenic nerve resection;
3. Persistently recurring sterile effusion;
4. Fixation of the lung in a collapsed position preventing re-expansion after pneumothorax collapse;
5. Excessive displacement of the mediastinal structures, after healing of the tuberculous lesion;
6. Infected tuberculous empyema;
7. Severe or recurrent hemorrhage, in case adhesions prevent artificial pneumothorax.

His contraindications are as follows:

1. Rapidly progressing unilateral disease;
2. Active progressive tuberculosis in the opposite lung;
3. Active or extensive extrapulmonary tuberculosis;
4. Conditions contra-indicating any major surgical procedure;

Multiple stage operations may be indicated in the following types of cases:

1. Patients with mixed fibrous and exudative adhesions;
2. Patients with moderately extensive healed, or localized quiescent lesions in the opposite lung;

3. Extrathoracic tuberculosis of mild grade, or non-tuberculous disease;

4. Patients with symptoms of recurrence following the posterior extrapleural thoracoplasty, symptoms being referable to the incompletely collapsed lung;

5. Childhood and advanced age when operation is otherwise indicated.

Edwards⁴ considers the right choice of patients the most important factor influencing the after results of surgical procedures. "In considering this factor, as a general rule acute early phthisis is excluded so far as all major surgical procedure is concerned. The cases which are almost invariably submitted are those of the chronic third stage type. The chief factor influencing ones choice is the condition of the "better lung." "It is extremely rare that there is no evidence, either clinical or radiological, of the previous existance of contralateral disease. This alone is not necessarily of significance, but one adopts as a working hypothesis the rule that this disease shall have shown no activity for at least months before operation:"

"Cases in which artificial pneumothorax has been induced and carried on for some time ---months or even years----and in which, following cessation of refills, the disease becomes active again, almost invariably respond well to major surgical collapse. It is only rarely possible to reinduce the artificial pneumothorax, and time should not be wasted in other measures before submitting these cases to thoracoplasty."

"Another type in which thoracoplasty is of great value is that in which either during artificial pneumothorax therapy or as a result of spontaneous pneumothorax, fluid develops, which later becomes purulent."

"Cases in which drainage of an infected tuberculous empyema has been performed should, other circumstances permitting, be submitted to thoracoplasty, as soon as is reasonably possible, since delay may result in the establishment of lardaceous disease".

"Apart from the types mentioned previously it may be taken in general that thoracoplasty is indicated in all those cases in which complete unilateral artificial pneumothorax is indicated, with the proviso that more care should be devoted to establishing the presence or absence of active disease in the better lung, and that early cases should be given an extended trial of all other medical measures before operation is considered."

Schouwald gives us his observations on ninety thoracoplasties performed on forty-five patients. "Thoracoplasty is indicated if:

1. The patient cannot reasonably be expected to recover without surgical intervention;
2. The disease is far advanced and unilateral;
3. Extensive adhesions render the induction of a satisfactory artificial pneumothorax impossible;.

Schouwald evaluates the great importance of a careful study of the contralateral lung. "In seven of the cases, the other lung showed some involvement, in the majority of these cases even some activity being present. Four of them or 57 percent are dead; two or 28 percent are arrested; one, or 14 percent is still ill. Of ten cases with slight and inactive involvement of the contralateral lung, four or 40 percent arrested; 3 or 30 percent dead; 3 or 30 percent ill. The remaining twenty-two showed nothing in other chest. Two or 9 percent are dead; sixteen or 72 percent are arrested and four or 18 percent are still ill."

"Thoracoplasty is contraindicated, if the general condition of the patient is very poor, the hemoglobin below 60 percent or a severe

*See page 120 for
Observations
on thoracoplasty*

tuberculous complication somewhere else in the body exists. Moderate laryngitis is no contraindication. We have encountered it in one case."

"Tuberculous enteritis, has proven to be the most unwelcome and fateful complication. Of the fatalities five were due mainly to enteritis. In only one case has the condition cleared up satisfactorily." Of the two cases of pneumonic type, one died probably due to syphilis, the other had a good result."

Schiffbauer⁶ agrees very much with Hedblom in his indications and contraindications.

Davies believes, with one exception a thoracoplasty should not be done until artificial pneumothorax has been tried and has proven valueless. "It is sometimes easy to decide that the amount of gas which it has been possible to get into the pleural cavity is insufficient to be of any value; but occasionally it is very difficult to determine when an artificial pneumothorax which is producing a partial collapse and is exercising a slight control on the symptoms should be given up. In such cases the benefit of the doubt may be given to a more prolonged trial of the pneumothorax in the exudative type of case without cavity formation or much secondary bronchial change. Where there is extensive fibrosis, however, with dilatation of the bronchi and bronchioles, or cavities, it is probably a waste of valuable time to continue with the pneumothorax; this should be abandoned in favor or a thoracoplasty."

Having considered the indications and contraindications of thoracoplasty, we shall take up the preparation for operation. Alexander¹ recommended the following:

1. Anaesthesia as given by "CRILE" for thyroids;
2. Forcing of fluids (1 liter of 5% sodium bicarbonate and two ounces of paraffin in the bowel;
3. Pressure with pneumothorax is released;

4. Sedatives----bromides given night before;
5. No purgation;
6. Empty lungs---expectoration two hours and again one hour before operation;
7. Prepare skin.

Archibald² recommends the following:

1. That the surgeon study patients condition during several days before operation in respect to amount and character of sputum, the exact location of cavities, and the strength of the heart;
2. Give opiates if necessary to give the patient several good nights sleep;
3. Give special attention to diet and supply extra feedings;
4. On morning of day of operation give fair amount of fluid preferably with glucose or some form of sugar, up to three hours before the operation.

Schonwald⁵ states, "Our preoperative management has been very simple, consisting of some digitalization in cases where a fast pulse or a marked accentuation of the second pulmonic seemed to warrant some cardiac support. Normal saline and glucose given intravenously sometimes during the operation or immediately afterwards. In more resistant cases we give it by proctoclysis. Caffeine-sodium-benzoate and camphor are valuable as stimulants, when needed. Sufficient morphine or pantopon is given to alleviate the post-operative shock, pain, and cough."

Decker⁸ states, "Unquestionably, there is considerable shock attached to thoracoplasty, so that preliminary stimulation with digitalis, caffeine, and ephedrin is often advisable, and again, post-operatively. There is a loss of hemoglobin, often amounting to five or ten percent after a complete thoracoplasty. Because of lowered vitality, wound infection should be guarded against by extreme care in local skin preparation and subsequent technique."

There is a difference in opinion as to the conduct of the operation. Most men believe the operation should be done in more than one sitting, the number depending a great deal on the condition of the patient, the majority being done in two sittings. Alexander and Lilienthal believe in removing the upper ribs first, on the ground that it is important to preserve the action of the diaphragm and the lower chest for purposes of efficient cough. They believe that the reverse method is responsible for an undue proportion of post-operative pneumonias. Sauerbruch's method has always been to remove the lower ribs first. By securing a collapse of the lower lobe, which is the more healthy portion, he believes that he prevents a later aspiration from apical cavities when he comes to do the second stage and compares the upper lobe. Archibald² supports Sauerbruch because, "A brief trial of Alexander's method seemed to show that the danger of spreading the disease was greater when the upper ribs were removed first." Schonwald⁵ reports, "We have in most of our cases followed Sauerbruch's argumentation and started with the resection of the lower ribs. In six cases only have we followed Lilienthal's and Alexander's suggestion, to begin with resection of the ribs of the apex. Among these are our cases of immediate post operative mortality and another casualty. It seems to me that the danger of aspiration and congestion is greater with this procedure, as Sauerbruch has pointed out many years ago, because most of the lungs which require thoracoplasty show the important pathology, especially cavities in the upper lobe, while the lower lobes contain more breathing lung tissue."

Brunner⁹ follows out the Sauerbruch operation. He also maintains, "There is still a divergency of opinion as to whether the operation should be carried out in one or two sittings. A number of surgeons advocate, on principle, the operation in two stages. We are of the opinion that here, too, no hard and fast rules should be laid down. We continue to maintain, with Sauerbruch, that the one-stage operation

has been an advantage over the other, provided all the circumstances justify it. The compression is of better appearance and more regular when the eleventh up to and including the first rib are resected in one sitting. And what is still more important: the patient is only subjected once to the certainly heavy psychological pressure to which he is exposed by an operation carried out by means of local anaesthesia. The chief conditions for thorough success are naturally a satisfactory general state of health and a good heart functioning. If these conditions are not complied with, it is advisable to operate in several stages.

As to the type of anaesthetic employed we find most men giving local anaesthesia, novocaine (0.5% for the skin, and 1% for the intercostals). Many men also employ gas-oxygen in addition to the local.^{1,2,4,5,8,9} Some men also employ morphine to control the cough. Ether and chloroform are but seldom used.

The skin incision varies with the operator. Sauerbruch makes his incision several centimeters from the vertebral spines and parallel to them, over the back muscles. Portions of the ribs are removed varying according to the compression desired. Alexander gives the following lengths in describing the Wilms-Sauerbruch operation:

Rib I 3 cm. removed
 Rib II to V 5-8 cm removed
 Ribs VI to VIII 12-15 cm. removed.
 Ribs IX and XI 12-6 cm removed

The total being about 110 cm. The average interval between the first and second stage is two weeks. It should be less than six weeks. The most important features of the operative procedure according to Hedblom³ are as follows:

1. Rigid asepsis;
2. Efficient regional anaesthesia, with or without ethylene gas anaesthesia;

3. Resection of the first to and including the eleventh, rib, flush with the transverse process;
4. Resection of sufficient length of rib to secure an adequate collapse;
5. The number of stages, and the intervals between them, should be graded according to the condition of the individual patient;
6. A secondary antero-lateral costectomy should be performed if necessary for an efficient collapse.

The immediate results within the^{1,2} first few weeks are frequently most gratifying. Cough and sputum are diminished to an encouraging extent. Fever, if previously present, disappears, although the pulse is apt to remain moderately rapid, and shortness of breath may be increased. After a few weeks the sputum may again increase in amount, and then fall gradually to its minimum during succeeding months. The patient shortly begins to feel better generally; appetite improves and weight is gained. There is often a quiet, steady improvement which reaches its maximum only after a year. All these good effects are ascribed partly to the actual compression of diseased tissue, with retardation of lymph flow, and consequent diminution of toxic absorption, partly to the induced state of physiological rest of the lung. Fibrosis is given a fresh stimulus, through the lack of continued toxemia, through an altered venous circulation, and through the general improvement in resistance. The walls of cavities are brought into contact either wholly or partly, according to their size and the condition of the lung about them, and are thus given some opportunity of becoming obliterated by granulation. In favorable cases the lung is so diminished in volume as to resemble a spleen. In cases, however, showing extensive destruction, the cavities may be so large that obliteration is impossible and accessory operations may have to be done later to increase the collapse of the lung. Such, however, are advisable

only if the degree of destruction is not too large, the heart reasonably strong, and the general condition of the patient not seriously toxic.

The post-operative care. After the operation Archibald² supports the whole side by long straps of adhesive, running from the opposite shoulder around across the abdomen to the opposite iliac crest, in order to reduce the excursions of paradoxical respiration. Moderate cough is allowed, morphia being lessened. Excessive unproductive cough is controlled by codeine or heroine. If the sputum becomes tenaceous and is causing an irritating, unproductive cough and expectorant is given.

Schonwald⁵ straps the side after the skin wound is healed; but not too tightly, with elastic adhesive; which he later replaces with an el goetz splint. He keeps the patient at a complete rest in bed for at least two months, and then has him gradually moved out of bed, provided that his symptoms have completely subsided. After one year the patient may, as a rule, be allowed to return to a more or less normal life.

Early Mortality. The most recent reports show a mortality of 7 to 10 percent.

Some of the causes of early death are paradoxical respiration with flapping mediastinum, pendulum air, and the serious loss of vital capacity, which can for the most part be avoided by strict observation of the rule which forbids doing too much at one time.

The second most important cause lies in the development of an acute tuberculous infection of the sound lung, either by aspiration of cavity contents or by acute activation of pre-existing disease.

The third important danger lies in heart failure from myocarditis.

A fourth cause consists in novocaine poisoning.

A fifth is acute absorption of tuberculo-protein.

A sixth is wound infection, either as a violent sepsis or from secondary hemorrhage.

Late Mortality. Deaths not ascribable to the operation. 15 to 20 percent. The particular lesions in any given case, especially such lesions as very extensive cavitation, the particular resistance of the patient concerned, the character of his post-operative care or environment, the amount of exercise allowed, the chance complications of other types of infective diseases, the coincident lesions of the heart, kidneys, and other organs concerned with metabolism----all these things have to be considered as causes of ultimate death. Therefore one must expect a late mortality during five to ten years after the operation of around 20 percent.

There are certain other operations which will now be considered. The first of these is the phrenicotomy which is the paralysis of the phrenic nerve. This brings about a rise in the level of the corresponding diaphragm to the extent of 1 to $1\frac{1}{2}$ inches.

It is assumed that this not only reduces to a slight extent the capacity of that side of the thorax, but also limits the excursions of the corresponding lung during respiration. It has been extensively used of late by some surgeons as a preliminary measure several weeks before an ordinary thoracoplasty in order to procure the largest degree of collapse possible. It is perhaps more useful when used to test out the resistance of the good lung in patients, who, being otherwise fit subjects for a thoracoplasty, give evidence of some disease on the good side which is possibly active. Under these circumstances a primary phrenicotomy frequently imposes a slight strain upon the good lung and if there exists active disease on the good side the patient may not do well; whereupon it becomes clear that a thoracoplasty is contraindicated.

A third indication for phrenicotomy consists in its value as a secondary operation for the easier maintenance of an artificial

pneumothorax. It has been found that phrenicotomy retards the absorption of air, so that refills can be made at much longer intervals than usual.

The operation of phrenicotomy, technically, is not a difficult, but demands exact anatomical knowledge. Archibald⁴ prefers the vertical incision at the posterior border of the sterno-mastoid muscle, to the transverse incision just above the clavicle as used by Alexander. The sterno-mastoid is drawn inwards, and the areolar tissue lying under it and just outside the jugular vein is discovered, whereupon one can easily feel the scalenius anticus muscle. The nerve crosses this muscle obliquely from without inwards, and is found immediately underneath the thin fascial sheath, through which it can be seen without trouble. The jugular vein may have to be drawn inwards. The mere cutting of the nerve is insufficient, according to Felix, in nearly one fifth of the cases, as accessory branches join the main nerve lower down in the thorax; consequently Felix has devised the gradual evulsion of the nerve, called exeresis, in order to be sure of removing these last. If only a temporary paralysis, lasting for months, is desired, the nerve may be injected with alcohol or, perhaps better, as advised by Yates, may be simply crushed with a heavy forceps. The removal of two to three inches of the nerve is considered sufficient, but often it is found that practically the whole nerve is drawn out. The avulsion is painful and demands a few minutes of general anaesthesia, though the nerve is easily exposed under local anaesthesia.

The indications^{7,10,11,12} for phrenic evulsion are:

1. In cases of basal tuberculosis. It can be tried also in cases of basal bronchiectasis, but it is only rarely that any real or lasting success is obtained;
2. In cases of chronic basal effusions with thickened pleura; partly to reduce the space, and partly to relieve the dragging sensation;

3. In cases of more generalized tuberculosis when artificial pneumothorax has been tried and has failed;

4. For the relief of symptoms such as pain, dragging, cough, and tachycardia;

5. As an accessory to artificial pneumothorax, when the base of the lung is adherent. It is also of particular value in that it lengthens the intervals between refills. Hemidiaphragmatic paralysis is said to help in preventing effusions or in checking the recurrence of them, but this is challenged by some;

6. As a preliminary to thoracoplasty;

7. As a prophylactic measure, to prevent the later development of bronchiectasis in a case with unresolved basal pneumonia;

8. As a preliminary procedure in artificial pneumothorax, especially when cavities are moderately thick-walled, and where the pneumothorax will be carried indefinitely;

9. As a preliminary procedure to artificial pneumothorax when the cavities are thin walled and situated in the infra-clavicular region. Phrenicectomy under these circumstances may result in a complete closure of cavities and pneumothorax be unnecessary;

10. In moderately advanced pulmonary tuberculosis that has shown no improvement following three months routine bed rest;

11. In patients clinically well who have a unilateral lesion and a persistently positive sputum in the absence of definite cavitation;

12. In those individuals, who, by reason of temperament, or lack of normal intelligence or self control, are unable to bring themselves to undergo routine sanatorium care, and the prolonged fight and self-denial necessary for recovery, phrenicectomy is helpful;

13. In acute and progressive pulmonary tuberculosis, phrenicectomy may slow the progress and initiate improvement. The negro falls within the latter two indications.

Honan gives as indications:

1. All incipient cases;
2. Those cases in which artificial pneumothorax is desirable but cannot be attained;
3. A preliminary step in cases for which thoracoplasty is necessary.

Another surgical procedure is extrapleural pneumolysis which has now narrowed itself to apicolysis. It is used where there exists chronic disease which is strictly limited to the apex, the rest of the lung being healthy. It is a limited operation for limited disease. The operation consists in resection of some three inches of the second rib in front, and the stripping of the lung, keeping outside the parietal pleura, over the entire attic. The space is then filled with some solid substance as abdominal fat (Tuffier), soft paraffin (Baer), and pectoral muscles (Archibald)

Apicolysis is indicated as a late supplementary operation to thoracoplasty to compress the apical cavity which has been insufficiently compressed.

Another surgical procedure is the cutting of pleural adhesions but this is successful only when done by highly experienced men which a Thorascope Jacobaeus, Watson and a few others attempt it.

Alexander gives a procedure in which he cut the intercostal nerves but this is not accepted by many as a good procedure.

SUMMARY.

The surgical treatment of certain forms of pulmonary tuberculosis has now come to stay, yet the bulk of the profession remains in the dark concerning its beneficent possibilities. The indications are very limited and the surgeon must be very well acquainted with the progress of the patient before he attempts any surgery.

The surgery will not replace the medical treatment of pulmonary tuberculosis but it will rescue from death and repair the health of a great number of individuals who are doomed to die unless aided by surgical treatment.

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How about work of Everts Graham, etc.
all of them?