A Lecture

ON

THE PRINCIPLES OF TREATMENT OF PULMONARY TUBERCULOSIS.*

BY

CLIVE RIVIERE, M.D.LOND., F.R.C.P.,

PHYSICIAN, CITY OF LONDON HOSPITAL FOR DISEASES OF THE HEART AND LUNGS, AND EAST LONDON HOSPITAL FOR CHILDREN.

CONTRARY to common belief pulmonary tuberculosis is one of the most curable of infective diseases. Many of us sitting here have weathered it in its slighter forms, and even the more severe outbreaks are very amenable to proper treatment. Why, then, it must be asked, is the disease responsible for so large a death roll? The reasons for this lie far more in human nature and our social conditions than in any failure on the medical side. Neglect and ignorance delay the diagnosis, and impatience and lack of opportunity prevent treatment being carried through to a cure. It has been said by some that the sanatorium treatment of phthisis is a failure, but this is far from true. It is, in fact, a wonderful success; but on account of impatience and lack of opportunity it is rarely given a chance of carrying a case through to the stage of cure. Compare with it the institutional treatment of surgical tuberculosis—admittedly a triumphant success. Where does the difference mainly lie? Undoubtedly in this—that for these cases, mostly children, the average time of treatment runs into years, till, in fact, “arrest” is really carried into “cure.” Among these children impatience and desire of change do not break off the cure at the critical time as too often happens in adults; nor does the need of wage-earning or lack of funds return the half-cured case to the unhealthy conditions out of which the disease arose. Pulmonary tuberculosis is a disease of slow progress and still slower retrogression; it needs for its cure the years that are given to the treatment of surgical tuberculosis, and without them failure must follow, however successful in itself the form of treatment employed. Remember, therefore, at the outset that time is one of the essential elements in its treatment, and that this must be measured in years.

Now, what is the first essential in the treatment of active inflammation in any organ? You will answer, without hesitation, “Rest.” This is as true of the lung as elsewhere, but how are we to apply it? For movement is the essence of the lung’s function, and we cannot prevent it. We can, however, damp it down by reducing the need for oxygen through general bodily rest, and this in many cases suffices. Let the patient be put at rest, preferably in bed, as soon as the disease is diagnosed, or even before; it is well that he be impressed at the outset with the fact that he has an inflamed lung, and that the treatment for this is general bodily rest. Having seen to this, the next question that will be asked is, Should he go into a sanatorium?

Sanatorium Treatment.

The modern sanatorium lays itself out to employ all or most forms of treatment applicable to pulmonary tubercle, and the principles of sanatorium treatment are roughly the principles of the treatment of phthisis. They are, in the main, twofold: first, to build up the body’s natural resistance to disease by general hygienic measures, and towards this open air, abundant daylight, and good feeding especially contribute; and secondly, to increase the specific resistance to tuberculosis by all known measures, of which the proper application of rest and exercise are the most important. Let us consider open air first, so as to clear the ground for the more important subject of rest and its corollary, exercise.

Open Air.

The real father of the open-air treatment of tuberculosis was George Bodington, who published his book *On the Treatment and Cure of Pulmonary Consumption* as long ago as 1840. In it he advised the unstinted use of open air in all weathers, and insisted especially on the value of cold air, both indoors and out—a revolutionary doctrine in those days. He advocated the provision of institutions for this outdoor treatment, and himself took a house for this purpose at Sutton Coldfield. But, surprising as it may seem, the value of fresh air in sickness appears to have been recognized long before this. Recently there has been unearthed in America a precious morsel from the writings of Benjamin Franklin about the year 1786; it runs as follows:

“It is recorded of Methusalem, who, being the longest liver, may be supposed to have best preserved his health, that he slept always in the open air; for when he had lived 500 years an angel said to him, ‘Arise, Methusalem, and build thee an house, for thou shalt live yet 500 years longer.’ But Methusalem answered and said, ‘If I am to live but 500 years longer it is not worth while to build me a house . . . I will sleep in the air as I have been used to do.’ Physicians, after having for ages contended that the sick should not be indulged with fresh air, have at length discovered that it may do them good. It is therefore to be hoped that they may, in time, discover likewise that it is not hurtful to those who are in health; and that we may then be cured of the aerophobia that at present distresses weak minds, and makes them chuse to be stifled and poisoned, rather than leave open the window of a bedchamber, or put down the glass of a coach.”

Open air in the treatment of phthisis should be as complete as possible, and the patient must be inured to it gradually. In particular, it is to be insisted that the patient be exposed to full daylight, unobstructed by glass. This is a very important element in open-air treatment, but sun, unless the air is cold, is safest avoided by patients with active lung disease. A prolonged sunning may lead to undesirable congestion of the tuberculous areas. The effect of open air, and especially of cold air breathed, seems to be a stimulation of metabolism, leading to increased appetite and well-being. Climate is secondary to open air, but is, I think, of more value than is sometimes admitted in this country. Tuberculous patients do best in a dry climate, and in this country are best sent east or south-east, according to the time of year. But with active disease the regime is more important than climate—even more important than open air—and this brings us back to rest and exercise, the first essentials in treatment.

Rest and Exercise.

Now although the house at Sutton Coldfield already referred to may be considered the prototype of the sanatorium as we know it, it must be noted that the importance of rest and exercise was recognized much later. Bodington’s patients got their open air for the most part by walking and driving. But some twenty years later there was founded by Hermann Brehmer, at Görbersdorf in Germany, the first sanatorium on anything like modern lines. To Brehmer and his assistant Dettweiler belongs the credit of recognizing the importance of the regulation of rest and exercise in the treatment of pulmonary tuberculosis. Brehmer enjoined gentle exercise up sloping paths with rests at intervals. Dettweiler at a later stage became impressed with the need and value of rest above all things, and about 1880, at Falkenstein, initiated the famous *Liegekur*. His patients, febrile and afebrile alike, spent their time in reclining chairs in the *Liegehalle*. Dettweiler was also the founder of “absolute rest,” called by him “cadaver Ruhe,” but in this country often referred to as “typhoid rest,” for the control of troublesome fever. Since that day rest and exercise, pursued under open-air conditions, have formed the basis of sanatorium treatment the whole world over; only in the proportion and dosage of these has any difference of opinion obtained. There is universal agreement that cases decidedly febrile must be kept at rest as long as fever persists—beyond that point differences of opinion and practice exist. On the whole it may be said that Continental sanatoriums advocate rest, rather to the avoidance of exercise, while British institutions enforce less rest and make exercise a part of their routine.

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The Control of Auto-inoculation.

Now where the Continental physician speaks of "the correct dosing of rest and exercise" (Dettweiler), here, thanks to spread of the ideas first initiated by Almoth Wright, we are apt to talk of "treatment by controlled auto-inoculation." For Wright has taught us the pleasant game of "antigen" and "antibody" on which the practice of vaccine therapy has been built up, and this has been of notable value in the rational application of rest and exercise in pulmonary tuberculosis. He showed us how the body's resisting power to chronic infections depends on a proper balance between them; how a suitable supply of bacterial products (antigen) is needed to produce an immunizing response (production of antibody), and how excessive and uncontrolled dosage may overcome antibody formation, with the result that symptoms appear and disease spreads; how, further, once the balance is upset it can only be recovered by control of the bacterial toxins let loose (control of auto-inoculation) by rest. For auto-inoculation may follow upon "all active and passive movements which affect the focus of infection, and upon all vascular changes which activate the lymph stream in such a focus." Now, at once it becomes clear that, for better or worse, our tuberculous patient is an unconscious vaccine therapist—nothing less, in fact, than an uncontrolled tuberculin factory whose products are at the mercy of his bodily activity. When he exercises he receives a dose of auto-tuberculin, and when he rests the dosage is reduced. Doubtless other tissue poisons and toxins from other bacteria also come into play, but these may here be neglected. Thus the treatment of tuberculosis demands above all some knowledge of the action of tuberculin and of the means whereby it can be turned to therapeutic use. This knowledge will be necessary, not only in the control of rest and exercise and the understanding of the patient's symptoms, but also in the use of many drugs, in addition to tuberculin itself, used in the treatment of pulmonary tuberculosis.

The Action of Tuberculin and Auto-tuberculin.

Now all vaccine therapists know the stages of an "immune reaction"—how dosage with antigen is followed by a "negative phase," during which resistance to disease is lowered, and later a "positive phase" with improvement; and how, also, if the dosage is excessive the negative phase may persist, and no positive phase of raised immunity follow. If an effective dose of tuberculin is given to a tuberculous patient it is followed, after an interval of eight to twenty-four hours, by a "reaction" corresponding to the negative phase. At the point of injection there may be a "local reaction," with redness and swelling; a "general reaction" is shown by fever, malaise, and perhaps headache; and a "focal reaction" occurs in every active tuberculous focus. It is this focal reaction which especially concerns us. Each area of disease becomes flooded with blood, and this leads to an increase of physical signs, and of symptoms such as increased cough and sputum. If the dose has not been excessive for the type of case all these symptoms may quickly clear and a positive phase of immunity may follow. If, however, the focal reaction has been severe, and has occurred in areas of very active disease, other phenomena may follow. Further toxins and bacilli washed out may lead to further "secondary" reactions, both general and focal, with corresponding prolongation of fever and illness, and these may continue and increase owing to further spread of disease and increased sensitiveness to tuberculin. This gives us the picture of autotoxic tuberculosis brought about by neglect of treatment.

Now if instead, the dose of tuberculin has been moderate and followed by a mild reaction, it will be found that a period of increased "tolerance" to tuberculin ensues. During this period a larger dose will be tolerated, and by giving a gradually increasing dose at the best interval, which is found to be about twice weekly, we can establish tolerance to very large doses. The same can be accomplished with auto-tuberculin on a system of graduated exercise. If, however, instead of raising the dose we continue the same small dose, or if we seriously overdose our patient, the opposite condition to tolerance may sometimes

be brought about—namely, a hypersensitiveness to tuberculin.

Now let us apply this to a case of pulmonary tuberculosis. If he is ill and febrile we know he is overdosed with tuberculin from the diseased lungs. He is suffering with "general reactions," shown in fever and symptoms, and at the same time with "focal reactions," leading to congestion of the tuberculous areas, further washing out of toxins and bacilli, leading to further "secondary" reactions, and to increased activity and spread of disease. This is a vicious circle which can only be broken by cutting down the supply of auto-tuberculin. This is achieved by complete bodily rest—the demands for oxygen are thereby reduced, and lung movements and lung circulation are damped down. After a time the auto-tuberculin reactions die down and the patient becomes afebrile and free from symptoms. But disease is still active—get the patient up again and fever again appears.

After an interval for the tissues to recover their lost balance it will be found possible by a graduated regime to bring the patient back stage by stage to active movements without any fever resulting and even with a steady-*ing* of temperature. With each step forward it may be found that the temperature shows a slight rise, or an increase of the diurnal fluctuation, but these after a short time again subside. These are evidences of "immune responses" to auto-tuberculin accompanied by a steady rise of tolerance. Finally the patient, with disease which is far from being arrested, may yet be following a vigorous regime without any untoward symptoms—thanks to this tolerance. But if tolerance is upset at any point by too rapid rise of dosage violent reactions may occur and a period of rest be again required.

This means of establishing tolerance has been pushed further by Paterson and others into a system of "graduated labour," whereby considerable physical exertions are undergone towards the end of treatment. The advocates of this have spoken of the "high tide of immunity" thereby achieved, but high tolerance of tuberculin is probably something quite other than increased immunity to tuberculosis, and recent evidence seems to show that the ultimate results of graduated labour are inferior to those obtained by systems where a more resting regime is followed.

Ought Auto-inoculation to be Employed?

And now, having seen that we can, once autotoxic symptoms have been controlled by rest, in many cases get our patients up again with disease still active, we may inquire whether we ought to do so. I may remark at once that, owing to lack of beds for pulmonary tuberculosis among the hospital class, and of nursing accommodation in sanatoriums, the establishment of tolerance at an early stage has become almost a routine of practice in this country, so I am putting to you no hypothetical case. The answer to the question must depend to a large extent on the type of disease from which our patient is suffering. In disease of chronic, fibroid, "proliferative," or "productive" type, mild reactions and a full blood supply seem in many cases to promote the healing of disease, though even in such cases it may be argued that increased movement may tend to spread the fibrosis and prevent the proper encapsulation of the tuberculous areas. But in cases of acute, caseous, or "exudative" type a very different result must be anticipated. Both reactions and congestion may lead to softening of caseous areas, and though in the neck glands this may be of little consequence or even convenient, in the lungs it is a serious matter, for it leads to cavitation. Now tolerance may prevent reactions during exercise, but yet all exercise means flushing of the lungs with blood, for the pulmonary circuit must hand on all blood which the systemic circulation puts into motion. Moreover, the lung movement, a serious bar to healing, must also increase. Therefore no patient with caseous areas of any extent should exercise till disease is fully quiescent; and since most cases of tuberculosis are of mixed type and contain some areas of caseous disease, exercise should be regarded as a somewhat dangerous measure in pulmonary tuberculosis until all evidence of activity is past.

Febrile Cases.

The patient should be put at rest as soon as the disease is suspected or diagnosed. If there is fever, rest in bed must be carried on, under open-air conditions, until all fever has gone, and as long after as symptoms and signs suggest that disease may still be active—for activity is not limited to the period of fever. Where fever continues in spite of rest in bed, this must be continued in the hope that eventually it will subside, which it may do after even three or four months or more of waiting. In such cases more complete rest must be aimed at—what is known as “typhoid rest” tried, talking forbidden, and possibly some means of “splinting” the inflamed lung attempted. The possible need of collapsing the lung in such a case by artificial pneumothorax must not be neglected till too late. As long as fever persists rest is the one essential of treatment, and such a patient may be better nursed in his own home, if conditions are suitable, than in a sanatorium. Sanatoriums do not provide nursing accommodation for many febrile cases, so the febrile stage is best arranged elsewhere. The same also applies to the hospital class; if these could receive bed treatment in their own homes, during the early stages, as has been so successfully done under the so-called “class method” in Boston and Montreal, the institutions now provided could be put to their proper purpose—namely, the establishment of tolerance when disease has become quiescent, not, as now, while it is still active. Many cases end fatally where, if rest could have been carried on for a year or more, recovery might have ensued. Six or more months’ rest is not a bit too much for a case of serious type.

Afebrile Cases.

Cases with little or no fever will require less in the way of strict rest, but at the outset a period of bed, and later bed and couch or lean-chair, will be needed. The symptoms which bring them under observation are an evidence of active disease, and active disease requires rest. There will come a time with these patients, however—and also, though later, in febrile cases that progress—when the question of movement and exercise will arise. At most Continental centres for the treatment of tuberculosis exercise is for the most part considered a mere necessary return to normal life and not as an element in treatment. I think this is the safest view to take of it, but with a somewhat liberal interpretation. When disease is arrested the patient should be got slowly but steadily back to normal exertions, and five to eight or ten miles’ walking exercise daily is not too much to end up with. But this must be slowly and steadily achieved, with an eye on the temperature chart; any rises of temperature must be met by a return to a more resting regime. It is especially during this stage that the sanatorium is of unique value, providing as it does the skill of a physician specially trained in this difficult work. At the same time that exercise is being steadily pushed to these moderate heights the patient must have some hours of complete rest on couch or lean-chair during the day, and for some part of this time should relax his muscles and do nothing, or sleep if he will. In British sanatoriums some two hours’ compulsory rest is usual, one hour of which is before lunch. On the Continent at least seven or eight hours’ daily rest is the rule. I think myself that in this country we do not carry rest far enough, and the rest between lunch and tea invariably practised abroad might be adopted here with advantage.

I have been careful to utter a warning about the possible dangers of exercise, even graduated exercise given therapeutically, in cases of pulmonary tuberculosis not fully quiescent. Nevertheless I have admitted that graduated exercise, or “controlled auto-inoculation,” is a method of treatment that can be pursued with advantage in certain quiet types of case. But “immune responses” may be obtained by other means than exercise, and these other means must now be considered—first, tuberculin treatment, and secondly, treatment by certain drugs which produce reactions.

Tuberculin Treatment.

I have already considered the effect of a tuberculin injection—how a large dose may lead to severe reactions,

local, general, and focal, and may, like auto-tuberculin, upset immunity, and start the patient in a vicious circle of reactions with serious results. I have also shown how, with a step-like increase of dose, the patient may receive a desirable “immune response” to each dose, and establish a growing tolerance. For localized tuberculosis, as in surgical cases, where there is little or no auto-inoculation, tuberculin can be used in small doses, repeated with the same response every two weeks, by which time tolerance will have dropped again. But in autotoxic tuberculosis, as in lung cases, where inoculation with auto-tuberculin already occurs, it is found better to raise the dosage steadily at a shorter interval and so establish tolerance. Otherwise it is impossible to find and keep the level of effective dosage, since this is interfered with by irregular additions of auto-tuberculin. Doses are started in the neighbourhood of a millionth to 100,000th of a cubic centimetre, and rise steadily, by geometric progression, to a final dose of 1 c.cm. Here again, as in “graduated labour,” we establish high tolerance to tuberculin, but we must not delude ourselves into the belief that this is the same as high immunity to tuberculosis. It is more probable that such good as arises from tuberculin treatment depends on the short immune response to each dose, rather than on any cumulative effect. There is, I think, no doubt that a well applied course of tuberculin does good in suitable cases, but the treatment has gone out of fashion here largely on account of the trouble involved to both doctor and patient. If it had been the remarkable remedy some have held this would certainly not have happened. If it is used, my advice is that large reactions should be avoided—that getting a minimum but definite response to each dose should be aimed at. Any marked reaction must be met by rest and the return to a lower dose at the next injection. But too timorous an advance is as bad in its effect as overboldness. The treatment is not suitable for febrile cases, nor for “exudative” types of disease. It is useful in those quiet chronic types for which graduated exercise may be employed with impunity or even with advantage. There are also cases of mild fever hanging fire where a minute dose of tuberculin (or auto-tuberculin) may sometimes start the body’s delayed effort at immunity.

The tuberculins on the market are very numerous, but their actions are very similar; the best known are Koch’s three preparations—old tuberculin, new tuberculin or T.R., and bacillus emulsion or B.E. Of recent years many preparations of split tubercle bacillus have appeared, among which may be mentioned Dreyer’s “defatted antigen,” which was introduced in 1923. My experience with this preparation is that it may do good in a certain class of case, just as do other tuberculins. It is no cure for tuberculosis.

Drugs causing Reactions.

I may now turn from tuberculins to certain drugs which cause “reactions” in patients suffering with active pulmonary tuberculosis. How these reactions are produced is not yet clear, but for some of the preparations recently introduced it is claimed that the tubercle bacillus is attacked and destroyed *in situ*. It has long been known to those treating cases of pulmonary tuberculosis that potassium iodide, arsenic, creosote, and some other drugs may cause “focal” reactions in certain cases, but it has been to the salts of the heavy metals that attention has been directed of recent years—those of copper and gold especially, and to a less extent of nickel and cobalt.

Copper.—Copper salts were used in very early days, and their use was revived in France by the Lutons, father and son, about 1880. They observed that they possessed a specific affinity for tuberculous tissues, just as did Ellis more recently with his “picric-brass paste,” and given internally they found that focal and general reactions followed. They gave for the most part copper acetate, and later workers have used copper chloride, a dimethyl glycol copper, and other preparations. Begun at first by the mouth and subcutaneously, they were finally employed intravenously. These experiments seemed to bring out two important facts: (1) a selective action possessed by copper for tuberculous tissues; (2) the apparent ability to get copper into contact with tuberculous tissues by general administration, and to cause reactions. These reactions

were followed by improvement in some cases, but in others by none, and this no doubt depended on the class of case treated. Feldt of Frankfort, working with gold salts, claimed that reactions following the use of these were, on the contrary, always beneficial.

Gold.—Gold therapy may be said to date from Koch, who in 1890 discovered that gold salts, especially the cyanides, possessed an inhibitory action on the growth of the tubercle bacillus *in vitro*. Gold potassium cyanide had been recommended for internal use in pulmonary tuberculosis by Chrestien as long as sixty years ago, and its use was revived about the year 1913. Later, about 1917, a gold-cantharidin preparation called "aurokantan" was introduced by Feldt, and this gave place to a body called "krysolgan," which was given intravenously in 10 per cent. solution. Reactions followed the use of these preparations and were said to lead to improvement. Feldt claimed that krysolgan "increases the production of normal and specific antibodies, brings the histological disease products to healing, renders the tubercle bacillus harmless, and that in doses which for the remaining body cells are not only harmless but exert a stimulating influence." Lydia de Witt of Chicago, however, testing it on tuberculous guinea-pigs, found that life was not prolonged and disease not checked. From an analysis of the organs of healthy and tuberculous animals so treated she concludes "that gold has shown no specific affinity for tuberculous tissues." Moreover, she found that tubercles flourished in organs containing large amounts of the metal. In 1924 Moellgaard of Copenhagen published a book on the chemotherapy of tuberculosis. He had produced a preparation named "sanocrysin," a double thio-sulphate of gold and sodium, which, he claimed, would diffuse through the non-vascular tuberculous tissues, penetrate the fatty capsule of the bacillus, and attack it *in situ*. Intravenous injections of this body in 4.5 to 5 per cent. solution lead to violent reactions, often with erythema and albuminuria, and in some cases "shock" symptoms, and these have been ascribed, as they may well be in part, to the mobilization of auto-tuberculin. A serum has been used with the hope of neutralizing these toxic effects, but it appears to be of doubtful utility. Various results, some good and some bad, have so far been attained, and the method is still under trial. Whether we are here dealing with a true chemotherapy, or only a treatment by reactions, still remains, I think, to be proved. It has, of course, always been foreseen that the difficulty which would be met, if chemotherapy could ever be applied to tuberculosis, would be the large and perhaps fatal reactions caused by the release of auto-tuberculin.

Before leaving the subject of treatment by reactions it will be well to mention one or two other subsidiary forms of treatment which probably act in similar manner and have had their advocates. The first of these was that by nascent iodine, which is, I think, no longer used. Then there is the sodium morrhuate treatment, introduced by Leonard Rogers, the substance injected being a sodium salt of the unsaturated fatty acids of cod-liver oil after extraction by ether. Lastly, there is colloidal calcium. It is curious that these substances should produce reactions very similar to those produced by tuberculin, but so it is, and in certain cases, as happens with other methods of auto-inoculation, a certain measure of improvement follows. Whether with any of these measures the results justify the means, or whether they present any definite advantage over the "controlled auto-inoculation" produced by suitable rest and exercise, is a question difficult to answer. Certain it is that no striking results, unobtainable by other means, have ever been demonstrated.

It will be clear from the consideration of the action of tuberculin or auto-tuberculin, that the treatment by reactions, however they are induced, is a treatment which must be pursued with caution, and not applied to cases of exudative or caseous type. Only it may be said, that if a true chemotherapy be proved for gold or others of the heavy metals, then some risks may, perhaps, be justifiably run during the destruction of bacilli in areas of active disease. But in a disease so treatable as pulmonary tuberculosis, in all but its later stages, there is a strict limit to this.

Excessive Auto-inoculation.

I will now turn away from the cases—mostly afebrile, or at least ambulant febrile—where artificial auto-inoculation might be considered, to the directly opposite condition where auto-inoculation is excessive, whether from the amount or type of disease, and must be controlled if the patient is to live. This will be the febrile case with disease progressing in spite of bodily rest, and with this I will consider the case where disease, whether febrile or not, has reached a stage where mechanical factors prevent healing. It will be found that a proportion of such cases are wholly or largely one-sided, and among these collapse of the lung by artificial pneumothorax or other means has been attended with notable success.

Artificial Pneumothorax or Lung Collapse Treatment.

As long ago as 1821—that is, as soon as the elastic recoil of the lung was an established fact—James Carson of Liverpool had recognized how serious a bar to healing were the elasticity, condition of extension, and constant movement of the lungs, and on these grounds urged lung collapse as a method of treatment. In abscess of the lung he noted how "the sides of the abscess are prevented from falling into a salutary contact, not by the matter which lodges between them, but by the powerful elasticity and retraction of the surrounding substance." By collapse of the lung, on the other hand, "the diseased part would be placed in a quiescent state, receiving little or no disturbance from the movement of respiration, which would be performed solely by the other lung, and the divided surfaces would be brought into close contact by the same resilient power which before had kept them asunder." With regard to "consumption," he remarked: "in those cases in which the disease is placed in one of the lungs only, the remedy would appear to be simple, safe, and complete." He also foresaw its value in pulmonary haemorrhage. Later on in the century the occasional improvement following spontaneous pneumothorax was noted by various observers, but pneumothorax as a form of treatment may be said to have seriously started with the publication of cases by Forlanini in 1894 and 1895. Now it is recognized as a most valuable measure all the world over. The cases for which it is suitable fall into two categories: (1) cases of active disease which strict recumbency has failed to arrest, and where more complete rest of the lung is needed, and (2) cases where cavitation and extensive disease have rendered healing impossible in the extended lung. To these may be added recurrent severe haemoptysis. Disease must be, in the main, one-sided, or if disease is present in the better lung it must be of quiet type and not too extensive. Much experience is needed to decide what is a suitable case, but in a doubtful case an artificial pneumothorax can be tried and its effects watched.

As a rule, under pneumothorax treatment the functioning lung improves rather than deteriorates. This might be almost expected, for by collapsing the bad lung we remove the source of auto-inoculation whereby severe focal reactions, tending to increased activity and spread of disease, were occurring in all tuberculous foci in the better lung.

Artificial pneumothorax is brought about by the injection of air or nitrogen gas into the pleural cavity, and for this all that is needed is a gas bottle, a pressure bottle containing liquid, a water manometer, rubber tubing connecting these, and continued through a cotton-wool filter to a suitable needle. The needle is passed through the chest wall under proper precautions, and its arrival in a free pleural space recorded by the manometer. As soon as it is clear that the needle end is in the pleural cavity gas is allowed to enter. The main risks during the operation are those of gas embolism if a vein is entered, or "pleural shock," a reflex disturbance which is occasionally encountered. Gas is given every few days at first, in quantities varying from 300 or 400 to 800 c.cm., and full collapse of the lung attained after about seven to ten days. With full collapse the lung becomes a small solid mass against the spine, and the heart and mediastinum are carried over towards the opposite side. This displacement must not go too far, and is controlled by the gas pressure. A lung full of disease collapses but slowly. After the first few fillings there is often an increase of fever, and as the lung collapses

its contents are squeezed out and appear as an increase of sputum. But in a short time, in a successful case, the sputum again diminishes or disappears, the fever wanes, and the patient rapidly reaches a condition of "clinical recovery." But the diseased lung, though removed from view and no longer, thanks to the stagnation of its lymph and blood supply, providing poisons, will need a long period to reach "anatomical recovery." This takes place by an active fibrosis throughout the organ, and treatment can generally be given up after some three or four years. The lung's re-expansion will then depend on the extent of disease, and is often pretty complete unless it is bound down by a thickened pleura resulting from pleural attacks during treatment. Pleurisy is a common complication of artificial pneumothorax, and attacks, generally in a slight form, fully 50 per cent. of cases at some time during treatment.

The main trouble in pneumothorax treatment is the very common presence of pleural adhesions, which tend to limit collapse. Sometimes only a few bands are present, which stretch or break under treatment. But in many cases part of the lung, often the most diseased part, is held out to the chest wall, and we have attained only a partial pneumothorax. This may, in some cases, suffice to arrest symptoms and eventually ensure a cure. But often the pneumothorax is thereby rendered useless. In a few of these cases adhesions holding the lung may be artificially divided, whether by thoracoscope and cautery or by open operation, but very few are suitable for these measures. In a proportion of cases, also, otherwise suitable for pneumothorax treatment, total adhesion of the pleural surfaces is found to exist.

Surgical Measures.

For those cases where pneumothorax treatment has failed owing to adhesions, there remains still the possibility that the diseased lung may be collapsed by suitable surgical measures. Many operations have been devised and have been more or less successful, but the operation which holds the field at the present time is that known as extrapleural thoracoplasty. Thoracoplastic operations with a view to collapsing cavities date from de Cernville of Lausanne in 1885, but their use as a substitute for failed pneumothorax was first pursued by Brauer and Friedrich about 1907. The modern form of operation—a paravertebral resection of ribs—is especially associated with the names of Sauerbruch, Wilms, Brauer, and to a less extent of Saugman. Portions of all the ribs, from the first to the tenth or eleventh inclusive, are resected through an incision running down the back over their angles. The aim is to obtain a satisfactory collapse of the hemithorax, and for this it is necessary to cut the ribs back to the transverse vertebral process, and especially to include the first rib so that the ribs may fall like the handle of a bucket. The shoulder girdle remains intact, and hence there is little deformity. The operation is done in one or two stages, according to the condition of the patient, the lower part first. Sometimes the operation is preceded by phrenicotomy to paralyse the diaphragm; the main danger is aspiration pneumonia, and this is thought to help in its avoidance. The results of these operations in skilled hands have been highly encouraging, but they can only be performed with advantage in carefully selected cases. In the main, cases suitable for pneumothorax are suitable for thoracoplasty, but the indications must be much more rigidly drawn. The other lung must be more severely scrutinized—it is all too likely to break down under a surgical operation. Also thoracoplasty is more suitable for the second class of case mentioned under indications—extensive chronic disease—than in the first class, where lung rest is desired in a case of active disease. It is claimed from large statistics that 36.8 per cent. of advanced disease are cured, and 24.4 per cent. improved as the result of thoracoplasty—no small success when the class of material is considered.

Principles of Treatment in certain Important Complications and Symptoms.

Haemoptysis is, to the patient, a very terrifying experience, and the first point is to allay anxiety and instil

confidence, since thus cardiac excitement is stilled, and restlessness mitigated. For this morphine, the usual panacea, should be avoided, especially if the haemoptysis is large, or at most given in small doses. Better is a large dose (30 to 60 grains) of sodium bromide. The danger of haemoptysis lies more in the retention of blood in the lungs, leading to pneumonia or further spread of tuberculosis, than in the quantity of blood expectorated; consequently it is of the utmost importance that the cough reflex be not abolished by drugs, such as morphine in large doses. The patient is best propped in the semi-upright position, so that coughing is easy, and told to restrain too violent or needless cough. Speaking should be avoided. Aspiration of blood and secretion will probably do no harm unless too long retained, and this is not likely to happen if the cough reflex is intact, or only slightly dulled, if too violent, by quite small doses of heroin or codeine.

To control the haemoptysis we should have three things in mind: (a) reducing the pulmonary blood flow; (b) increasing coagulability of blood; (c) contraction of the bleeding vessel.

(a) The first of these is best achieved by damping down the systemic circulation by rest, a cool surface, and avoidance of cardiac excitement. Vaso-dilators and vaso-constrictors should be avoided, for both increase pulmonary blood flow. Cardiac depressants, such as the depressant expectorants, are unpleasant remedies; but pituitrin, which is said to act as a depressant to the right heart only, may be used and has proved effective. In large haemorrhages binding the limbs and cupping the abdomen will hold up blood from the lungs for a period.

(b) Increased coagulability of the blood is best attained by "salt action," whereby tissue fluids carrying thrombokinase are drawn into the blood vessels. Sodium chloride may be given intravenously in hypertonic solution (5 c.cm. of 10 per cent. solution), or by the mouth—a teaspoonful in half a tumblerful of water; some of this may be replaced by sodium bromide, which has the same action. Binding the limbs probably adds thrombokinase to the blood when the pressure is released. These effects, though valuable, are apt to pass off quickly, though their application can be repeated. Other remedies which may have more lasting effects on blood clotting are calcium, given intravenously or intramuscularly, gelatin, horse serum, or such preparations as haemoplastin, coagulen, etc., but the action of all of them proves very doubtful in practice.

(c) Contraction of the bleeding vessel we can influence little or not at all. If the bleeding area is known an icebag may be applied; ice must not be given to suck, since this has been found to dilate the pulmonary vessels. Sandbags and strapping have been largely abandoned owing to the fear of retention of blood clots. Lastly, the bleeding-point may in many cases be closed by pneumothorax. In arranging the after-treatment it is useful to remember that it takes twenty-four to forty-eight hours for a vessel thrombus to fix, and many days or weeks for organization of the clot.

Fever.—Fever we must regard as evidence of toxæmia, to be treated by the reduction, by all means in our power, of auto-inoculation. Only in some subpyrexial cases it seems as if a mere hypersensitiveness exists, to be controlled in some cases by a careful increase of auto-inoculation or a minute dose of tuberculin. The use of antipyretics, especially of pyramidon and cryogenin in small doses, has been extolled by some in febrile cases of pulmonary tuberculosis. I do not think myself that by their use we break any vicious circle, as is claimed, nor improve the patient's well-being in any way.

Cough.—Cough is in some cases a troublesome symptom, in that it disturbs healing of the lung and increases auto-inoculation. The patient must learn to restrain it, and with practice may do much. Often it is easier if rendered looser, especially by that useful drug ammonium chloride. Opium preparations should be postponed as long as possible—they soon upset general well-being. Lozenges containing demulcents, as liquorice and perhaps some menthol, will often suffice; or for some patients an occasional inhalation containing menthol, creosote, and chloroform.