Apparently in this case there is as yet no evidence of familial affection. The patient has several brothers, all younger than himself, who are healthy.

Our reason for reporting this case lies in the fact that myopathy starting in the thigh muscles and described as the type of Leyden, Moebius, and Zimmerlin is of some rarity.

We have to thank Dr. C. E. Ligertwood, medical superintendent of this hospital, for permission to record the case.

ARTIFICIAL PNEUMOTHORAX.*

BY

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It is now some thirty years since artificial pneumothorax came into practical use in the treatment of pulmonary tuberculosis. During this period the roll of its adherents has steadily increased as its value has become more and more widely recognized, and the opposition which new methods always have to encounter, and which in this case has never been very strenuous, appears to have died down or disappeared. At the present time the treatment is practised in most of our sanatoriums, and in London the County Council have arranged to supply it to patients of the hospital class. As to the opposition it has encountered, such opposition as I have observed has shown itself rather in a studied neglect of the method than in open antagonism. Among those who have really investigated and practised the treatment I have neither met nor read of opposing opinions as to its value. This unanimity among the initiated has seemed to me nothing less than remarkable; for it is a treatment that involves no small amount of art and judgement, as well as some knowledge, and the success achieved might well be expected to differ, and differ widely, in the hands of various operators. If there have been any persistently "unlucky" centres, their fame has never reached my ears; and in this connexion it is important that the class of case treated be taken into careful consideration before any judgement is passed on results.

Those who reserve the treatment for advanced and otherwise hopeless patients may well find ill-fame in spite of the utmost skill; on the other hand, those who treat early cases by pneumothorax will achieve a success which they in no way deserve. The peculiarly individual character of each pneumothorax case, both as to the nature and amount of disease, and the varying features of the "gas pad" applied, defeats all efforts to classify the results; those who wish to convince themselves must do so on individual cases. The return to health of a single case of advanced unilateral disease under pneumothorax treatment will have an effect on their minds which statistics will neither increase nor diminish. I shall not, therefore, waste time now over the results, feeling that I shall open this discussion more usefully by inviting your remarks and criticisms over a wider field. If we achieve the best possible in the selection of cases and in the art of their treatment, we may safely leave the results to win a steady recognition for themselves.

Indications for Treatment.

First, as to indications for pneumothorax treatment—for the first essential to success lies in the proper selection of cases—these must miss on the one hand those who can recover by other means, and, on the other hand, those for whom a pneumothorax will merely mean acceleration of their inevitable end. Forlanini's dictum can, perhaps, hardly be improved upon. "Pneumothorax," he remarked, "is indicated every time that life is threatened by the extension of a local lesion." This is not to say, of course, that all such cases are suitable, since contraindications may exist, but in all such cases the question of a pneumothorax demands investigation. In practice it is surprising how many cases with disease of the whole of one lung turn up for this treatment. This is not, I am convinced, as a rule due to the negligence of physicians who have allowed disease to spread from apex to base before they awoke to the need of doing something. But disease in these cases

is of hilus origin, has progressed in the deep parts of the lung, and on reaching the surface is soon evident to auscultation over the whole of one side. In such patients the x rays will often discover advanced disease of the opposite lung also, though to the stethoscope it may appear quite sound because the process has not yet reached the surface. For this reason it is imperative, where at all possible, that a radiogram be taken before a pneumothorax is embarked on, for above all other considerations the condition of the other lung is the point of the most moment. How much disease may be permitted in the other lung without its forming a contraindication to pneumothorax is a matter which cannot be described on paper, and is often very difficult to decide upon in practice. In my experience the question of activity is of far greater importance in this decision than extent or locality of disease. Rarely is the other lung altogether free of disease unless in pneumonic cases, and in these, nevertheless, the prognosis is bad. But torpid lesions, even of wide extent, may be expected to clear up or improve—the strain of increased function seems to be more than counterbalanced in these cases by the removal of focal reactions and toxæmia, and the effects of the hyperæmia which is probably brought about. Active lesions, on the other hand, tend to spread and get worse. But even to this there may perhaps be exceptions. Many writers, notably to my recollection Mary Lapham, and Parfitt and Crombie, have recorded improvement and recovery under pneumothorax in cases where the other lung was so bad as to appear to be a contraindication. In some of these the x rays were not used till after the pneumothorax was initiated, and the writers are therefore inclined rather to discount the x-ray findings in deciding on the suitability of a case. Nevertheless the x ray must be our standby, and if we are to extend our field of treatment to cases of more doubtful suitability it can only be through increased experience of the radiological appearances.

Conducted Riles.

One of the warnings I should like to make while speaking on selection of cases is against mistaking conducted sounds for evidence of disease in the better lung. Sharp consonating crepitations are nearly always audible on the opposite side near the spine, and not infrequently about the axilla, though, curiously enough, they may be less plainly heard in some cases in the area between these points. Often a pneumothorax will unexpectedly remove sounds in the functioning lung, and frequently, I am sure, these sounds have been merely conducted. Crepitations at the base or round the heart on the good side are not always, I think, a contraindication to pneumothorax, where the x rays show only quiet peribronchial disease. Such signs may clear as treatment progresses. In cases where the better lung is of doubtful reliability a waiting period of complete rest may improve matters; but in other cases the chance of doing a pneumothorax may, through waiting, pass by and be lost.

Intervals and Quantity of Gas.

To pass over the initial operation, regarding which I have nothing new to remark, and to come straight to the pneumothorax already induced, I should like to refer to the intervals between refills, and to the quantity of gas it is wise to introduce. I find a tendency in this country to give larger fillings, and hence at longer intervals, than are advised by the most experienced Continental authorities. For example, Forlanini in Italy recommended only 200 to 300 c.cm., rising at most to 500 c.cm. at each filling; Dumarest in France rarely leaves longer than three weeks between refills, unless in cases of thickened pleura; Brauer and Spengler, in Germany and Switzerland respectively, advise 400 to 800 c.cm. In this country fillings of 1,000 c.cm. or more seem to be approved of, and one authority teaches, I am informed, that the intervals achieved should be one month in the first year, two months in the second year, and three months in the third year of treatment. This has led, in one case I believe at least, to the need for two refills on consecutive days before the pneumothorax could be re-established at its former volume and pressure. Such a release of collapse seems to me very undesirable, and is condemned on grounds of *post-mortem* experience by some of the best authorities.

Personally, I have found that it is not possible to fix any standard interval between refills, but each case must be a

* Opening paper in a discussion at the Royal Society of Medicine on May 24th, 1921.

law unto itself. For it may happen in one case that a weak mediastinum prevents our achieving complete collapse of the lung, with the result that gas absorption is rapid, and the intervals have to be short—as in a case of mine who can at most achieve a two and a half weeks' interval in the fourth year of treatment; or, on the other hand, pleurisy may early limit absorption and permit of long intervals even near the outset of treatment—as in another patient, whose pneumothorax was started last July, and who has received but 1,120 c.cm. of gas, in two refills, since November last. In my experience it is not wise to let refills run above 700 or 800 c.cm., and in most cases 500 c.cm., or even less, is a preferable amount. The selected quantity will, of course, determine the interval, and this will be long or short according to the rate of absorption. But, quantity of gas apart, a long interval may allow of expansion and attachment of an imperfectly collapsed lung, as happened in the case of weak mediastinum quoted above. This patient was persuaded on one occasion to lengthen his interval to one month, with the result that the lung became adherent to the chest wall in two places. The doctor who made this recommendation was unaware that the lung, though out of reach of the stethoscope, was but imperfectly collapsed at such pressure as could be used, —a fact which was only revealed to x-ray examination.

Pleural Sclerosis.

There is no doubt that the x rays are a well-nigh indispensable adjunct to treatment, alike in the fixing of the optimum pressure at the outset, and also in the readjustment of this at intervals during the course of treatment. In process of time, even apart from the occurrence of definite pleurisy, the pleural layers undergo a chronic inflammatory thickening, followed by contraction, and the mechanical conditions in the chest are thereby altered. Where the heart has been pushed far over to the opposite side it may be seen to return towards the pneumothorax, and therewith the lung may show a tendency towards re-expansion. Under these conditions the interpleural pressure must be steadily raised or the heart and lung will become attached to the chest wall and treatment be interfered with. This readjustment of pressure is a point which must be constantly in mind as treatment progresses. In some cases of pleural thickening, and particularly after purulent pleurisy, no amount of pressure will prevent gradual closing up of the cavity and re-expansion of the lung. In such patients, nevertheless, the expected disaster does not always materialize, for the pleural fibrosis may spread through the lung itself, and healing be thus brought about.

Weak Mediastinum.

Another side to the problem of intrapleural pressures is that concerned with weak mediastinum and with ballooning of the pleura. Mediastinal over-displacement may be difficult to discover without x-ray examination, for the manometric signs described by certain writers (slow rise of pressure, with stationary points, and small fluctuations) are not, I think, of much value. The symptoms may be vague, and the position of the heart may not appear to be unduly altered. As a matter of fact, the same amount of displacement may be borne without discomfort in one patient but cause marked symptoms in another. The symptoms may amount to vague discomfort, with ill-defined distress and inability to sleep, or pseudo-asthmatic symptoms may appear, with dyspnoea, an audible wheeze, and attacks which may be of a very alarming character. All these symptoms disappear as soon as their cause is recognized, the pressure lowered, and the mediastinum allowed to recover its tone. In these cases, and in some others where the displacement is less striking, crepitations may appear at the opposite base and may continue for months or years. They are an indication for a lowering of pressure, but such lowering may be impossible without allowing the lung to expand. Where the signs have, from necessity, been allowed to remain I have not seen any harm result from their presence. They represent presumably an oedema of the lung base in most cases, but in some the dryness of the sound, and its appearance or increase immediately after a filling, suggests mere atelectasis as the explanation. In two of my cases, also, I have experienced a definite lung oedema with frothy sputum during the early stages of treatment, owing to circulatory embarrassment in the better lung.

Inflamed Pleura and its Treatment.

A condition which seems to tempt operators to a raising of pressure—always, I am sure, to the patient's harm—is the onset of pleurisy. This is illustrated by a chart, among many I have seen, which came under my notice a few days ago. At the sixth injection the pressure was raised for the first time to the modest figure of $-3+2$; four days later fluid was found, and the pressure was $+1+8$, and yet 40 c.cm. were put in and the pressure raised to $+3+9$; at a later stage in the same case a return of fluid is noted, and the same increase of pressure was instituted, though it had been kept low in the interval. I do not regard this as a rational procedure, but agree with Continental observers that we should hold our hand, and even avoid puncture altogether, during the earlier stages of pleurisy, since such interference may aggravate the inflammation. Moreover, it may lead, as I have seen in these cases, to troublesome displacement of the mediastinum. There is, fortunately, no need for puncture during the early stages of pleurisy, since gas absorption almost ceases, but it is, I fancy, the small amount of gas which can be put in that tempts those who do puncture to raise the pressure. The loss of resilience due to inflammatory congestion must not be confused with the stiffness of chronic thickening, in which condition, of course, high pressures can and should be employed.

"Ballooning" of the pleura towards the healthy side at certain weak spots, and particularly in front under the sternum between the first and fourth rib articulations, is an occurrence which is quite common, but has not attracted a large amount of attention. It reveals itself by giving the physical signs of a gas pocket, and is generally visible to x rays as an elliptical encroachment on the healthy side with a visible sharp border. I have so far seen no harmful results accompany this occurrence.

Surgical Treatment of Adhesions.

A subject of the greatest moment, in that it promises to open a doorway from pneumothorax treatment into wider fields, is the surgical treatment of adhesions and especially of adherent pleura. Localized adhesions, if solitary or few, can be divided without opening the chest by the galvano-cautery or with a tenotome. Jacobaeus's method consists in the introduction of an instrument called the thoracoscope, with which the adhesions are visualized, and thereafter in the introduction of a cannula in the neighbourhood of the adhesion, and its severance by a galvano-cautery introduced through the cannula. The technique is difficult, but a good deal of success has attended its use in skilful hands, as may be gathered by an article by the Norwegian Holmboe in the October, 1919, number of *Tubercle*. Division of adhesions with a tenotome has been practised by Morriston Davies in this country, the operation being carried out under the x rays.

For cases where a few strong adhesions are preventing treatment one or other of these methods may succeed; with multiple adhesions I am inclined to think opening the chest may prove a more satisfactory procedure.

About a year ago, in a private patient for whom I produced a pneumothorax, the lung failed to collapse adequately owing to the presence of numerous firm adhesions to the chest wall. Persistent low pressures did not lead to their stretching or separation, and higher pressures were barred on account of the presence of large and numerous cavities which I feared might be torn open. Recently the condition was becoming less and less satisfactory owing to the further shortening of the adhesions as the result of chronic pleural inflammation and fibrosis. Some three weeks back Mr. Romanis at my request opened the chest wall through the third space, and divided, with scissors and galvano-cautery, seven strong adhesions, mostly rounded bands, but one with a fairly wide attachment. This allowed the lung to collapse, which it did to a moderate degree only, being solid with disease. The actual operation took twenty-three minutes, was done under gas and oxygen only, and no rib resection was contemplated or performed, an ample opening being obtained between the spaces with special retractors. The operation led to very little reaction or other disturbance, except for the expected temporary increase of sputum. A refill was given on the seventh day and again on the twelfth, and all seems well save for doubts as to the ultimate behaviour of the functioning lung.

Separation of Adherent Lung.

Of recent years the separation of lung adherent over a larger surface to the chest wall has been attempted on various occasions. In 1918 Professor Schöttmüller, of Hamburg-Eppendorf, described how he advised the trial

of this for a case in which Jessen had found the pleural surfaces adherent. Jessen refused to attempt it, but Sudeck removed most of the fourth rib and separated many adhesions by hand, and a good result was recorded. Eden of Jena, stimulated by this, operated on a case, but found the surfaces very difficult to separate, and had to confess that the pneumothorax obtained was only partly intrapleural. Some days later the patient ruptured a lung cavity during the act of coughing. Ulrici also treated a case by this means, but the operation lasted one and a half hours, and the patient succumbed eventually to extension of disease in the opposite lung and other organs. I cannot feel that the separation of adherent pleura, apart from well-defined bands, by surgical means, is at all a sensible proposition, and fortunately there appear to be other possibilities.

Stripping the Costal Pleura: Tuffier's Operation.—Just a year ago I got Mr. Romanis to strip the parietal pleura from the endothoracic fascia over the apex (apicolysis) in a private patient who suffered with a bleeding cavity, and to pack the resulting space with solid paraffin. I was so much impressed on this occasion with the ease with which the parietal pleura stripped, and with the comparative mildness of the operation, done under gas and oxygen and without rib resection, that I felt encouraged to try it in other cases where adherent pleura prevented the production of pneumothorax. Not long after this I came upon a paper by Rieckenburg, working under Ulrici at Sommerfeld, in which he describes two cases of adherent lung where the costal pleura was stripped from the chest wall, and a pneumothorax maintained outside it. He points out the value of the double covering over large cavities in diminishing the danger of perforation, and notes that the raw pleural surface in healing contracts down and prevents further expansion of the lung. The cavity holds gas only under low pressures at first, but eventually it becomes effectively "gas-tight." Encouraged by the possibility this offered, I asked Mr. Romanis in January last to strip the whole costal pleura in a case eminently suitable for pneumothorax, but with total adhesion of the pleural surfaces. The patient had chronic disease of the whole right lung with cavitation, and ran fever to 100.5° in spite of prolonged rest. The left lung was an excellent organ. The chest was opened through the third space, and the pleura separated with the hand over all but the inner surface of the lung. Ample room for insertion of the hand between the ribs was obtained by strong retraction, and the pleura stripped with the greatest ease, but the lung collapsed little as it was solid with disease. The operation lasted but twenty minutes, and was followed by very little shock or reaction. It was realized that the absorption of air would be rapid, but I thought a week could be left before the refill. Most unfortunately, however, the patient only came into my hands again after an interval of twelve days, and by then all the air was found absorbed and the lung re-expanded. It would be wiser, I think, in such a case to leave a small opening to the outer air, and to close this at the end of a week, when refills can be conveniently substituted. The sequel in this case was interesting, for the temporary immobilization of the lung allowed the patient to re-establish tolerance, and the temperature fell to 99° and has remained there; at the same time both lung and general condition have improved. This improvement is reminiscent of some experiences of Schroeder, who found lung fibrosis and recovery to follow a severe traumatic pleurisy in three cases where he attempted, without success, to separate adherent pleural surfaces after a pneumothorax operation by Brauer's open method.

Extrapleural Thoracoplasty.

I have referred to the possibility of thus creating and maintaining an extrapleural pneumothorax because the idea may be new to some of those here present. Of the better recognized means of dealing with adherent pleura, by extrapleural thoracoplasty under local anaesthesia, I shall not here speak, but I hope some others now present may do so. Two admirable papers on this subject by Scandinavian authorities appeared in our journals last year, one in *Tubercle* of April, 1920, by Saugman, dealing with 41 cases, and one by Bull of Christiania in the *Lancet* of October 16th, 1920, with an account of 37 cases. The results appeared to be excellent, and the actual operation mortality small, amounting to but 4 cases in each series.

With regard to all these surgical procedures, it must be noted that operations are not to be lightly undertaken in the subjects of pulmonary tuberculosis; the cases require even more careful selection, especially as regards the condition of the better lung, than they do for mere pneumothorax treatment. Before leaving the subject of adherent pleura I should like to insist that no operative measures must be undertaken for its relief until its actuality is determined by experiment. It might well be supposed that where a great displacement of organs and closing in of ribs has occurred, we are then necessarily dealing with

adherent pleura. But this is by no means the case, as I can illustrate by a radiogram from a patient on whom I induced a pneumothorax some three weeks ago. The heart was entirely in the right chest, and the trachea was drawn over and distorted; and yet the pleural surfaces proved un-adherent, with the result, as would be expected, that the intrapleural pressure had fallen to a very low figure—actually to -27 -25 cm. of water.

Pneumothorax treatment is a big subject, because it involves so many possibilities. What I should like finally to insist on here is the comparative narrowness of its indications, but its striking hopefulness within these limits. All is possible to a case of unilateral, or practically unilateral disease, if only we are sufficiently persistent. It is for that reason that I have wandered to-day into the byways of surgical interference, feeling that in these cases adherent pleura is no excuse for folding our hands and giving in. The patient with one lung has a good fighting chance if only our skill and resourcefulness suffice to discover for him the road to victory.

Memoranda:

MEDICAL, SURGICAL, OBSTETRICAL.

THE DESTRUCTION OF BACILLI BY ELECTRICITY.

In 1915 I started some experiments for the destruction of bacteria by electricity. Pus from a streptococcal abscess was collected in a sterile copper vessel; cultivations on agar yielded a virulent streptococcus. After passing a continuous electric current of 100 milliamperes through the pus for an hour no growth was obtained on agar, but at the bottom of the copper vessel I found a deposit of copper salts sufficient to kill the most virulent streptococcus.

I next tried an electric bath with a carbon pole. I had a patient with a very bad septic forearm, which did not improve with free drainage and antiseptic treatment. I obtained a large porcelain arm bath, filled it with 10 per cent. saline solution, and put one carbon pole at one end of the bath; I made the patient's septic arm the other pole by attaching a zinc plate to his shoulder and allowing him to rest the limb in the warm saline solution. I now passed 80 milliamperes continuous current through the bath and left the arm in it for half an hour. The following day the arm looked very much cleaner and the granulations much healthier. Each day it improved, and within about ten days with daily baths it was almost healed. I discussed the treatment with my colleagues, and we agreed that in all probability the improvement was due to free chlorine gas, which was being liberated by the electric current passing through the saline solution. I was, however, struck by the rapid growth of healthy granulation tissue, which I was convinced was stimulated by the current.

From 1917 to 1919 I continued my observations at the Norfolk and Norwich Hospital, and there treated a number of gunshot wounds with septic sinuses by means of copper sulphate ionization. The sinus was cleaned out and filled with a 1 per cent. solution of copper sulphate. A copper rod was then put down the sinus and a zinc pad placed on the patient's back. The two poles were connected respectively to the anode and cathode of a galvanic battery and a constant current of about 8 milliamperes passed through for about fifteen minutes daily. The rapid healing of the wound was marked by the rapid growth of granulation tissue.

In an attempt to prove that the electric current actually played a part in the destruction of organisms I constructed an apparatus by which the current passed through some pus, but the poles were not in it. By this means the gas given off at the pole could not play a part in the destruction. I obtained a glass vessel, divided into three compartments by plates which would conduct the current. I placed some pus laden with *Staphylococcus aureus* in the middle compartment and the positive pole into one and the negative pole into the other of the two remaining compartments, which were filled with normal saline. A current of 50 milliamperes was then passed through for half an hour at 70° F. By incubation on agar for eighteen hours a very small growth of *Staphylococcus aureus* was obtained. The current was allowed to continue running