THE SURGICAL TREATMENT OF PULMONARY TUBERCULOSIS

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INTRODUCTION.

Thirty years ago the term collapse therapy was synonymous with artificial pneumothorax treatment, but to-day it is used in a much wider sense and, indeed, its benefits can only be achieved by those who have at their command the complete range of collapse operations which will be briefly summarized in this paper.

The decision to employ collapse therapy in any of its forms is a grave one, and it must only be made after repeated radiological examination and as the result of careful consultation between physician and surgeon. The importance of general sanatorium measures, diet, and more especially, prolonged bed rest, cannot be over-emphasized but there are many cases in which the anatomical and pathological features of the lesion are such that natural healing cannot occur even if general measures succeed in improving the general resistance of the patient. It is in these cases that collapse therapy is urgently indicated.

Almost 70 per cent. of the cases of pulmonary tuberculosis (sputum positive group) under treatment by the London County Council in 1926, had died by 1932. H. L. and L. R. Barnes (1928), quoting American figures, showed that of 1,454 patients with cavities who did not have any form of collapse therapy, 80 per cent. were dead within one year and 90 per cent. had died within five years. Although the Registrar-General's figures may indicate that pulmonary tuberculosis appears to be losing its pre-eminence as a social problem, the statistics quoted above make it clear that the outlook for the individual patient is little better to-day than it was 50 years ago, if collapse therapy cannot be brought to his aid.

GENERAL PRINCIPLES.

In the approach to surgical treatment we would stress the need for close co-operation between physician, surgeon and radiologist, and in this connection the division of all cases of pulmonary tuberculosis into two types—*productive* and *exudative*—is of paramount importance.

Characteristics of productive Phthisis.

- (1) The disease runs a slow and chronic course.
- (2) The patient is usually afebrile, or at the worst suffers only from occasional fever.
- (3) Trachea, heart and mediastinum are pulled over to the affected side.
- (4) Radiologically, an effective local reaction is seen and the foci are surrounded by fibrosis. The older the individual foci, the sharper they are in outline, and the greater their density.

Fibro-cavernous phthisis is the extreme example of "productive" disease.

Characteristics of "exudative" Phthisis.

- (1) The disease runs a rapid course.
- (2) The skin is damp, there is a hectic flush, and poor peripheral circulation.
- (3) Very little, if any, pulling over of the trachea and mediastinum.
- (4) Radiologically the foci are larger, their density is not great and the shadows are not homogeneous—the opacity being greater towards the centre and fading off towards the edge. These foci show a marked tendency to coalesce and break down with cavity formation; there is little or no tendency to fibrous tissue formation or to calcification of the individual foci.

Acute pneumonic phthisis is the extreme example of "exudative" disease.

The adoption of collapse therapy depends entirely on the type and stage of the disease, for the acute forms of exudative disease extending over more than one lobe render the case unsuitable for collapse owing to the fear of an increase in the general toxæmia and to the production of local complications. It is in the productive type of lesion that collapse therapy finds its greatest indication.

From what has already been said, it is clear that radiographic investigation of each case is of the utmost importance. A definite diagnosis—or prognosis—cannot be made without the evidence afforded by X-rays, which not only determine the extent of the disease but reveal its location in areas where it might have been unsuspected. In particular is this true of tomography, which, by reproducing the appearances at different depths of the chest, will often reveal lesions normally hidden by the rib shadows or masked by superimposed foci of disease (McDougall and Crawford, 1937).

In considering the principles governing surgical intervention, it is essential to know something of the pathology of the disease. Tuberculosis manifests itself pathologically as a granuloma; this is simply a tumour composed of granulation tissue formed by the reaction of the normal tissue round the organisms, and its function is to enclose and destroy the bacilli. It is therefore formed in response to the call for protection and, if successful, will disappear, leaving only a small scar behind. But when the granuloma fails to overcome the invading bacilli, the formation of granulation tissue increases rapidly at the expense of healthy lung tissue, which is thus destroyed. Thus the future of a person whose lungs have become invaded by tubercle bacilli depends chiefly on the efficacy of the granuloma in controlling the infective processes. There are three essential factors which influence the functioning of the granuloma:

1. The general resistance of the patient.
2. The dose of the infection.
3. The local conditions to which the granuloma is exposed.

Improvement in the resistance of the patient is obtained by general hygienic measures, regular hours of rest, and a nutritious diet. The granuloma, however, is subject to constant movement during respiration, and to spasmodic and violent movement during coughing. But the conditions which are most favourable for the granuloma to succeed in controlling the infective processes, are those of rest—especially rest of a degree closely approximating to the immobilization of a tuber-

culous joint. Ordinary rest in bed may diminish the rate of inspiration and expiration, but it cannot give that degree of rest which is so essential in many cases. Now the normal lung, being an elastic and expansile organ, is constantly under tension which increases with inspiration and decreases with expiration; and the guiding principal of all forms of collapse therapy is to lower this intra-pleural tension and thus to produce a reduction in the volume of the lung and a collapse of the diseased area. Furthermore, the reduction in intra-pleural and intrapulmonary tension favours the formation of fibrous tissue, enables cavities to close, removes the danger of hæmorrhage, reduces toxæmia and produces that degree of immobilization which is essential if healing is to occur.

COLLAPSE OPERATIONS.

The general indications for collapse therapy are perfectly clear and definite. Collapse is indicated when the mechanical conditions present constitute an immediate threat to life, e.g. a cavity with its risk of hæmorrhage and bronchogenic dissemination, or when the mechanical conditions prevent the natural healing of an old established lesion.

Collapse operations are designed to permit retraction of the diseased lung and so allow any natural healing tendency present to attain its objective. A perfect understanding of the mechanics of respiration is necessary to enable this result to be obtained without violating basic physiological principles, for in collapse therapy, physiology and pathology are of equal importance.

Artificial Pneumothorax.

Without exception the first operation to be attempted is the induction of an artificial pneumothorax, and in suitable cases with a free pleural space this measure will suffice to control the disease. Very often however, collapse of the diseased portion of the lung is impeded by adhesions to the chest wall and then the Jacobæus operation of endoscopic section of the adhesions must be done. Attempts to cause stretching of the adhesions by increasing the pressure in the pneumothorax or prolonged trial of an incomplete pneumothorax should no longer form part of the practice of an informed clinic. The first is responsible for the production of infected pleural effusions and the second wastes valuable time during which progress of the disease may exclude the patient from the benefit offered by other collapse operations.

Indications for Pneumothorax.

- (1) Acute unilateral disease—particularly those cases of early sub-clavicular infiltration (*Frühinfiltrat* of Redeker) which so often occur in young patients as a sequel to an acute febrile attack resembling influenza. This type of lesion can proceed to cavity formation in an incredibly short time, and active treatment must be instituted without delay unless serial radiograms demonstrate that resolution is occurring within a very short period.
- (2) Sub-acute unilateral disease—this is more common than the first group, and while many of these patients improve on rest and simple measures, delay may be dangerous. If no response to treatment is made within a few weeks, a pneumothorax should be induced.
- (3) Chronic unilateral disease.

- (4) Cavitation—particularly the following groups:
 - (a) occurring in association with acute disease, always remembering that if the disease is acute it is wise not to wait until cavitation appears.
 - (b) fibrous wall cavity containing secretion; these cases are sputum positive, a danger to others, and liable to secondary infection with spread of the disease.
- (5) Hæmoptysis.
- (6) Complications such as tuberculous laryngitis, pregnancy, and toxæmia, shown by pyrexia, tachycardia, loss of weight, and poor blood picture (high sedimentation rate, high monocyte count, low lymphocyte count).

Contra-indications to Pneumothorax Therapy.

- (1) Caseous, pneumonic type of disease—pneumothorax is not only ineffectual but may be dangerous.
- (2) Patient over 45 with an old fibrotic lesion—this type has good resistance and responds satisfactorily to routine treatment; if not, then phrenic paralysis is better than pneumothorax.
- (3) Presence of asthma, emphysema or chronic bronchitis.
- (4) Evidence of considerable cardiac or renal failure.

The ideal case for treatment by artificial pneumothorax is one of fibro-cavernous disease with the lesion limited to part of one lung, the pleura being free and the contra-lateral lung sound. The following case-history is a good example.

E. B., aged 36, was admitted to Preston Hall July 1934. Fig. 1a, Plate 1, is the radiograph of his chest on admission, and it will be seen that the lesion consists of fibro-cavernous disease over the right mid-zone, the typical fan-shaped distribution of a "productive" lesion being well illustrated. The left lung was clear. Sputum was heavily positive, but his general condition was fairly good. A pneumothorax was induced on the right side and an excellent selective collapse was obtained Fig. 1b, Plate 1, Sputum became negative and the patient was discharged fit for full work; at the present date his condition remains excellent and the refills are being given at monthly intervals.

Unfortunately, the ideal case as illustrated above is rare, and as we have already noted, a satisfactory collapse may be prevented by the presence of multiple adhesions, or there may even be a completely adherent pleura which will prevent the induction at the very outset. A pneumothorax with an effective collapse and control of the disease is excellent, but unless effective collapse is obtained more harm than good may be done.

It must always be remembered that every case of artificial pneumothorax is a potential tuberculous empyema. A pneumothorax which fails to control the lesion can have no therapeutic value and merely exposes the patient to the risk of incidental complications which may in the end plague him more than his original disease.

Thoracoscopy and division of Adhesions (Internal Pneumolysis).

This operation was introduced by Jacobeus, and its main use is to assist in the division of pleural adhesions which prevent effective collapse after the induction

of an artificial pneumothorax. After the adhesions are localized by radiography and/or tomography, the thoracoscope (an instrument like a cystoscope) is passed through a canula into the pleural cavity; if division is feasible, a cautery is passed into the chest through a second canula and the adhesions are divided under direct vision. A good example of these measures is the following case.

D. K., aged 31, was admitted to Preston Hall in June 1935. His sputum was positive, there was slight evening pyrexia, and the radiogram of his chest revealed fibro-caseous disease over the right upper zone with a fairly large cavity behind the clavicle; the left lung was clear. A pneumothorax was induced, but a satisfactory collapse was prevented by apical and mid-zone adhesions (Fig. 2a, Plate 1). Endoscopic division was carried out in two sessions, and (Fig. 2b, Plate 1) reveals the right lung well collapsed and the cavity obliterated. (A small effusion is present at the base but was absorbed without incident). His sputum became negative and has remained so; he is now at full work and having refills at monthly intervals.

In skilled hands this procedure is a satisfactory measure, but hæmorrhage and sepsis are two important complications, and the wounding of lung tissue may lead to the development of a pyo-pneumothorax.

On rare occasions pleural adhesions have been divided by open operation after the resection of a portion of rib, but the number of occasions in which it is indicated is small. When extensive adhesions are present, it is usually advisable to practise some form of extra-pleural operation.

Phrenic Nerve Operations.

This operation may be done primarily to produce a degree of collapse of the lung, or for relief of symptoms—e.g. the dragging pain due to basal adhesions, diaphragmatic cough, tachycardia and dyspnoea due to pericardial-diaphragmatic adhesions in cases with extensive fibrosis and displacement of the heart.

Its value as an independent line of treatment is doubtful, and it is more often used as an accessory to other surgical measures. Permanent or temporary paralysis of the hemi-diaphragm may be produced depending on the operation performed—section or evulsion of the nerve being permanent in its effect, while crushing produces a paralysis of only four to six months' duration. Following the operation, the diaphragm loses its state of tonic contraction and becomes an inert, flaccid muscle. The rise which is produced varies in different cases, but increases as the atrophy of the muscle progresses. Some degree of collapse of the lung is produced, but the rest given to the hemithorax is probably of more importance.

Indications for a Phrenic Operation.

- (1) Cases of basal tuberculosis.
- (2) Where artificial pneumothorax is indicated but the induction has failed.
- (3) As an accessory to pneumothorax, particularly to relax small adhesions.
- (4) To supplement the régime of absolute rest in a case of exudative disease.
- (5) As a test operation before proceeding to more radical surgery.
- (6) To aid in the obliteration of a persistent empyema cavity.
- (7) Palliative measure for the relief of symptoms (as noted above).

With the exception of tuberculous empyema, in which the radical operation is done, phrenic crush is just as efficacious for the indications enumerated as either of

the two permanent operations. There are many patients with bilateral disease for whom some form of bilateral collapse operation would offer a prospect of cure, but a permanently paralysed diaphragm would rule out such a possibility. Furthermore, permanent paresis may constitute a serious handicap in middle age: not only does it produce a greater reduction of vital capacity in the middle-aged than in young adults, but its effect on cardio-vascular function in later life must also be borne in mind. It is chiefly on these grounds that the adoption of phrenicoplasty (phrenic crush) has been recommended (O'Shaughnessy & Crawford, 1936).

Illustrative Case.

P. O. McC., aged 27, admitted with a positive sputum and a lesion on the right side, the radiograph being shown in Fig. 3a, Plate 2, and revealing a large cavity in the right mid-zone close to the hilum with considerable surrounding infiltration. This patient had already had 12 months' routine sanatorium treatment without any real improvement, and an attempt to induce an artificial pneumothorax had failed. A right phrenic crush was done and paralysis of the right hemi-diaphragm resulted for a period of six months, during which time the patient made satisfactory progress and his sputum became negative. Serial radiographs revealed the gradual disappearance of the cavity and clearing of the infiltration. In order to maintain the paralysis for a further period, a re-crush of the nerve was performed, and after the second operation normal movement of the diaphragm returned after five months had elapsed. Fig. 3b, Plate 2, gives the radiographic appearance at the end of this period; the diaphragm is still somewhat raised, while the cavity has completely resolved. The patient has now been at work in the City for three years without a relapse and his sputum is still negative.

Thoracoplasty.

Thoracoplasty is reserved for cases with obliteration of the pleural space and there are various types of operation now in common use. The operation of choice is the Sauerbruch paravertebral thoracoplasty in which ribs one to eleven are excised, each for a distance of six to eight centimetres from the costo-transverse articulation. It is essential that the resections should extend right back to the transverse processes of the vertebræ, and actual excision of the transverse processes may have to be done in a few cases to increase the degree of collapse in the paravertebral gutter.

After the resection, the rib-ends approximate, and in addition each rib drops to a lower level, so that the anterior cut end of each rib falls at least one space and finally unites with the cut posterior end of the rib below. Sauerbruch has shown that the maximum collapse is not obtained unless a portion of the first rib is resected or divided, the other ribs being suspended from it. The amount of each rib resected varies with the extent and character of the disease; in chronic fibrotic disease with no obvious cavities, less bone need be removed than when there is a large, rigid-walled cavity.

The indications resemble in a general way those for a pneumothorax, with certain important additions. The general condition of the patient must permit a major surgical intervention without risk of immediate collapse—the condition of the myocardium being of special importance. It is also essential that there should be a predominantly "productive" element in the disease, and as a general rule cases of less than a year's standing should never be operated upon. The most favourable indication is fibro-cavernous disease of some years' duration, and in such cases the operative mortality is low—one to two per cent. "Exudative"

disease is a definite contra-indication, for not only is this type of lesion capable of little benefit from thoracoplasty, but it also carries with it the great risk of an immediate mortality from mediastinal flutter.

Illustrative Case.

M. J. T., aged 24; (a sister had died from pulmonary tuberculosis). Admitted to Preston Hall in February 1935, with a positive sputum, blood sedimentation rate of 22 (one hour—Cutler technique) and signs of cavitation in the left lung. Fig. 4a, Plate 2, is the radiograph shortly after admission. There was a five years' history in this case, and pneumothorax had been tried but abandoned after a few months owing to unsatisfactory collapse.

After a preliminary phrenic crush, total paravertebral thoracoplasty was carried out in two stages. He stood the operation well, and convalescence was uneventful. Four weeks after the completion of the operation the sputum became negative and the sedimentation rate had improved to 16. Sanatorium treatment was continued for six months, after which he returned home. Unfortunately, his home conditions were very poor, and he was unemployed for a long time; his condition deteriorated and he was re-admitted to the sanatorium in 1937. He had lost one stone in weight during his period at home, but though his condition was poor, the sputum was still negative (including culture), and his sedimentation rate was only 10. In short, despite the privations to which he had been exposed there had been no reactivation of the disease, and his poor condition was really due to prolonged under-nourishment. It was interesting to observe that even under such adverse conditions, the lesion had remained quiescent. Fig. 4b, Plate 2, is the radiograph on re-admission; satisfactory collapse of the left lung can be seen, with compensatory emphysema on the right side. Tomography confirmed the complete closure of the cavities.

He has made rapid progress under routine treatment, and regained the weight he had lost. At present his condition is good, blood sedimentation rate is only 8, and he is working well as a hospital orderly in the sanatorium where he remains under continual close supervision.

There is comparatively little deformity even after an extensive paravertebral thoracoplasty, despite a widespread but erroneous belief to the contrary. Fig. 5 is a photograph of the patient whose case history is given above, and the slightness of the deformity is at once evident.

Partial Thoracoplasty. Since 1930 there has been a considerable vogue for thoracoplasty limited in its effect to the upper lobe of the lung. An operation which will preserve the function of a normal lower lobe has, *a priori*, great attraction, but we believe that the too frequent adoption of partial thoracoplasty is to be deplored. Paravertebral thoracoplasty has achieved many of its successes not only by allowing a cavity system in the upper lobe to heal, but by giving rest and relaxation to the entire lung.

There are, in actual fact, few cases where, if the disease in the upper lobe is sufficiently advanced to warrant a thoracoplasty at all, the lower lobe is really free from disease. The results of paravertebral thoracoplasty have stood the test of time—there are many healed cases who had this operation more than 20 years ago—and despite the good immediate results which have followed partial thoracoplasty (Semb's recent modification is of extreme technical interest), we believe that a partial operation is only indicated when the most careful radiological investigation—including tomography—reveals a normal lower lobe, and when it is clear that natural healing is not to be expected.

FIG. 5.—(a) Same patient as in Fig. 4 showing no deformity when dressed.

FIG. 5.—(b) Same patient showing healed scar of operation.

Secondary Thoracoplasty. It sometimes happens that despite the production of a satisfactory collapse following paravertebral thoracoplasty, the sputum remains positive, and although ordinary X-ray examination may fail to reveal any particular cavities in the more or less opaque shadow which results after the operation, tomography frequently brings to light an incompletely collapsed cavity. Indeed, it is in the investigation of this type of case that tomography is of special value.

In all these cases, the question of a further operation arises and a case will be described in which a secondary (or "*korrektur*") thoracoplasty was performed with success. The operation should be carried out under general anaesthesia as distortion of the normal anatomy renders proper local infiltration of the nerves most difficult.

Illustrative case.

C. L. A., aged 21. Admitted with a positive sputum and a history of one year's duration; there was gross disease on the right side with cavitation in the upper lobe. The left lung was clear. After six months' routine sanatorium treatment he had made

no progress, and an upper thoracoplasty was advised. This was carried out in 1934, after a preliminary phrenic crush, and, though the sputum became negative for a few months, there was a recrudescence of activity in 1935, following a hæmoptysis. The thoracoplasty was made complete, but a positive sputum persisted. Fig. 6a, Plate 3, gives the radiographic appearance in 1937, while Fig. 6b, Plate 3, is that of the dorsal tomogram taken on the same day. An elongated cavity, quite obscured on the ordinary skiagram and certainly impossible to delineate, is clearly revealed on the tomograph picture.

Secondary thoracoplasty was performed in June, 1937, and five weeks later the sputum became negative on examination, including culture and guinea-pig inoculation. Fig. 6c, Plate 3, is the dorsal tomograph film, taken some ten weeks after the secondary operation, and confirms that complete closure of the cavity has been obtained.

Thoracoplasty in the Treatment of Tuberculous Empyema. The treatment of this condition is at first on conservative lines, by aspiration and air replacement; but if the general condition of the patient fails to improve, and especially if there is reason to suspect a mixed infection, more radical treatment must be considered. To obliterate the empyema cavity, paravertebral thoracoplasty is necessary in almost all these cases, and if the operation is delayed too long the patient may be left in too weak a state to withstand so great an intervention. The value of such operative measures is revealed in the following case history.

H. H., aged 24. Admitted with tuberculous empyema following artificial pneumothorax. Sputum had been positive, and the effusion was teeming with tubercle bacilli; blood sedimentation rate was 27. Fig. 7a, Plate 4, is the radiograph after partial aspiration and air replacement. Thoracoplasty was carried out in three stages, and Fig. 7b, Plate 4, shows the appearance six months later. On discharge he had no sputum at all, blood sedimentation rate was 10, and he is now working regularly as chauffeur.

Extra-Pleural Pneumolysis.

There are occasions when collapse of a patent cavity in the lung is urgently indicated, but pleural adhesions prevent the induction of a pneumothorax, and general factors such as the presence of contralateral disease, age of the patient, etc., render the performance of thoracoplasty inadvisable. Under these conditions pneumolysis and plombage is indicated. After resection of a rib the parietal pleura is separated from the chest wall, and into the resultant extra-pleural space a mixture of paraffin wax and bismuth is inserted.

Illustrative Case.

R. L., aged 33. Admitted in poor condition; sputum positive; sedimentation rate, rapid fall. A large cavity was seen in the right upper zone, with surrounding fibrosis and scattered infiltration over the upper half of the left lung. There was a history of recurrent small hæmoptyses in this case, and extra-pleural pneumolysis was done for the right upper-lobe cavity, using paraffin wax with vioform as the "plombe." Convalescence after the operation was uneventful, and the patient made a fairly good recovery. Six months later, however, the lesion on the left side proved progressive and his condition began to deteriorate, and he died of active pulmonary tuberculosis eight months after the operation. At the post-mortem, however, the "plombe" was found to be firmly in position, with good compression of the cavity and no ulceration of its wall. Acute caseous disease was found in the left lung, and was clearly the cause of death.

FIG. 1a.—Showing fibro-caseous disease over the upper half of the right lung, with a cavity in the mid-zone (below the axilla).

FIG. 1b.—Artificial pneumothorax with selective collapse of the diseased area; sputum negative and patient at work.

FIG. 2a.—Ineffective pneumothorax with adhesions holding out a large cavity below the clavicle; also smaller cavities in mid-zone.

FIG. 2b.—After endoscopic division of adhesions; effective collapse has been obtained with obliteration of the cavities. Sputum negative and patient working regularly.

FIG. 3a.—After 12 months' routine sanatorium treatment; large cavity in mid-zone and sputum positive. Artificial pneumothorax failed.

FIG. 3b.—Six months after phrenic crush (see text). Cavity closed, sputum negative, and diaphragm, though still slightly raised, shows normal movement on screening. Patient has been at work in the City for 3 years without relapse.

FIG. 4a.—Gross fibro-cavernous disease of left lung; sputum heavily positive; blood sedimentation rate showed rapid fall.

FIG. 4b.—After paravertebral thoracoplasty (ribs 1-X); sputum negative and blood sedimentation rate normal.

FIG. 6c.—Tomogram at same depth taken after secondary thoracoplasty. Cavity obliterated and sputum negative to culture and guinea-pig inoculation.

FIG. 6b.—Tomogram taken 7 cms. from back of chest and showing clearly a patent cavity in the right upper lobe.

FIG. 6a.—After total paravertebral thoracoplasty: sputum still positive uncompensed cavity is not discernible.

FIG. 7a.—Showing pyopneumothorax after artificial pneumothorax; both sputum and pleural fluid loaded with tubercle bacilli.

FIG. 7b.—After total paravertebral thoracoplasty; empyema cavity obliterated and sputum negative. Patient is in good general condition and has been working regularly as a chauffeur for 2 years.

FIG. 8a.—Case with 7 years history; artificial pneumothorax had failed and sputum was still positive. Picture shows gross fibro-cavernous disease of right lung with very marked distortion of mediastinum, the heart being pulled over completely to the right side. Symptoms of Cardiac distress due to the mechanical factor, were present.

FIG. 8b.—After total paravertebral thoracoplasty; heart in normal position and effective collapse of lesion has been produced. Sputum negative and patient working regularly.

Extra-Pleural Pneumothorax. The continued presence of a foreign body is an obvious disadvantage, and infection of the "plombe" bed may be followed by perforation into the lung; and in an attempt to overcome this disadvantage Graf has recently revived the old operation of extra-pleural pneumothorax. In this operation the pneumolysis is performed in the usual way, the wound is closed and an attempt is made to maintain the extra-pleural space by the insufflation of air in the days following operation. On the Continent, where this method was tried extensively some years ago, it was found that complications were very frequent and after a brief spell of popularity the method was abandoned. It would appear that Graf has had some very good results, but an operation which violates so many basic principles of surgery and pathology must expect a critical reception.

It seems to us that the new plombe material recently introduced by Rehn, which is very gradually absorbed over a period of a year or more, may constitute a more real advance.

Collapse in Bilateral Disease.

One great danger of any collapse operation is the awakening to activity of some latent focus in the opposite lung. In view of this it is clear that deliberate intervention in the case of gross bilateral disease is only to be attempted by the most experienced, and even then with caution.

Bilateral pneumothorax is now quite frequently used, and in the rare cases where an effective collapse of the diseased area in each lung can be achieved this is a good procedure; but the mere presence of air in both pleuræ cannot be useful and may be harmful. The literature contains records of several cases of bilateral upper thoracoplasty, of the successful establishment of a pneumothorax on one side with phrenic paralysis on the other, and also of bilateral plombage. These occasional successes in the hands of experts should not encourage wholesale exploitation of collapse therapy in bilateral disease.

Recent Operative Proposals.

Ligature of the Pulmonary Vein. It is well known that patients with mitral stenosis only rarely develop pulmonary tuberculosis, and that when phthisis does occur in such patients it carries with it a relatively favourable prognosis. This is believed to be due to the chronic venous congestion in the lungs which favours healing of the tuberculous infection, and a review of the literature in support of this view has already been published (O'Shaughnessy, 1935). There is considerable experimental evidence to show that passive hyperæmia, but not acute oedema, is produced in the lung after ligature of the pulmonary vein, and that the lung then offers a very high resistance to the spread of tuberculous foci. The experiments of Tiegel (1911) are of particular value in this connection.

Kerschner (1930) reported the results of the operation in four cases, and although arrest of the disease occurred in only one patient, in two others there was marked improvement. We have carried out the procedure in a few cases mainly belonging to the group which is least amenable to collapse therapy—that is, the group with exudative disease and little natural tendency towards fibrosis. It is emphasized that this operation is not an alternative to thoracoplasty or any collapse measure. But at the same time there are very many patients who at present are excluded from the benefits of collapse therapy by reason of the

nature of the lesion, and who carry with them a prognosis which on conservative lines remains so bad that it seems justifiable to explore other possibilities.

The type of case undergoing this operation is usually in very poor condition; yet we have been struck by the slightness of the general disturbance which follows operation, and the smooth convalescence which has occurred in each case.

CONCLUSIONS.

There are two requisites in the successful exploitation of the surgical treatment of pulmonary tuberculosis—there must be a low immediate mortality, and a patient who has submitted to surgical treatment rightly expects cure rather than mere improvement. In thoracoplasty a low operative mortality is, of course, of special importance, and can only be attained by strict adherence to physiological principles.

Healing in the lung is a gradual process, and probably the most important recent advance in the surgical treatment of pulmonary tuberculosis is the introduction of the Zencker technique⁽¹⁾. The application of this solution to the rib bed after resection delays bony regeneration, and thus subsequent retraction of the lung is possible over a period of months instead of weeks.

The second important advance has been on the pathological side. Once we were content if, following a collapse operation, the sputum became negative on ordinary Ziehl-Neelsen examination. Now we are not content until the sputum has been shown to be negative on culture or guinea-pig inoculation, and, in the absence of sputum, examination of the gastric contents is carried out. By working to this end-point, and persisting in rest and sanatorium régime for a period of at least three months from the date when this point has been reached, good final results can be obtained.

There have been many excellent statistical surveys of the results of collapse therapy. We may cite the special report by Bentley on artificial pneumothorax, the large series of thoracoplasty cases quoted by Sellors, and the rather astonishing and so far unequalled results for thoracoplasty recorded by Schedtler. In the confines of a surgical unit in a sanatorium we must of necessity be influenced by individual rather than mass results, and by consideration of the physiological pathological rather than the statistical basis of collapse therapy. We have given representative case histories which show that collapse therapy can restore to active life patients who otherwise could only look forward to prolonged sanatorium treatment without any hope of a permanent arrest of their disease.

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(1) Formula: Mercuric chloride 5 pts., potassium bichromate 2½ pts., sodium sulphate 1 pt., water to 100 pts.

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