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THE SURGERY OF PULMONARY TUBERCULOSIS MAIN PRINCIPLES *

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The only method which deserves consideration in this connexion is the one dealing with the continuation of artificial pneumothorax treatment. All other attempts at treating the disease surgically—for example, by drainage of cavities or lung resections—have long ago proved fruitless. On the other hand, the pneumothorax principle has proved to be so relatively effective as to encourage its use also when localized adhesions compromise the effect, or when adherent pleura prevents the establishment of an artificial pneumothorax. In these cases the pneumothorax principle can be carried out only by operative measures.

The operations can be considered in two groups: (1) operations which intend to transform an ineffective artificial pneumothorax into an effective one by removal of localized adhesions; and (2) operations which intend to replace an artificial pneumothorax which, on account of more extensive adhesions, cannot be made effective or cannot be established at all.

Theories

Before the different methods in this classification are mentioned one must explain how the pneumothorax really acts. Many theories have been in vogue during the history of artificial pneumothorax, and most of them have had to be abandoned. The mere name "collapse therapy," the term in general use, expresses an interpretation which requires thorough revision. This name would indicate that an artificially produced collapse of the lung tissue causes a better resistance of the tissue and thereby a quicker arrest of the disease.

To explain this effect different hypotheses have been formulated, such as immobilization of the organ, compression of the tissue causing local stasis of the blood- and lymph-circulation, and an increased tendency to fibrosis. Recent physiological and pathological research has shown that these supposed factors are not present at all or, if they are, that they do not exert the influence which is claimed. The more the clinician has worked with these methods the more evident it is that the effectiveness of this principle must be explained in another much simpler way.

The only theory which will withstand criticism is that of "relaxation" as the effective principle of this therapy. The aim should not be to stimulate the lung tissue to increased resistance by active compression, which cannot be done, but to leave the active factors of healing to the organism itself, and only in a more passive sense to establish conditions for the lung to exert its own spontaneous tendency for retraction. Such conditions are not present so long as the lung is kept expanded in the thorax cavity;

the result is that cavities form which cannot close spontaneously. In short, this treatment has one aim: to make the closure of cavities possible by relaxing the tension of the lung. A more suitable name, therefore, would be "relaxation therapy."

The reason that this theoretical question is emphasized is that it has more than theoretical interest. The correct interpretation of the effect forms the necessary basis for the right use of the method. It is indispensable for considering the proper indications, and for deciding the principles of technique as well as for choosing among the different methods suggested.

Indications

According to the theory of relaxation the indication for operative measures only arises when there is a tendency to spontaneous retraction, and when this tendency requires improved conditions for the effective closure of the cavity or cavities. So long as the tuberculous process is in an active stage with fresh infiltration or a tendency to spread any major surgical intervention is likely to do more harm than good. The patient's immunity is already strained, and the strain added by the operation and the after-treatment may cause a serious or even fatal result.

Before a major intervention is ventured upon the disease must have reached a certain degree of demarcation. To assist the body to reach this stage conservative treatment only is indicated. It is much more important that the right phase of the disease be reached than that it should be unilateral. Unilateral disease may be quite unfit for surgical treatment, whereas bilateral disease may be fit for treatment on one or on both sides. The decision whether a case is ready for surgical intervention must be made from the indications, general and local, which show respectively a rise in the power of immunity and a demarcation of the process in the lung.

The general criteria of a phase favourable for surgery are a normal or only slightly raised temperature and stationary or increasing weight. Complications, especially in the larynx and intestines, need not be a contraindication; but they do contraindicate so long as they are under development, thus expressing a temporary or more permanent drop in the resistance power of the patient. These general symptoms, known from old times, should not be undervalued. They are not, however, always sufficient for a reliable judgement to be made. Even when the general condition is apparently good the phase of immunity may be unsafe for more radical treatment. To the old criteria must therefore be added some of more recent discovery. The blood sedimentation rate gives comparatively clear information about the development of resistance; this

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rate, tested by serial examinations, ought to show a decreasing scale. While the rate is increasing, or keeping high, great care is advisable.

The sedimentation rate, however, is not always reliable, since it may be influenced by irrelevant factors. More reliable information is given by serial examination of the blood picture, the leucocytes being counted differentially by the Arneth or Schilling method. The "shift to the left" of the leucocytes seems to indicate more surely than any other sign the present reserve of immunity. So long as this examination shows an increase of young leucocytes compared with older ones it is wiser, so far as possible, to postpone any major operation.

The local criteria showing a demarcation of the process are to be judged chiefly by serial x-ray examinations of the lungs. So long as the films show large foci of fresh infiltration and spread, the indication for surgical treatment is not present. When the x-ray examination shows a demarcation in the form of excavation without further dissemination spontaneous retraction can be expected to begin; only then is it time for the surgeon to intervene, if the process is unlikely to heal by Nature's help alone.

Taking into consideration the principles here stated, the indications may be summed up as follows. Although artificial pneumothorax can be induced or attempted without any serious influence on the reserve power of the immunity, and should not be postponed until adhesions have formed, major surgery in pulmonary tuberculosis should be kept in the background until the power of immunity has been regained and the local findings show sufficient demarcation and retraction to justify operative relaxation. As a rule there is no risk in waiting until the conditions are the best possible. Surgical treatment should be considered an addition to Nature's spontaneous healing, making this permanent instead of merely temporary. Any procedure under conditions which are not in accordance with these principles should be carried out only on vital indication, and as such may be the only chance of helping the patient. Experience, however, shows that the results of operation on vital indication are very poor.

Principles of Technique

The theory of relaxing the tension of the affected part of the lung has modified greatly the technical problems of this treatment. Both in artificial pneumothorax and in thoracoplasty the original idea was to accomplish a total collapse of the lung. In artificial pneumothorax this was achieved by using positive pressures to keep the lung compressed, often to extreme degrees. In thoracoplasty the same idea made the total operation the usual one even in cases of localized upper lobe affections. These methods, still favoured by several schools, should be replaced by a more reasonable technique, the aim of which should be to secure sufficient relaxation of the affected part of the lung, while the sound parts are kept expanded, fit for continued function.

Thus from the principle of total collapse has developed the principle of selective relaxation. This development has several advantages. It saves respiratory function, thus causing less invalidity to the patients. It has reduced the risk of the operations, it has made it possible to perform most of the operations in one stage, and it has enlarged the field of intervention by extending it to bilateral cases, in which both lungs may be treated by these partial measures in varied combination. All these advantages have been obtained without loss of effect, for statistics show improved permanent results.

This is also due to another factor. Along with the limitation in extent, the modern technique has increased its intensity. Not only does it intend the least possible

waste of function, but also it has been developed with the earliest possible effective closure of cavities in view. Many shortcomings of the old-fashioned methods have emphasized the importance of this demand. The way to achieve this is to individualize the technique according to the size and exact position of the cavity, and to secure the relaxation of the lung in such a manner that the retraction can take place in the correct direction—namely, concentrically. It may not be sufficient to obtain a simple collapse from the side towards the mediastinum; in many cases the relaxation from above downwards or antero-posteriorly is equally or even more important.

The progress which has been made in technique enables us to pay attention to all these details on which depends the success of the treatment. It is necessary to observe each case individually, and to study the exact position of cavities and the localization of adhesions to the chest wall before the suitable operative treatment can be planned. Not until one knows exactly where tension is present in the thorax should one attempt to relieve it.

Choice of Methods

Working along these main lines it is found that the problem involved in the choice between the innumerable methods suggested is simplified. At the same time the operator is encouraged to change from one method to the next, if the first one tried does not fulfil expectations.

(1) The first method to be tried in practically all cases is artificial pneumothorax. When this succeeds at once in producing a selective retraction no further measures are necessary. Unfortunately the number of such cases represents a small minority. The formation of adhesions is such an early feature in the course of pulmonary tuberculosis as to make an adhesion-free artificial pneumothorax very rare. Scarcely 10 per cent. of artificial pneumothorax cases will be found to be totally or practically free from adhesions; these, when present, are naturally localized around the focus of disease, the relaxation of which is all-important.

Instead of trying, by positive pressure in the artificial pneumothorax, to enforce the closure of the cavity against localized adhesions at the expense of the sound parts of the lung, an early recourse to cauterization is advisable. The operation of Jacobaeus deserves to be more widely applied than it has been up to the present. Through the thoracoscope one can ascertain whether the adhesions can be severed. The operation itself in experienced hands is of great value in increasing the efficacy and reducing the shortcomings of an artificial pneumothorax immediately as well as permanently.

The time ought to be past when a contra-selective artificial pneumothorax—which means that only the sound part of the lung is collapsed, while the affected part is kept expanded by large surface adhesions—is continued for months or years. Statistics show that such contra-selective artificial pneumothoraxes are not only of no benefit, but actually give the patients a slightly worse prognosis. To continue this state of affairs cannot be too strongly deprecated. An artificial pneumothorax of this type, where cauterization as a rule is not practicable, should be replaced, as soon as the general and local condition allows, by a selective thoracoplasty.

A word of warning against other methods suggested to help an ineffective or contra-selective artificial pneumothorax. Oleothorax, as a whole, is in disharmony with the principles of selective relaxation, and this may be the reason why severe and most disagreeable complications so often occur. In very special cases of lower lobe cavities this method may still be of some value, but its efficacy is so limited that it is considered justifiable to abandon it

altogether. Continuation of artificial pneumothorax combined with local operative treatment must as a whole be considered inadvisable. Either the artificial pneumothorax should be made effective, or it should be replaced entirely by a selective or total operation.

(2) The main surgical methods for replacing a contra-selective or impracticable artificial pneumothorax are: (a) interruption of the phrenic nerve; (b) apico- or pneumo-lysis with wax plugging; and (c) thoracoplasty.

Some other suggestions have been made, such as scalenotomy, interruption of the intercostal nerves, etc., but they do not deserve further attention in this survey.

(a) Evulsion of the phrenic nerve, crushing, alcoholization, or other methods of temporary and permanent interruption of the nerve have claimed an attention far beyond all reason, from the point of view of the main principles here stated. The phrenic operation is contradictory to the idea of selective relaxation when used in cases of upper lobe affections, which represent the great majority. The statement that the paralysis of the diaphragm acts equally well on the apex as on the base of the lung has not been verified by statistical research on the permanent results of this operation. The only effect which is certain is that paralysis of the diaphragm reduces considerably the function of the lower lobe. When the lower lobe is sound this reduction may be a great disadvantage to the patient; it may—as has been shown by recent research—be a handicap in establishing an effective operative relaxation of the apex. The sooner it is realized that phrenic interruption should be abolished in apical or subapical affections the better. The method, however, still has its uses, not as a "test operation," still less as a preparatory operation to partial upper lobe intervention, but only as an attempt to close cavities in the lower lobe, middle field, or near the hilus.

(b) Apicolysis, with plombage, when undertaken after exact localization of the cavity, may be considered the most selective of all methods. It is attractive also on account of the relatively small demand on the patient's reserves and its elegance as an operation. On the other hand, this method is handicapped partly by the tendency for serious complications to occur in the earlier or later after-treatment and partly by its effect being inferior to thoracoplasty. It has become more and more recognized that the closure of cavities takes place more slowly and less frequently after apicolysis than after a well-performed thoracoplasty. The final judgement on apicolysis has not yet been passed, but at the moment its popularity seems to be on the decline.

(c) Thoracoplasty, in virtue of its more modern technical improvements, is the method holding the leading place in this group of operations. Here particularly the intensity has been developed at the expense of extent, thus combining greater effect with less risk. "Total" or "sub-total" thoracoplasties with resection of eight to eleven ribs should now be reserved for the more extensive affections and the larger empyemas, while more localized affections should be treated by partial operations only. The types of operation which should now be adopted are the "upper partial" thoracoplasty, in which six or seven ribs are resected to treat upper lobe affections, and the "apical" thoracoplasty with resection of only four or five ribs to treat purely apical cavities. These two types of operation must be individualized according to the size and exact location of the cavity, the length of each rib resected being so planned as to allow complete retraction to take place. The two upper ribs especially may have to be removed in their entirety, which can be accomplished through the paravertebral incision alone.

Even the most radical removal of the upper ribs may yet be insufficient to close the larger or less accessible cavities. The most radical relaxation from the side towards the mediastinum is not always sufficient to close the cavity which remains as a slit between the collapsed chest wall and the upper mediastinum. This experience has made surgeons combine the operation of "partial-upper" and "apical" thoracoplasties with apicolysis (without plugging), performed extra-pleurally or extra-fascially. By this addition to the technique the suspension of the apex of the lung, or rather of its adherent parietal pleura, can be so loosened as to allow the apex to sink down in the collapsed thoracic cavity, and shrink not only from the side towards the mediastinum and antero-posteriorly but also from above downwards.

Results

The progress which the surgery of pulmonary tuberculosis has made, when performed along the lines here stated, is evident when the improvement in the results obtained is considered. This will be demonstrated in different ways from the material of Vejleljord Sanatorium. The material, now amounting to more than 1,600 cases treated since 1907, including those of pure artificial pneumothorax, has recently been statistically reviewed. Many interesting details have been revealed by this examination, the value of which has been increased by the fact that it has been possible to trace 100 per cent. of the patients.

Out of the large statistical material only two tables will be demonstrated here, as proof of the progress which has been made.

TABLE I.—Operative Mortality in Thoracoplasty

	Case Nos. 1-200	Case Nos. 201-400	All 400 Cases
At the end of first week ...	11=5.5 %	4=2 %	15=3.7 %
" " second week	(+4) 15=7.5 %	(+7) 11=5.5 %	(+11) 26=6.5 %
" " sixth week...	(+10) 25=12.5 %	(+7) 18=9 %	(+17) 43=10.7 %

1. The material consists of 450 cases of thoracoplasty operated on since 1916. The operative mortality is shown in the table, from which it will be seen that the risk connected with this operation has gradually been considerably reduced.

TABLE II.—Fitness for Work in Percentages, Fifth Year after Discharge in each Consecutive 100 Count of Treatable Cases of Artificial Pneumothorax and Operative Treatment

Vejleljord Sanatorium, 1907-32

2. The accompanying curve shows the results of an examination of the permanent results in the first 900 cases considered suitable for "collapse" treatment (including artificial pneumothorax cases). The cases are well suited for comparison, since all hopeless cases which, particularly in the early days, were given a chance by one method or the other, have been excluded from the material. The 900

cases are tabulated in groups of 100 each. The results are judged by each patient's "fitness for work" in the fifth year after discharge from the sanatorium. In the first three groups, which refer exclusively to artificial pneumothorax, the percentage rises from 37 to 42 only. Then the curve begins to rise more rapidly; this coincides with the introduction of the various operative measures: thoracoplasties from the 200-300 group, cauterization from the 300-400 group. It will be seen that the curve has continued to rise throughout the groups until it has reached 74 per cent. in the 800-900 group—twice the figure of Group I. (Of the last two groups a decreasing number of patients have been able to be observed throughout the whole period of five years. But a careful calculation by percentage of the average mortality during the last one or two years of this period makes it possible to indicate the probable direction of the last part of the curve.)

This curve shows how, by the surgical work in combination with and in continuation of artificial pneumothorax, it is possible, more and more effectively, to help patients with pulmonary tuberculosis. The gradual improvement in the results is an encouragement to continue the progress.

(N.B.—During the course of the lecture slides of *x-ray* plates were shown, illustrating the various methods described.)

RATIONAL PNEUMOTHORAX TREATMENT

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Argument

1. The reputation of artificial pneumothorax treatment for tuberculosis is based on striking successes in a minority of cases. In a larger number of cases not grossly dissimilar, either its success is only partial or temporary, or it fails completely.

2. The reason for this inconstancy of results lies in the fact that the treatment is not a specific for tuberculosis. Collapse is capable of providing certain kinds of help to the body in its fight against the disease, and that help may, or may not, be of the particular kind that an individual case requires.

3. Selection of cases should therefore be based upon an estimate of the kind of help required, and the subsequent control of the treatment upon the degree to which this help is provided.

4. The different kinds of help—styled "desired effects"—are discussed in this article, and a scheme of treatment, based on them, is outlined.

For some fifteen years artificial pneumothorax treatment has had a recognized place, and has enjoyed an increasing popularity, in the treatment of pulmonary tuberculosis in England. During this time it has been the means of restoration to health of a large number of patients; in fact, the striking results obtained in certain cases have been the chief justification for the use of the treatment and the extension of its scope. But too frequently it either fails, or succeeds only partially or temporarily, and the general results, though favourable, seem hardly sufficient to warrant the confidence that its adherents place in it. It is not, of course, a cure; it is merely an aid to the patient in his fight against the disease in the sense that it may be able to correct or remove certain conditions which are delaying or preventing the natural healing process. When a patient comes to us for

treatment we should not, in effect, say, "Artificial pneumothorax treatment is recognized as a valuable form of treatment for tuberculosis, especially if the disease is unilateral. This patient should therefore be given the advantage of it, and perhaps it will prove a striking success." We ought rather to try to discover just what help the patient needs, and to use a pneumothorax only if there is a reasonable prospect that it will give that help. In other words, the treatment must be placed on a rational basis, rather than on an empirical. Unless this is done, the results will not improve and discredit may fall on what is, or might be, a very valuable remedy.

The object of this article is to suggest how the special needs of individual cases should be considered, to what extent artificial pneumothorax treatment can supply those needs, and how the progress of the treatment should be watched. The first section deals with some of the physiological and pathological results of collapse of the lung; the second with the possible therapeutic results in their bearing on certain types of case; and the third with the progress, control, and duration of treatment. In the fourth, points arising in the preceding sections are discussed.

1. The Physiological and Pathological Results of Collapse

Relaxation.—A lung is an elastic and expansile organ—that is, it can be distended. When distended it is under tension, and is therefore contractile. The greater the degree of distension the less the expansibility (i.e. a greater force is required to produce a given amount of further distension), and the greater the tension and contractility. In other words, tension and contractility vary directly, and expansibility inversely, with the degree of distension. Applying these principles to certain possible states of the healthy lung, we find that the compressed lung can expand to the size of the relaxed lung without increase of tension; that the relaxed lung can expand with, at first, only slight increase of tension; that the lung in expiration is under moderate tension; and that the lung in inspiration is under greater tension. Tension in the lung means that on any point in its framework an outward or centrifugal force acts. If at this point there is a tuberculous focus, the latter is subjected to this force which, moreover, alternately increases and decreases with inspiration and expiration, a state of affairs prejudicial to the formation of fibrous tissue. One important object to be attained by an artificial pneumothorax is therefore the abolition, or at least the material reduction, of tension in the diseased areas.

Decreased Flow of Blood and Lymph.—Collapse of lung may be considered to produce a decrease in the flow of blood and of lymph, though this fact does not appear to have been proved experimentally. The result is a reduction of toxæmia, and clinical evidence suggests that if toxæmia is reduced to the level at which evening pyrexia ceases, the formation of antibodies is at its maximum. This theory is the basis of treatment by graduated exercise, and by tuberculin, and accounts, in collapse therapy, for the healing of tuberculous lesions elsewhere, particularly in the other lung and in the larynx.

The Spread of Disease by Means of the Bronchi is Checked.—It is arguable, and to me probable, that spread of disease in a progressive tuberculous lesion takes place mainly by means of the air passages. According to this theory, a plug of infected mucus which is almost occluding a small bronchus will be drawn towards the periphery during the inspiration preceding cough, but will move very little in the opposite direction during the expiratory phase of coughing because the volume of air behind it is small, especially if the plug of mucus has caused local atelectasis, and because the plug of mucus, if drawn into the wider spaces at the base of the terminal lobule, can then allow