RECENT ADVANCES IN THE SURGERY OF THE LUNG AND PLEURA.

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INTRODUCTION.

The surgery of various parts of the body has always been subject to fitful periods of stagnation alternating with periods of progress, set going usually by some new discovery as to the nature of a disease or by some development in general technique. For the intrathoracic region the inactive period has been a very long one, and it is only within the last decade that the change has come. Yet so marked is this change, so rapid the progress which is being made, that although previously, few conditions other than some of the acute inflammatory ones were dealt with by surgical measures, at the present time there is scarcely an intrathoracic lesion, from bronchitis and emphysema to carcinoma of the lung, which does not yield a steadily increasing proportion of satisfactory and encouraging results to the new methods of active treatment.

Many who have not followed closely modern advances in the surgery of the lungs, have erroneously conceived the idea that the progress has been exclusively in the technique allowing of operations in the open chest. The realization by Sauerbruch and Brauer of their endeavour to discover the means of overcoming the dangers of operating with an uncompensated pneumothorax has undoubtedly greatly facilitated the surgical treatment of certain groups of intrathoracic diseases. The total number of cases, however, in which this technique is necessary is quite small compared with the great number of patients who have benefited by modern progress. The result of such progress has been the emergence of three main lines of treatment, which may be termed: (1) Treatment by collapse, (2) Treatment by consolidation and fibrosis (solidification); (3) Treatment by excision.

Treatment by collapse is the most striking advance in pulmonary surgery in that it is applicable to many pathological conditions and is an entirely original procedure applicable to no other part of the body.

DIAGNOSIS.

As a natural sequel of the possibilities of progress in treatment, attention has been recalled to the necessities of early and precise diagnosis.

The advance in this direction has also been very considerable owing mainly to the great improvement in technique and in the interpretation of radiography, and to the realization of the immense value of the *x*-rays in furnishing definite and detailed evidence of intrathoracic conditions.

Such widely different diseases as mediastinal tumours, aneurysms, tubercle, streptotrichosis, syphilis, and tumours of the lung, may for long periods present the clinical picture of a bronchitis: deep-seated lesions often give no signs, specially when there is emphysema; patients with syphilis or streptotrichosis

have not infrequently been treated for weeks at sanatoria. Yet all these conditions are recognizable easily and early by means of radiography

It is still quite frequently said that radiography is of little value That is true just so long as the radiogram is indifferent and the individual unskilled in the interpretation of the shadows.

While our knowledge is still incomplete in many particulars, yet there are many of the clinical problems which can be solved at once. The difference between fluid and consolidation of the lung, between pneumonia and pneumothorax, the extent of a tuberculous lesion, the advance or healing of phthisis, can all be recognized by radiography, and it is by far the most accurate method of recording the progress of a disease.

It may be said emphatically that no diagnosis of any intrathoracic lesion can be complete until a radiological examination has been made.

THE THERAPEUTIC USE OF GASES IN THE PLEURAL CAVITY

When air is introduced into the pleural cavity the oxygen is rapidly absorbed, but the nitrogen and carbon dioxide remain for a much longer period. Murphy[1] injected nitrogen into the chest, and found by means of radiography that at the end of five weeks there was scarcely an appreciable diminution of the quantity of gas and it has been shown more recently that in whatever proportion the three principal gases of the atmosphere are introduced into the pleural cavity, the composition of the gases still present after about five days is some 96 per cent of nitrogen and 4 per cent of carbon dioxide.[2]

It is for these reasons then that when it is required to produce and maintain collapse of the lung for therapeutic purposes, as in phthisis, nitrogen gas is used, but when the object is to replace fluid and obtain expansion of a collapsed lung, oxygen is introduced.

Nitrogen Displacement for Pulmonary Tuberculosis.—The value of rest to a lung extensively affected with phthisis had long been observed in cases where a pleural effusion had developed during the course of the pulmonary lesion and produced compression of the lung: the improvement in the condition of those phthisical patients who survived a spontaneous pneumothorax, the result of rupture of a cavity, had often been recorded. Carson, as early as 1821, recommended the production of a pneumothorax in cases of pulmonary tuberculosis, and Forlanini even propounded the theoretical value of this procedure in 1882. But it was not till ten years later that Forlanini put his views into practice and established a pneumothorax as a therapeutic method in pulmonary tubercle. In 1898 Murphy independently adopted the same form of treatment.

The Choice of Case.—It was at first thought that this method of treatment was applicable to cases of unilateral phthisis only, but it is now realized that a slight amount of disease in the opposite lung is no contraindication. The most important fact to be ascertained as regards the least affected side is that there is sufficient healthy lung tissue to carry on the work of aerating the blood after the opposite lung has been put out of action by the pneumothorax.

As the production of an artificial pneumothorax is not entirely devoid of

risk, it is advisable not to adopt this method of treatment until the patient has had a reasonable course (about two months) of hygienic and tuberculin treatment, and it has been found by clinical and radiographical evidence that the lesion is not showing definite signs of clearing up.

Cases in which the disease appears as an acute and rapidly progressing miliary tubercle or as a caseating pneumonia are not suitable for this form of treatment. When, however, the disease is chronic and progressive despite the ordinary forms of treatment; when particularly there are cavities which cannot collapse owing to the rigid chest wall, except by extensive fibrosis of the lung; when the secondary pyogenic infection is marked, or when hæmoptysis is profuse or repeated, the collapse of that lung by artificial pneumothorax will very materially improve the general condition of the patient, and may in a considerable number of cases result in a complete cure of the lesion.

Technique.—During the actual production of a nitrogen pneumothorax two grave complications must be guarded against. These compiications, both of which may end fatally, are:—(1) *Nitrogen embolus;* (2) *The train of symptoms known as "pleural eclampsia" or the "pleural reflex."*

Nitrogen embolus is due to the needle entering the lung and the gas escaping into a blood-vessel. The "pleural reflex" may be caused by the needle puncturing the pleura, by the introduction of nitrogen under excessive pressure in a part of the pleural cavity localized by adhesions, and the resultant drag on these adhesions, or by the rupture of adhesions. Previous uneventful puncture of the pleura or the rupture of adhesions offers no guarantee that the reflex will not occur on a subsequent occasion. The phenomenon manifests itself usually as a syncopal attack, with partial or complete loss of consciousness, marked restlessness, pallor, and disappearance of the radial pulse. The symptoms usually disappear in a few minutes, but death may ensue. Both these dangers can be avoided, in the author's opinion, by suitable precautions.

To eliminate the possibility of a "pleural reflex," the parietal pleura must be anæsthetized, preferably with novocaine, at the point of puncture. The risk of gas embolus can be obviated by using the technique advocated by Brauer,[3] who exposes the pleura through an incision of 5 to 7 cm., and thus is able to see that the needle perforates parietal pleura only. A much simpler and equally safe method is to connect the needle with a water manometer, as advocated by Forlanini,[4] and never to introduce the gas unless the oscillations of the manometer synchronizing with the movements of respiration indicate indubitably that the opening of the needle is in the pleural cavity. A mercury manometer is valueless, as the excursions are too small. The water manometer is further an invaluable guide throughout the whole injection, as it records continuously the variations in degree of the intrapleural pressure. It will denote the presence of dense adhesions round the needle by recording a rapid rise of pressure in the space so confined, with a diminution of the oscillations. The presence of soft yielding adhesions is shown by the registration of a moderate positive pressure, the fluid in the manometer recording, in addition to the regular respiratory oscillations, irregular bigger variations as the pleural surfaces are gently forced apart.

Once an air space has been produced in the pleural cavity, subsequent injections are devoid of all risk of an embolus, unless during the deliberate rupture of adhesions by the production of a high intrapleural pressure (a most

dangerous proceeding) the lung is torn, and nitrogen escapes into the pulmonary circulation. The greatest danger exists at the first attempt, and to minimize this still further it is advisable that the first 100 c.c. of gas introduced should be oxygen.

Brauer injects from 500 to 1000 c.c. of nitrogen on the first occasion, and somewhat larger amounts on each subsequent occasion. Forlanini recommends the introduction of about 200 c.c. only to begin with, and this is certainly a preferable quantity, as the partial collapse of the lung causes a variable degree of auto-inoculation, and an excessive dose may produce marked reaction and even

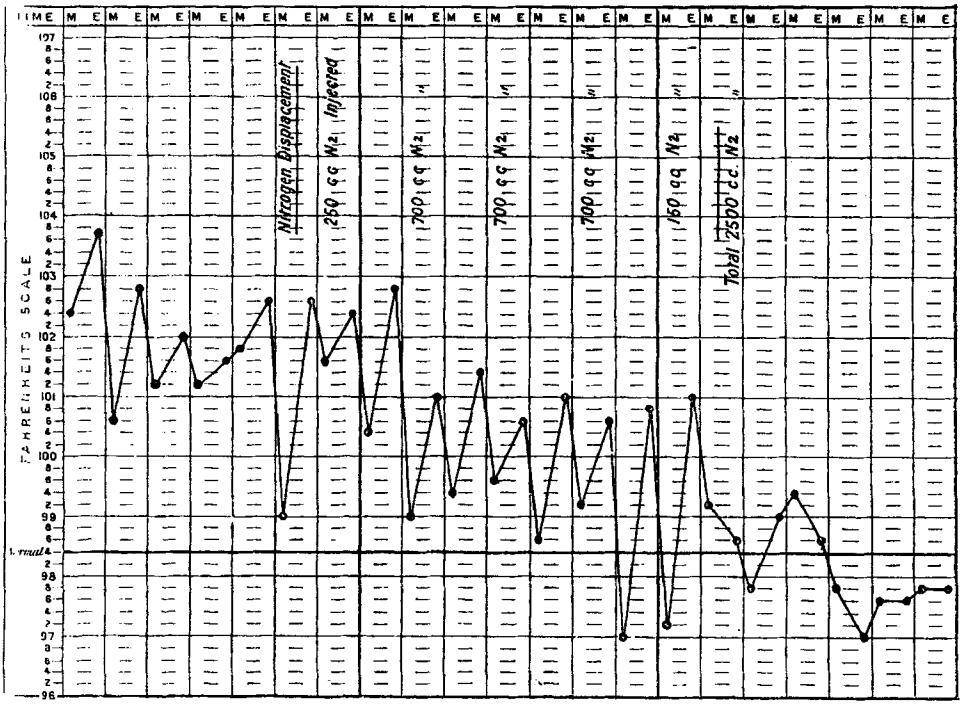

FIG. 105.—TEMPERATURE CHART OF A CASE OF PHTHISIS TREATED BY PNEUMOTHORAX.

an acute extension of the phthisis. If there is a reaction the next dose should not be given until the temperature has been steady again for at least three days. Subsequent doses may be increased to 700 or 1000 c.c., but the amount is regulated by the condition and comfort of the patient. The pleural cavity of an adult will tolerate about 3000 c.c. of gas.

If the pneumothorax is undertaken to check hæmoptysis, the amount introduced on each occasion may be greater, and the injections should be made daily instead of on alternate days.

Complications.—Whenever possible, the progress of the collapse must be controlled by frequent *x*-ray examinations. Besides the dangers of "pleural reflex" and gas embolism already described, two other complications may arise, sepsis, and pleural effusion.

Pleural effusion develops in about 15 to 20 per cent of cases as a direct result of the introduction of the nitrogen. It is not great as a general rule, and need not give rise to much anxiety. It must be remembered, however, that the effusion may develop or increase after the lung has been completely collapsed, after, that is to say, the pressure in the intrapleural cavity has been raised to the maximum desired. In these circumstances the additional displacement of the heart and mediastinum, and the added pressure applied on the sound lung, may produce both respiratory and cardiac embarrassment.

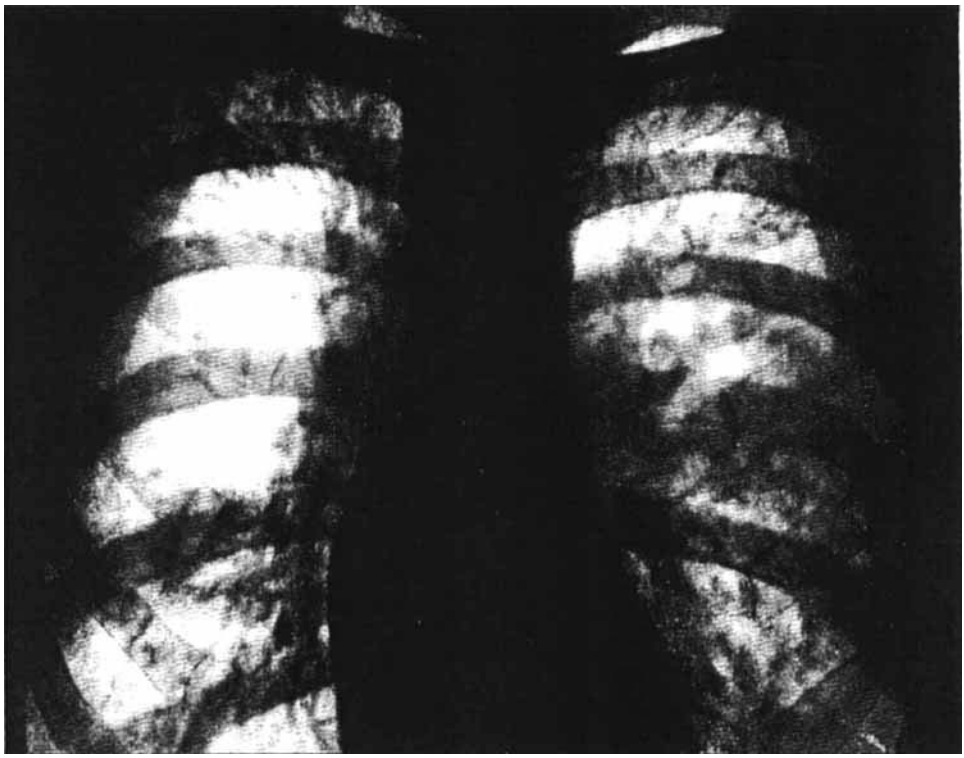

FIG. 106.—A CASE OF PHTHISIS.

On the right side the upper and middle lobes are involved. There is a cavity in the upper lobe below the level of the clavicle. Left side shows general peribronchial invasion. A pneumothorax was produced on the right side.

The distress thus occasioned is easily relieved by the withdrawal of some of the air or fluid.

Results.—It is generally recognized by all who have had experience in the treatment of phthisis by nitrogen pneumothorax, that the results obtained by this method are most encouraging. The improvement in the patient in properly selected cases is immediate and often startling, whilst the effect of the treatment in arresting the disease is equally gratifying.

The changes which are to be observed during the initial period of the treat-

ment are at first possibly an increase in the cough and expectoration, followed by a marked diminution and even disappearance of these symptoms, and a subsidence of the fever. With these, naturally follows improvement in the general condition of the patient; sleep is more easily obtained, and the appetite improves. In the chart (*Fig.* 105) shown on p. 231, the first part is typical of the temperature variations for the two previous months. Associated with the return to normal, the cough and expectoration both ceased, though previously from 3 to 5 oz. of sputum had been brought up daily.

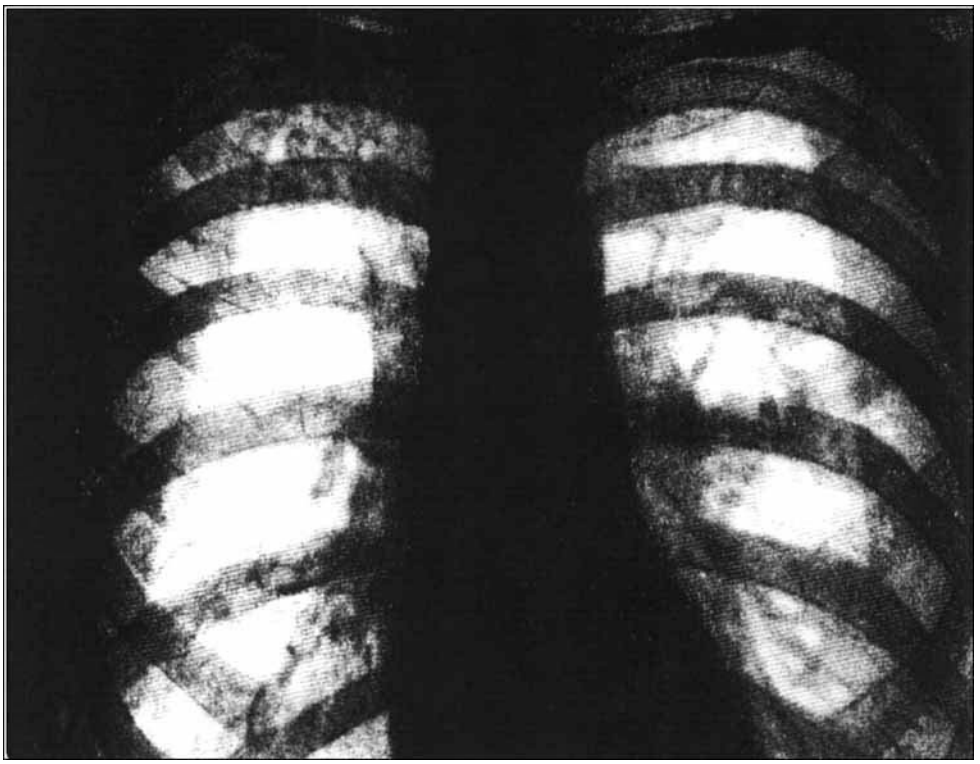

FIG. 107.—THE SAME CASE AS *Fig.* 106, TAKEN TWO MONTHS LATER.
Note the marked improvement that has taken place, not only in the re-expanded right lung, but also in the left lung.

After eight to ten weeks, the nitrogen becoming absorbed, the lung re-expands, and the improvement in the pulmonary lesion—the fibrosis which denotes the healing of the tuberculous foci, the obliteration of the cavities, and the disappearance of the surrounding pneumonic areas—can be clearly seen and recorded by radiography.

As it is usually necessary to maintain the displacement of the lung for about a year, fresh injections of nitrogen must be made every two to three months.

Except by a few dissentients, it is generally accepted that tuberculous

lesions in the uncollapsed lung tend also to heal as a result of pneumothorax on the opposite side. The two radiograms (*Figs.* 106 and 107; see also *Fig.* 115)

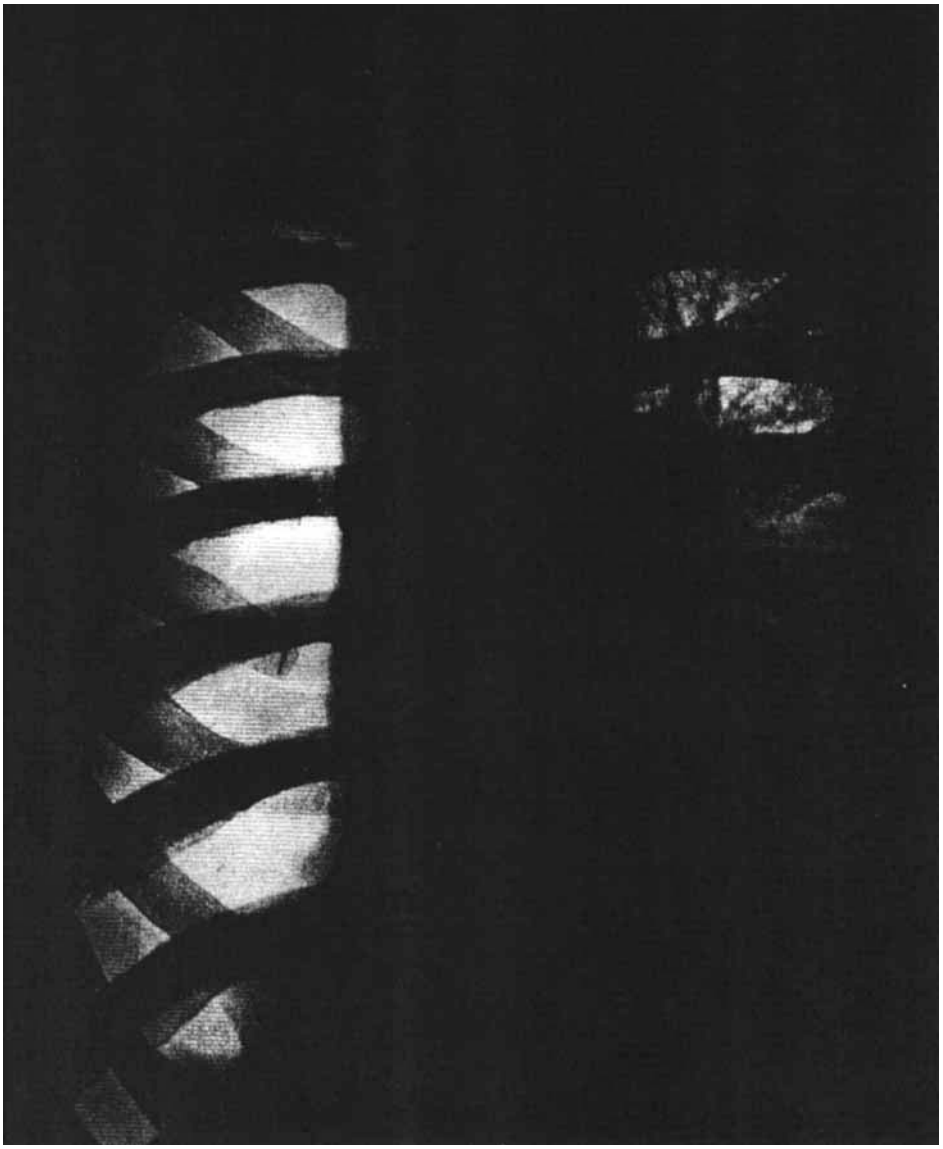

FIG. 108.—THE SAME CASE AS *Fig.* 113.
Production of artificial pneumothorax as a preliminary to extensive thoracoplasty.

taken, the one immediately before the introduction of nitrogen and the other after an interval of two months, show the change very clearly. This patient

had been under observation for two months before the penumothorax was produced, and the tuberculous foci had progressed rapidly during that period.

The surgical treatment of pulmonary tuberculosis, when the adhesions between the pleural membranes prevent lung collapse by nitrogen pneumothorax, will be discussed later.

Nitrogen pneumothorax has been tried also in the treatment of bronchiectasis and putrid bronchitis. The records of treatment in the latter complaint are not many, but great improvement and even cure have been recorded. The method certainly offers considerable possibilities for the relief of the disagreeable symptoms of this disease. Probably it can be of real value in unilateral cases only.

The results in bronchiectasis, compared with the operation of causing collapse of the chest wall, are disappointing. Improvement has been obtained in many cases, but it is temporary only, and when the lung re-expands the symptoms return. As a preliminary measure to the collapse of the chest-wall, however, a pneumothorax should be produced when possible, as it diminishes the cough, the amount of sputum, and the septic absorption, and also lessens the risk of suddenly flooding the air-passages when the subsequent thoracoplasty is done (*Fig.* 108).

Oxygen Replacement.—It has long been recognized that aspiration of fluid is not devoid of danger, and that the symptoms of distress after the withdrawal of four, three, or even two pints may be considerable. It must often, moreover, have caused a sense of disappointment that so few fresh physical signs appear over the lower lobe after paracentesis. Radiography has shown us that the reason of this is the comparatively large amount of fluid that still remains in the pleural cavity, obscuring not only the physical signs but also the details of the lung in the radiogram.

Air and even oxygen have occasionally been introduced to facilitate the withdrawal of fluid, but the importance of the exact regulation of the intrathoracic pressure has not been recognized till recently.

The author has shown that if during paracentesis, whenever there is the slightest symptom of distress, 100 c.c. of oxygen are allowed to flow in to the chest, "the operation (of paracentesis) can be performed with a minimum of discomfort to the patient, and without the occurrence of those symptoms of distress so commonly manifested towards the conclusion and often lasting for some time afterwards; that the whole instead of a portion only of the fluid can be withdrawn; and that the lung can be cleared so as to permit of complete radioscopy and radiography."

The aspiration is done with the ordinary needle and cannula, pump and bottle, in which the vacuum is produced. The hollow needle for the gas is connected with the gas apparatus such as is used for producing a penumothorax in phthisis, but filled with oxygen instead of nitrogen. The needle must, however, have a bore of at least 1 mm., in order that the intrapleural variations of pressure may be transmitted through the fluid which surrounds the opening of the needle. The cannula for aspiration is introduced into the lowest accessible part of the fluid, and the needle connected with the oxygen some two interspaces higher up.

The fluid is drawn off until the first indication of discomfort to the patient is noticed, when the aspiration is instantly stopped and 100 c.c of oxygen are slowly allowed to flow into the pleural cavity. Aspiration is then resumed till the appearance of a slight degree of pain or cough indicates that another 100 c.c. of oxygen must be let in. This alternation of withdrawing fluid (or towards the end fluid and oxygen) and introducing oxygen, is continued till the aspirator sucks out oxygen only, when a final 100 c.c. of oxygen are run in to lower the high negative pressure.

The method of oxygen replacement has further advantages. If the pleural cavity is filled with oxygen, this is rapidly absorbed and increases the intrapleural negative pressure; but at the same time, though less quickly, there is an exchange of gases, nitrogen and carbon dioxide replacing the oxygen. These in their turn tend slowly to be absorbed, and so a steady traction is maintained on the surrounding structures. If a lung has been compressed by fluid, and, owing to the thickening of the visceral pleura, is capable of only slow expansion, the substitution of oxygen for the fluid will assist this lung to re-expand, and undoubtedly tends to prevent the reaccumulation of the fluid.

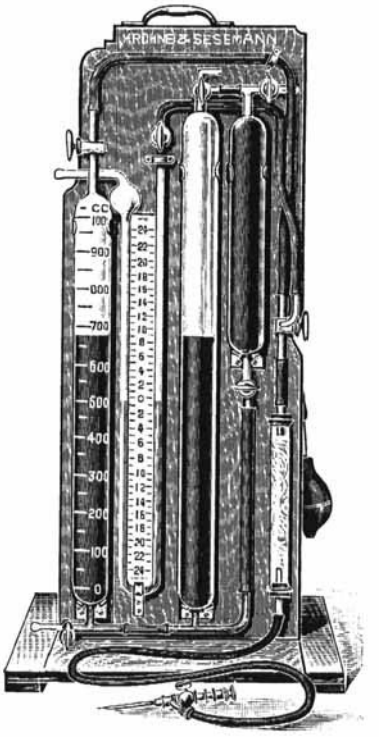

FIG. 109.—AUTHOR'S MODIFICATION OF DR. KORNMANN'S APPARATUS FOR INJECTING EITHER NITROGEN OR OXYGEN INTO THE PLEURAL CAVITY.

The principal modifications are: (1) The adjustment of the bulbs which allow 1000 c.c. of gas to be displaced by the weight of the columns of water alone. (2) The needle, which can be used for either nitrogen displacement or oxygen replacement.

Further, in tuberculous pneumothorax the patient often experiences considerable distress from the weight of the fluid. If the effusion is removed by oxygen replacement this distress is prevented, the influence of the oxygen on the reaccumulation of the fluid is again noticeable, and the capacity of the lung to expand can be determined. Garré[5] and Molon[6] have used oxygen with success to alleviate the pain of a dry pleurisy.

OPEN PNEUMOTHORAX AND THE MECHANICAL CONTROL OF IT.

Operative procedures on the organs within the thorax, when they necessitate opening the pleural cavity, are always accompanied with the grave danger of open pneumothorax.

It has been shown by Garré[5] that so long as an opening in the chest-wall which allows of communication between the outer air and the pleural cavity is not larger than the opening of the glottis, the physiological effects on the cardiac and respiratory mechanisms are not serious. In such circumstances, with each inspiration and expiration, less air enters and is driven out of the chest than passes in and

out of the glottis, and the lung collapses gradually. Alterations in the volume of the lung still occur with each respiratory effort, thus helping in the maintenance of the pulmonary circulation and of the aeration of the blood.

When a large opening is made into the pleural cavity there is complete collapse of the lung with total abolition of respiratory variations in size, and a loss therefore of the constant alteration in the pressure ratio of the pulmonary veins and arteries and of the alveoli and alveolar vessels.

The loss also of the difference between intratracheal and intrapleural pressures permits of a dilatation of the alveolar vessels, with the result that the collapsed lung contains more blood than the functioning lung, and is able neither to circulate nor aerate it efficiently.

Another concomitant of a pneumothorax with a large opening is a " to-and-fro flapping " of the mediastinum. With each inspiration the negative pressure in the unaffected half of the chest exerts a traction on the mediastinum and its contents to that side, the diminution of the negative pressure of expiration allows the mediastinum to resume its normal position, while the marked rise of pressure that occurs with forced respiratory efforts, e.g., coughing, drives the mediastinum to the opposite side.

This " to-and-fro flapping " of the mediastinum is thought by Sauerbruch and Garré to be the main factor responsible for the symptoms—cyanosis, dyspnœa, rapid irregular beating of the heart, and later, cardiac and respiratory failure—which appear when the pleural cavity is widely opened.

Within the last ten years these dangers have been greatly minimized by the discovery of means of controlling and compensating for the open pneumothorax.

The idea of preventing lung collapse by producing a differential pressure between the intra-alveolar air and the external air seems to have materialized first in 1895, when Tuffier and Hallion[7] made a primitive apparatus for supplying air at a positive pressure into the trachea. But it was not till 1903 that, at the instigation of Miculicz, Sauerbruch,[8] after much experimental investigation, evolved his hypo-atmospheric (*unterdruch*) and hyperatmospheric (*ueberdruch*) apparatus, but almost immediately gave up the latter in favour of the former. Brauer,[9] working at the same time, devised quite independently the principle of compensating the open pneumothorax by the hyperatmospheric apparatus, which was the first of this type to become generally known.

The essential difference between the hypo- and hyper-atmospheric principles is that in the former the patient's chest is opened in a chamber in which the atmosphere is at a negative pressure of 7 mm. of mercury. In this room are the surgeon and his assistants and all the appurtenances of the operation. The patient's head, however, is outside the room, a close-fitting collar surrounding the neck, so that he breathes air at atmospheric pressure. The anæsthetist is also necessarily outside, but can communicate with the surgeon by telephone. The lower part of the trunk and the lower limbs of the patient, though in the chamber, are enclosed in a rubber sack which is in direct communication with the external air, to exclude this part of the systemic circulation from the influence of the negative pressure.

The hyperatmospheric apparatus, on the other hand, supplies air to the lungs at a positive pressure of from 4 to 8 or more mm. of mercury, while the

surface of the lung when the chest is opened is exposed to a pressure of 0. In the Brauer machine, the air mixed with chloroform is forced by motor or hand-pump into a large casket in which the patient's head is enclosed, and the pressure is regulated by an expiratory valve. Several other forms of hyperatmospheric apparatus have been made, involving the use of motors, as in Brauer's; or of compressed air and oxygen with intervening rubber bag, as in that of Tiegel[10] and Lötsch,[11] or with intervening gasometer and regulation of pressure by a Stott governor, as in the author's[12] (*Fig.* 110). The air is conveyed to the patient by casket (Brauer, Karewski[13]), by mask (Tiegel, Schoemaker), or by intubation tube (author).

The pressure required if air is used mainly, is 7 to 8 mm. of mercury, increasing to 15 mm. of mercury just before the pleural cavity is finally closed. It has been found more satisfactory, however, to use a positive pressure of 4 to 6 mm. of mercury only, giving mostly oxygen with a small admixture of air.

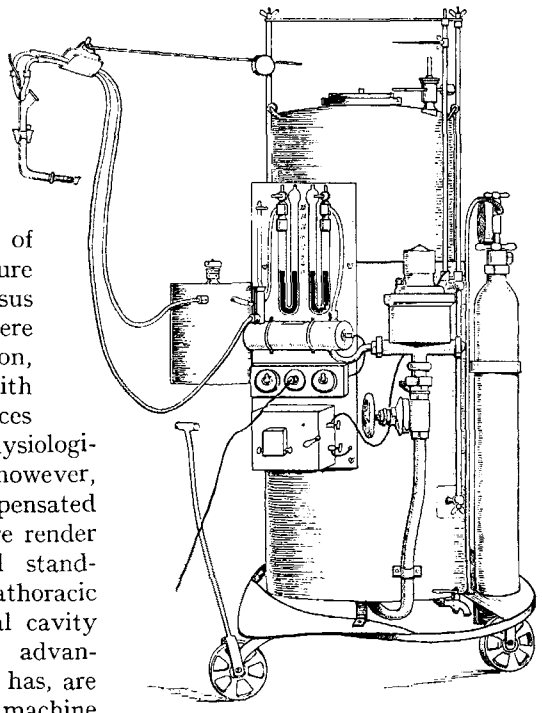

FIG. 110.
AUTHOR'S HYPERATMOSPHERIC APPARATUS.

Many and lengthy arguments, based on extensive experimentation, have been used to uphold the superiority of one form of differential pressure against the other (i.e., hypo- versus hyper-atmospheric system). There is no doubt, in the author's opinion, that the Sauerbruch chamber, with its negative pressure, reproduces much more nearly the normal physiological conditions. Both methods, however, abolish the dangers of the uncompensated pneumothorax, and both therefore render possible (from the physiological standpoint) the performance of intrathoracic operations in which the pleural cavity has to be widely opened. The advantages that the hyperatmospheric has, are the comparative smallness of the machine and its consequent mobility.

Meltzer[14] has introduced another principle, for inflating the lungs and anæsthetizing the patient at the same time. This "insufflation" method is applicable for all operations, and not only for those in which the pleura is opened. The air at a pressure above that of the atmosphere, and mixed with the anæsthetic, is administered by a catheter which passes down the trachea to a point immediately above its bifurcation, while the escaping air passes out between the catheter and the sides of the trachea and glottis.

THE VALUE OF THE VARIOUS METHODS OF ANÆSTHETIZATION FOR OPERATIONS ON THE THORAX.

The administration of a general anæsthetic to a patient, one side of whose chest is full of fluid causing displacement of the mediastinum, or who has an extensive pericaridal effusion, or on whom it is intended to produce partial collapse of a lung filled with septic matter, is such a serious undertaking that a few remarks on the question of the anæsthetic are justified in this article.

The introduction of local, or much more particularly of regional, anæsthetization has done much to aid the surgeon in this field of his work. The opening and draining of an empyema, the removal of ribs for bronchiectasis or chronic empyema, the "Pfeiler-Resektion" of Wilms for tuberculosis, the removal of costal cartilages for bronchitis and emphysema or for the opening of a pericardial effusion, should all be done, whenever possible, under regional or local anæsthesia with novocaine.*

For the more extensive intrathoracic operations, infusion ether anæsthesia offers many advantages, and when using my hyperatmospheric apparatus, I consider this method of anæsthetization preferable to all others. When a general anæsthetic is given other than by the intravenous method, chloroform is the least irritating, and should be used in preference to ether.

The adoption of the principle of "anoci-association" (Crile[15]) is proving of great value in the major operations.

SIMPLE, TUBERCULOUS, AND PYOGENIC EFFUSIONS IN THE PLEURAL CAVITY.

Simple and Tuberculous Effusions.—These have already been discussed under "Oxygen Replacement."

Empyema.—Ever since the time of Hippocrates, thoracotomy, with or without rib resection, has been the surgical procedure for acute empyema. Improvements in technique have possibly been developed since that early date, a knowledge of infection and the means of guarding against it have certainly been acquired, but the mortality is still very high (20 to 30 per cent), and the cases that become chronic with either a fistulous track or cavity are far too numerous (10 to 20 per cent).

In those cases in which, despite adequate drainage, a delay in the obliteration of the empyema occurs, even though the lung is healthy and primary disease of the pleura (e.g., actinomycosis) and rib caries have been excluded, the rigidity of the surrounding wall will be found to be the deterrent cause. The chest wall is capable of a slight degree of collapse, and the diaphragm of a moderate degree of upward displacement only. In the early stages, therefore, the chief hope of obliterating the space lies in the possibility of obtaining expansion of the lung by stretching the thickened visceral pleura.

For this purpose, various forms of apparatus for exerting continuous suction

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* For details on Regional Anæsthesia, the excellent paper of Dr. Rood in the *B. M. J.*, 1911, may be consulted.

and securing at the same time adequate drainage, have been devised and utilized by many surgeons. Lawrow,[16] in an extensive review of the subject, comes to the conclusion, as a result of his experience and that of others who have employed these means, that " the aspiration method exerts an undoubted influence on the expansion of the lung and the diminution of the size of the cavity. In cases of acute empyema, the expansion of the lung proceeds much more rapidly under the influence of aspiration than by the use of the previous ordinary methods of treatment." Lawrow uses a modification of Nordmann's apparatus.

Chronic Empyema.—In every case of chronic empyema, two operations at least are necessary. The first is directed entirely to securing free drainage of the cavity, exploring its extent, and dealing with foreign bodies or necrosed ribs.

The second and subsequent operations have for their object the freeing of the rigid walls which surround the cavity, by allowing either the chest wall to collapse, or the lung to expand. Three types of operation have been evolved. Originally described and done by Simon, in 1870, but modified and described under the name of thoracoplasty in 1878 by Estlander, the operation which is called after him came into general use. Estlander's operation consists of the partial resection of several ribs. Schede introduced his operation of removal of ribs and thickened parietal pleura in 1890. This method of treatment is severer than Estlander's, but is more suitable for large cavities.

Delorme, appreciating the capacity of a healthy lung to expand if not hemmed in by a dense pleura, advocated and practised with success the stripping of the thickened pleura off the lung surface. To this, thoracoplasty may often with advantage be added.

The author has done Wilms' " Pfeiler Resektion " operation (see p. 252) on a patient suffering from a chronic empyema extending from the 4th space in the mid-axillary line to over the dome of the apex. The operation resulted in a considerable reduction in the size of the cavity.

While the operation of Wilms can be applicable to cases where there is a shallow cavity between the two layers of the pleura only, it suggests the possibility of treating even large empyemata by removing either extremity of the ribs as a first stage, and at a later operation raising a large flap containing the divided ribs from off the thickened pleura, which is then cut away. The advantage of this is that the first stage can be done aseptically, and the second operation exposes a minimum of freshly-divided cellular tissue to the infection. The exposure of a large area of raw surface is an objection to Schede's operation, and is a procedure which not infrequently results in septic intoxication and death.

The treatment of fistulæ by bismuth paste is falling into disuse owing to the number of cases of bismuth poisoning which have been recorded. For radiographic purposes a 20 per cent solution of collargol is quite efficient and is non-toxic.

Calcification of the Pleura.—Fibro-calcareous changes in the pleura are an uncommon sequela of chronic infection.

Tuffier, Jardry and Gy,[17] in an admirable paper on this subject, have shown that as the result of the deposit of calcium salts, particularly in the wall of encysted empyemata, plaques and stalactites of varying size and shape may be formed on the surface of the lung or may even penetrate into that organ. Unless

they give rise to symptoms, the calcareous plates should be left, but if operation is undertaken they must be completely removed, otherwise a chronic sinus will develop.

INJURIES OF THE LUNG.

These occur as the result of :—(1) *Crushes or blows, without fracture, of the skeletal part of the thorax;* (2) *Lacerations associated with, or due to, fracture of ribs and sternum;* (3) *Penetrating wounds (bullet or stab).*

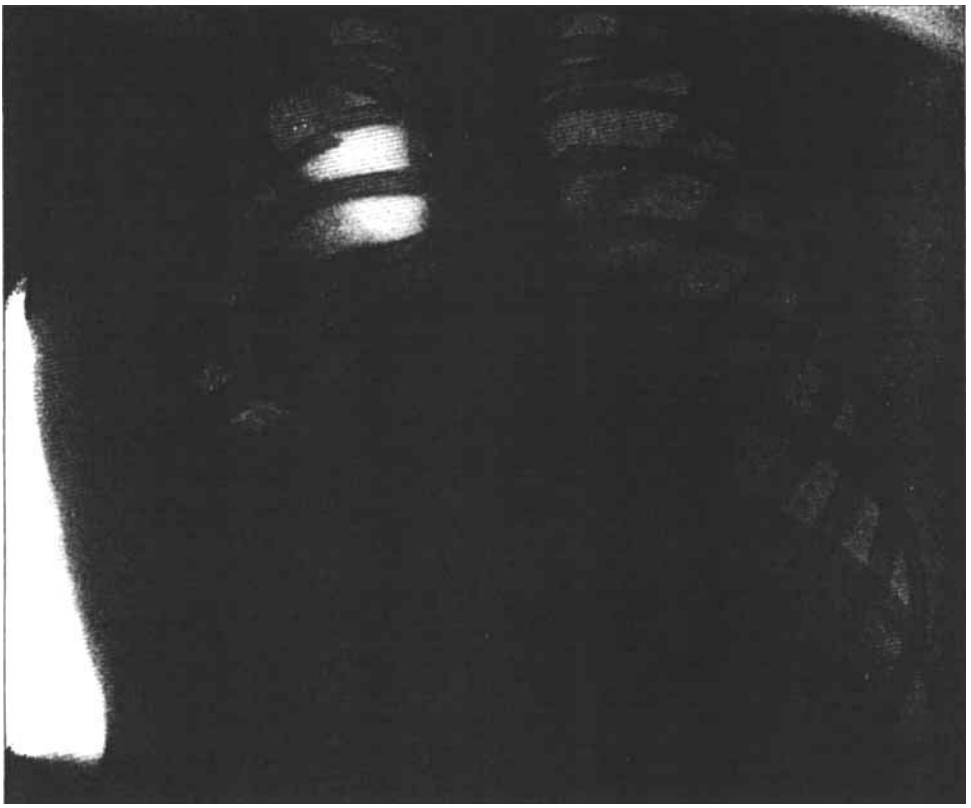

FIG. 111.—A CASE OF HÆMOPNEUMOTHORAX DUE TO FRACTURE OF THE 4TH AND 5TH RIBS ON THE RIGHT SIDE.

The lesion may be of the lung only, or may be complicated by injury of other intrathoracic structures or of intra-abdominal organs. The symptoms of rupture or laceration of the lung are shock, dyspnœa, with shallow respirations mainly abdominal in character, and constant distressing cough. Hæmoptysis, while it is the most certain indication of lung injury, is not always present. In addition to these symptoms are the physical signs of hæmothorax and pneumothorax.

The escape of air from the lungs is probably the most serious of all the

complications of lung injury. When the escape is into the closed pleural cavity only, there is danger of ingravescent pneumothorax, i.e., the condition of steadily increasing pressure of air which at first produces collapse of the lung, then displacement of the mediastinum and contents, and lastly compression of the opposite lung as well, and death.

This condition of ingravescent pneumothorax may be the result of a valve-opening in the lung allowing air to enter the pleural cavity but not to escape from it. Or it may be due to the "Pressatmung" of Sauerbruch,[18] the "grunting" breathing associated with a closure of the glottis, a reflex effect of the pain, the forced expiration raising the intratracheal and intrabronchial pressure, as in coughing and expelling the air through the rent in the lung.

If the pleural cavity in such circumstances communicates with the tissues of the chest wall, surgical emphysema will result, but though this may become very extensive, it is rarely dangerous.

Far graver is the escape of air into the mediastinum, as its presence is not recognizable until it has extended up to the neck, appearing round the trachea. The symptoms of mediastinal emphysema are marked dyspnœa, cyanosis, engorgement of the veins of the neck, progressive cardiac embarrassment, and great distress of the patient.

Nélaton was the first to call attention to an interesting condition—concussion of the chest. In a few cases, a violent blow on the chest has been immediately followed by syncope and death, and the autopsy has revealed no visible lesion. The experimental work of Meola[19] and Reidinger[20] indicates that the cause of this phenomenon is a reflex due to stimulation of the vagus and paralysis of the sympathetic.

Saar[21] has drawn attention to a small but extremely interesting group of cases in which, following on a lesion of the chest wall in such a position that no possible injury to the brachial plexus could have occurred, there has been a total or partial motor, sensory, or sensori-motor paralysis of the arm on the same side. This condition cannot be regarded as hysterical in all cases, but would appear to belong to the group of manifestations known as *pleural reflex*. In experiments on animals, Saar has obtained clonic movements of the fore limb by stimulation of the parietal pleura. A somewhat analogous condition is the muscular atrophy of the arm which has been noticed rarely after a severe hæmoptysis.

It is becoming increasingly obvious that the conservative treatment, when efficiently carried out, offers the greatest possibility of recovery in cases of lung injury, and that operation should be undertaken only when certain well-marked manifestations are present. Tuffier[22] says: "Plus je vois, plus j'ai la conviction que les indications opératives sont particulièrement rares, que la mortalité dans les plaies graves du poumon a lieu dans toutes premières heures après l'accident, et que, cette période passée, la guérison est la règle."

The indications for operation are excellently summarized by Garré[5] when he says: "In cases of lung rupture, as also of stab or bullet wounds, the indications for thoracotomy and suture of the lung are present when the condition is one of severe intrathoracic bleeding which, despite immediate palliative measures and absolute rest, manifests its progressive character by weakening of the respirations and pulse, and increasing cyanosis and anæmia. The same applies

to those cases in which the bleeding, at first arrested, is repeated and threatens life, and to those also with progressive mediastinal emphysema."

During the operation the pneumothorax must be controlled by some form of differential-pressure mechanism. The pleural cavity is emptied of clot, and wounds in the lung are stitched up, preferably with catgut, but extensively damaged portions should be removed.

For closure of the bronchus, Tiegel[23] recommends that the suture should pass through the outer wall only—and not include the cartilage—and that for additional security a portion of the neighbouring lung should be drawn over the wound and fixed in position by the first and last stitches in the bronchus, which are left long for this purpose.

Tiegel[24] has also suggested an ingenious method of relieving the acute symptoms of mediastinal emphysema, and so improving the condition of the patient for the more extensive operation of thoracotomy. An incision is made in the neck above the suprasternal notch, and a Bier's cup connected with a Sprengel's pump applied over this sucks the air out of the chest.

Sauerbruch has operated on patients with mediastinal emphysema in his "unterdruch" chamber, and finds that the negative pressure draws the air out of the mediastinum during the operation.

The statistics collected by Lenormant[25] indicate that drainage after operation for lung injury is inadvisable. Of forty cases which were not drained, 15 per cent developed sepsis, whilst in forty-five cases in which the lung was either sutured or plugged, 42 per cent became infected.

Emphasis must be laid on the necessity for absolute rest in the conservative treatment. *Absolute rest* must be taken in its most literal sense, as the slightest movement may accelerate the hæmorrhage or reopen a closed vessel. Morphia should be given freely to quiet the patient and relieve the discomfort of complete absence of any change in position.

Sauerbruch[26] advocates in cases of combined intrathoracic and intra-abdominal injury, that the chest should be opened along the seventh intercostal space, the pulmonary lesion dealt with, and that the abdomen should then be explored through the same wound, access to the cavity being obtained by cutting through the diaphragm at right angles to the fibres.

Foreign Bodies in the Lower Air-Passages and Lungs.—The great advances that have occurred in the removal of foreign bodies from the air-passages and the lungs are due to the accurate localization rendered possible by the *x*-rays, to the invention of Killian, to the perfection of the apparatus by Brüning for exploring the trachea and bronchi and carrying out manipulations in the depths of the air-passages, and to a less extent to the improvement in the technique of pneumotomy.

In 1897, the year that Killian published his first record of the successful use of the bronchoscope, Tuffier published the results of eleven cases of pneumotomy for the removal of foreign bodies. In ten of these the search was futile, and four of the patients died. Ten years later Killian[27] was able to report the treatment of 159 cases with a mortality of only 13 per cent. The removal of the foreign body was successfully accomplished from the upper air-passages in fifty-four cases, and from the lower in sixty-three.

The bronchoscope may fail on account of secondary changes in the bronchus and adjacent lung tissue, or because of the depths to which the foreign body has been inhaled, and operation must then be resorted to.

The extrapleural part of the bronchus can be reached through a posterior wound, the lung and pleura being displaced outwards. When, however, the seat of the trouble is in the lung substance itself, pneumotomy by the transpleural route (and the use of some form of differential-pressure apparatus) must be essayed. The added danger of pleural infection in such cases is very great.

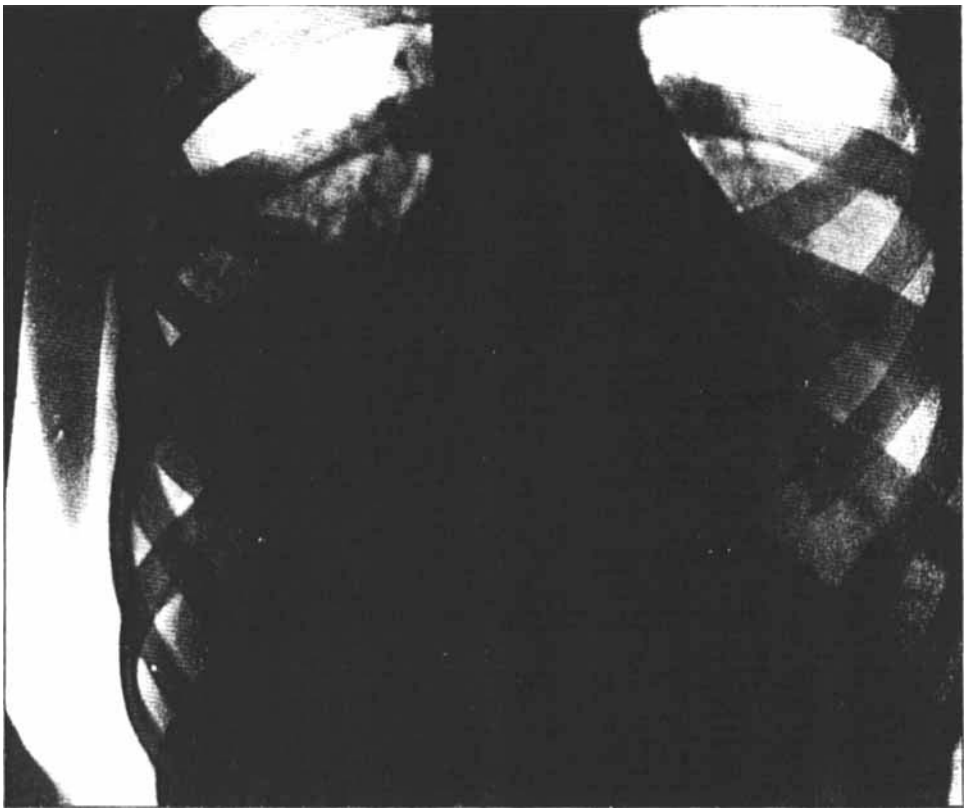

FIG. 112.—GANGRENE OF THE RIGHT MIDDLE LOBE.
In this case there were no adhesions of the pleural membranes.

ACUTE ABSCESS AND GANGRENE.

The separation of the acute infective processes of the lung into simple abscess, putrid abscess, and gangrene, is an unnecessary complication in nomenclature. The differentiation between the last two is by no means clear either clinically or pathologically. Gangrene is distinguished from abscess by the stinking character of the pus, the odour of which contaminates the breath; the

ragged ill-defined gangrenous walls of the cavity; and often by the presence of sloughs. The course of a gangrenous focus, moreover, is almost always a steadily progressive one, and spontaneous healing by rupture into a bronchus is a very rare occurrence. In the case of simple abscess, on the other hand, the condition may be progressive, it may even become gangrenous, or it may subside into a chronic condition. Spontaneous cure is somewhat more frequent than with the gangrenous variety.

As far as the treatment is concerned, the operative procedure in the two varieties is practically identical, apart from the fact that in the case of simple abscess it may be justifiable to delay for a few days in the hope that spontaneous healing will occur, bearing in mind however the dangers should the condition become chronic.

The necessity for immediate active treatment is evident from a comparison of statistics which show that cases of abscess and gangrene treated without operation have the appalling mortality of 80 per cent, while the mortality after pneumotomy varies from 34·5 per cent (Lenhartz[28]) to 17·5 per cent (Garré and Quincke,[5] 1912). The diminution in the death-rate within recent years is strikingly shown by Garré, who has collected the results of all published cases. In the 1903 edition of the *Grundriss der Lungenchirurgie*, the mortality in 400 cases was 25 per cent. Between that time and the second edition (under the title *Lungenchirurgie*) in 1912, a further 182 cases of gangrene and abscess have been collected, with a mortality of 17·5 per cent only.

This marked improvement in the results obtained by surgical interference in these acute suppurative conditions can undoubtedly be attributed to the increased facility for localization afforded by the progress of radiology, and to the diminution in the danger of opening the chest, in the absence of adequate adhesions, by the use of a differential-pressure apparatus.

The following points must be considered in regard to the operation:—(1) *The method of access*; (2) *The problem of adhesions*; (3) *The discovery of the abscess*; (4) *The treatment of the cavity*; (5) *The question of secondary abscesses*, (6) *The complication of empyema*; (7) *Secondary hæmorrhage*; (8) *After-treatment*.

1. The route of approach is determined by the position of the cavity as ascertained by clinical and radiological examination. The pleura should be exposed over a wide area to permit satisfactory exploration of the lung. The displacement of a flap is the best means of accomplishing this, and the ribs underlying the flap should be removed, so that by rendering the chest wall more yielding, the shrinkage of the cavity is facilitated.

2. When the parietal pleura is thin, the lung can be seen through it, and its movements studied. If these are evident it is certain that adhesions, if present, are not sufficiently firm to prevent a pneumothorax occurring. When the parietal pleura is thickened, however, the existence of adhesions cannot be determined. Firm adherence of the two pleural surfaces is found in 50 per cent of the cases only. The advantages of being able to compensate the possible pneumothorax by a hyper- or hypo-atmospheric apparatus are obvious. If the pleural membranes are free, the lung can be explored through an incision in the parietal pleura, and the affected area brought up to the chest wall and stitched to the parietal pleura. When no such apparatus is available the two surfaces of the pleura must be made to unite by stitching the parietal to the visceral layer

(including a portion of lung in each stitch) around the circumference of the exposed part, when the second stage may be proceeded with immediately or deferred for a few days. A delay is obviously very serious when acute gangrene is the lesion, but is less so in cases of simple abscess.

In the more chronic cases, Perthes[29] urges that the operation should always be done in two stages:—(1) Resection of ribs and suture of pleura, the cavity having previously been emptied by coughing and inversion, and the patient being anæsthetized with chloroform; (2) Cavity full, no anæsthetic other than morphia. Opening of cavity, and drainage.

The majority of Lenhartz's cases were done in two stages. Körte,[30] Garré, and Tuffier, on the other hand, prefer to complete the operation at once.

3. The discovery of the abscess, unless the lung has been palpated, is often difficult. Tuffier's method of extrapleural palpation is not to be recommended.

Exploration with needle and syringe is justified only after the pleural surfaces have been united. If pus is found, an incision is made along the needle which has been left *in situ*. When pus is not found by the exploring needle, a gradually deepening crucial incision should be made, the vessels being ligatured as soon as cut; great caution is necessary as the root of the lung is approached. If, even by this means, the abscess is not discovered, the wound should be packed in the hope that the abscess will burst into it.

4. The cavity found, it must be fully explored, and the pus and sequestra removed. The edges are stitched back so as to ensure free drainage, and the whole opening is plugged with gauze.

5. Secondary cavities may be known to exist, and their position ascertained by radiology. In such cases they may be looked for, but an extensive search is not justified.

6. When pus in the pleura complicates abscess, the prognosis is very grave. The empyema should be opened and drained as a preliminary to the search for the pulmonary abscess.

7. The possibility of secondary hæmorrhage must always be realized. Should it occur, the only possible treatment is tight packing of the cavity and the administration of morphia.

8. The special points which must be considered in the after-treatment, are the development of secondary abscess cavities and the inability of the cavity in the lung to close owing to the rigidity of the chest-wall. If the rib resection done at the first operation is not sufficient, together with the cicatrization of the tissues round the abscess, to allow of complete obliteration of the cavity, the chest wall must be rendered more mobile by the removal of further portions of ribs.

Tuffier[31] has in two cases attempted an extrapleural collapse of the lung by displacing the parietal pleura off the chest wall and implanting in one case a lipoma and in the other a large piece of omentum. The result in the former case, when seen two years later, was most satisfactory.

Methods of Producing Solidification of the Lung.—As will be seen in the two ensuing sections, solidification of the lung is the basis of the surgical treatment of bronchiectasis and tuberculosis.

The many methods which have been suggested and practised for effecting this purpose may be divided into two classes:—

1. That directed towards producing temporary collapse of the lung—nitrogen displacement.

2. Those directed towards producing permanent consolidation :—

FIG. 113.—BRONCHIECTASIS OF THE RIGHT LOWER LOBE.

a. Of part of the lung: Rib resection; Division of the phrenic nerve; Ligature of the pulmonary artery.

b. Of the whole lung: Rib resection; Rib mobilization.

Bronchiectasis.—Numerous classifications of bronchiectasis have been made, but from the surgeon's point of view three types only need be considered:

1. In which the main lesion is an abscess cavity.

2. The multilobular type, in which the whole of the lung is affected while the opposite side is partially involved or quite free from disease. Fibrosis is a marked feature of this variety, and the associated cicatrization produces excessive displacement of the heart and mediastinum to that side, with upward traction of the diaphragm and shrinkage of the chest wall.

3. A general cylindrical enlargement of the bronchi of one lobe, usually the lower, and no other change except possibly slight general bronchitis (*Fig.* 113).

The treatment of the first group of conditions is the same as that for chronic abscess cavities, viz., pneumotomy and drainage.

While it is but rarely that either of the other two varieties can be completely cured, it is not so difficult to produce a very considerable improvement in the patient's condition, and to lessen greatly the cough and sputum. Certainly it may be said that the results of surgical treatment of bronchiectasis are very much more encouraging than those obtained by medical treatment. As in chronic suppurative conditions of bones, however, the treatment is often of long duration, and necessitates at times repeated operations.

The difficulties in the treatment are well shown by the various methods which are being tried: nitrogen pneumothorax, thoracoplasty with preliminary pneumothorax, thoracoplasty with displacement of the affected lobe, amputation of the affected lobe, ligature of the branch of the pulmonary artery supplying the bronchiectatic area.

The results obtained by pneumothorax alone are discouraging. The symptoms are improved so long only as the lung is in a state of collapse; as soon as re-expansion occurs there is a recrudescence of the disease.

Thoracoplasty, to both a limited and an extensive degree, has been frequently tried, and with some measure of success. The mortality of extensive rib resection is high and the cures are few.

The author advocates collapse of the lung when possible by nitrogen displacement, so as to improve the general condition of the patient and lessen the sputum and cough, as a preliminary measure to rib resection. He has also tried, in a child with extensive but mainly unilateral bronchiectasis, the rib mobilization operation as done by Wilms for phthisis. The extremely satisfactory collapse of the lung and chest wall is seen in *Fig.* 114. The patient, who previously was expectorating several ounces of sputum per diem, brought up, twelve days after the operation (when the skiagram was taken), 1 dr. only.

Garré, in one case, after removing three ribs, displaced the lower lobe upwards and invaginated it, in an endeavour to promote atelectasis. The involvement of the opposite side, however, interfered with success.

Körte, Garré, Krause, Lenhartz, Kummell, and Heidenhaim, have all successfully amputated a bronchiectatic lobe.

The most recent suggestion in the treatment of this chronic disease comes from Sauerbruch and Bruns.[32] As the result of experimental investigations, they find that when a branch of the pulmonary artery is ligatured, the lobe supplied undergoes "a process of cicatrization and shrinkage by which the parenchyma is transformed into a thick firm scar. At the same time a chronic inflammatory process of the pleura develops, which leads to thickening and fixation of the surface of the pleura to the chest wall." The operation is done

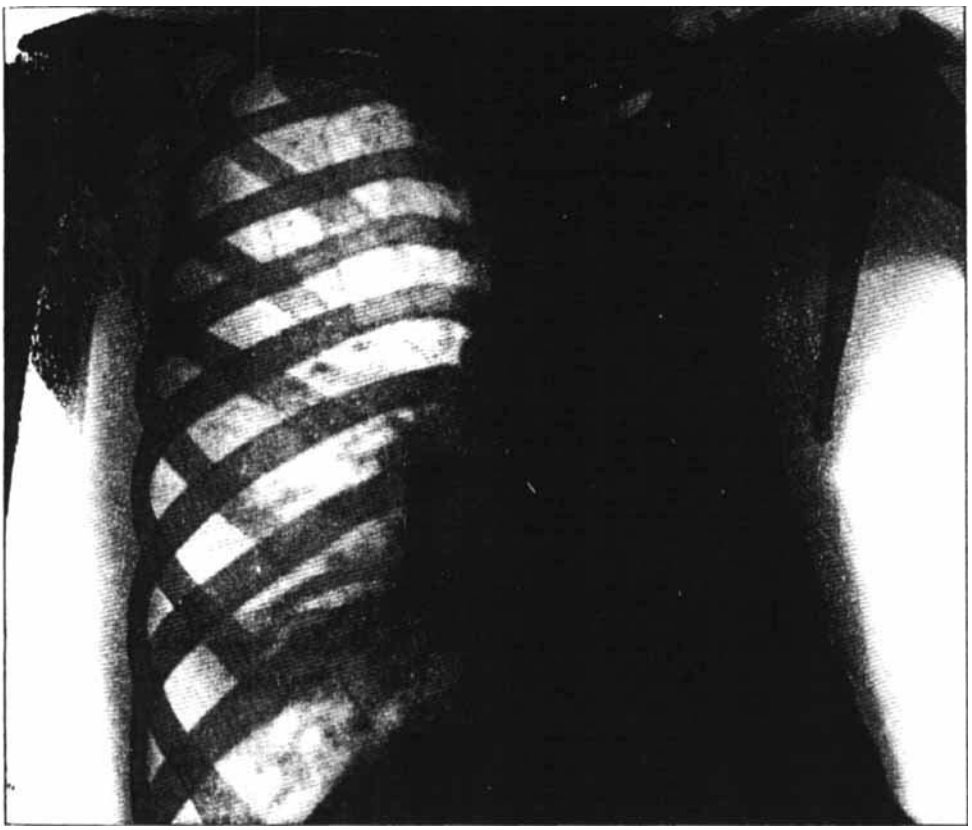

FIG. 114.—SKIAGRAM TAKEN TWELVE DAYS AFTER RIB MOBILIZATION FOR COMPLETE LEFT-SIDED BRONCHIECTASIS.

through an incision in the side of the chest along the fifth intercostal space. The upper and lower lobes are carefully separated from each other, any adhesions being cautiously divided. On reaching the hilum, the artery is recognized by its anatomical position, and ligatured. The wound is then closed. A hypo- or hyper-atmospheric apparatus must be used.

The second stage of the operation, the resection of the ribs overlying the lobe, is done some weeks later.

Sauerbruch[26] has done this operation seven times with most encouraging

results. He states, however, that Jehn has shown that in very chronic cases the rigidity of the widely-dilated bronchi may prevent the complete consolidation of the lung; Sauerbruch urges therefore the advisability of operating while these structures are still soft and pliable.

The author has ligatured the branch of the pulmonary artery in one case of unilobar bronchiectasis. Although gangrene of the lobe and a localized empyema developed after the operation, the subsequent effect has been most satisfactory. The patient now, two months after the operation, is apparently cured of his bronchiectasis, while the sinus through which the empyema was drained is rapidly closing.

Tuberculosis.—Of the many advances which have been made by the surgical treatment of pulmonary diseases, none are more gratifying than those obtained in phthisis. The resistance of the disease to the ordinary methods of treatment has resulted, in the great majority of cases, despite the frequency with which temporary improvement is seen, in a small percentage only of cures. The introduction, however, of measures by which the lung can be put into a condition of complete temporary or permanent collapse has very greatly improved the prognosis of all cases, at any rate, in which one lung is not extensively involved.

The importance of radiological examination before any such surgical step is taken cannot be too strongly emphasized, as, however thorough the clinical examination may be, it is impossible to be certain that either the extent of the disease is ascertained or the primary seat of the lesion is realized until such investigation has been made.

The great value of nitrogen displacement and the technique of the procedure have already been discussed in an earlier section. It was pointed out also that when the pleural surfaces were adherent, the collapse of the lung by this method was impracticable. In such circumstances collapse has been obtained by removing the ribs from over the affected part of the thorax, and allowing the lung and decostalized chest wall to sink in *en masse*. In the hands of certain surgeons this treatment has met with a measure of success, but it has the great disadvantage of necessitating a very big operation, or if done in stages, a series of smaller operations, on a patient already exhausted by disease. Friedrich[33] gives statistics of twenty-nine operations on twenty-seven patients with a mortality of 29·6 per cent.

In two of the fifty-eight cases of extrapleural thoracoplasty operated on by Sauerbruch,[34] the lower lobe, unaffected before the operation, became extensively involved owing to aspiration of the secretion squeezed out of the lower lobe, and both cases died.

To obviate the recurrence of such a catastrophe, Sauerbruch has tried in five cases, with considerable success, the effect of dividing the phrenic nerve in the neck. The result of this is to bring the diaphragm into the position of extreme expiration, which tends to collapse the lower lobe at the same time as it abolishes the inspiratory expansion of that part. A further change which is found to take place is a connective-tissue proliferation in the compressed tissues of the lung. Sauerbruch also recommends this operation in cases of bronchiectasis or tubercle of the lower lobe or of chronic empyema, combined in each case with thoracoplasty.

In one case in which the author divided the phrenic nerve, the paralysis of the diaphragm on that side was incomplete. This was probably due to the phrenic receiving a considerable accession of fibres below the point of section, from the nerve to the subclavius.

FIG. 115.—PHTHISIS. PARTIAL PNEUMOTHORAX.
Note the adhesions stretching from the diaphragm to the lung.

There are a few instances of extirpation of a lobe or even of a whole lung. Macewen[35] removed one lung of a patient with advanced phthisis; this man was alive and healthy more than eighteen years later.

Wilms,[36] in 1911, introduced the operation of rib mobilization ("Pfeiler Resektion") for cases of pulmonary tuberculosis in which intrapleural collapse of the lung was impossible. The principle of the operation is the removal of portions (2 to 3 cm.) of the posterior ends of the upper seven or nine ribs and of the costal cartilages of the first five or six ribs, the essential feature being the mobilization of the first rib; unless this is done, the rest of the operation is valueless. The difficulty is the treatment of the first rib, owing to the horizontal position of the posterior part and the proximity of the first dorsal nerve, and the overlying of the clavicle at the anterior end and the nearness of the subclavian vessels. Access is obtained by a long vertical incision front and back. A period of two to eight weeks should be allowed to elapse after removing the posterior portions before dealing with the anterior. Both operations are done, whenever possible, under local or regional anæsthesia with morphia.

The effect of this mobilization is that the ribs become approximated to the middle line, they tilt down (bucket-handle action), and the whole rib drops so that the divided ends lie at a level of one or two vertebræ lower than previously. The result is a remarkable collapse of the whole side of the chest. and necessarily, therefore, of the lung (*see Fig.* 114). The obliteration of cavities even the size of a walnut occurs.

One other suggestion for the treatment of apical tuberculosis must be mentioned. Freund[37, 38] regards the ossification which takes place in the first costal cartilage as a primary factor in determining the onset of tubercle in the apices of the lung, and asserts that when movement of the upper thoracic opening is re-established by fracture of the ossified cartilage, the apical tubercle heals. Freund recommends, therefore, the division of this cartilage when ossification of it is found in association with apical phthisis. The author,[39] however, has shown (in his article in the first number of this JOURNAL) that apical tuberculosis does not bear any direct relation to the presence of ossification in the first costal cartilage, and that the changes in the cartilages are a normal process progressing with the age of the patient, but occurring earlier and developing to a greater extent in men than in women.

Radiology has also made it abundantly clear that phthisis begins usually as a peribronchial condition, and probably the reason why clinically the signs point to the apex is that the thickening round the bronchus causes an obstruction to the air entry which affects, therefore, the aeration of the distal parts of the lobe, the signs being best heard where the lung is nearest the surface, viz., the apex.

Syphilis and Streptotrichosis.—The progress in our knowledge of the diagnosis and treatment of these two diseases has not been so great as in the conditions previously dealt with, yet there are certain points to which attention must be called.

Both these granulomata present a clinical picture which is frequently confounded with tubercle; but in syphilis, when fully developed, it is characteristic. My attention was first directed to this by Dr. Etlinger.

The striking feature in a typical case is the paucity of physical signs despite

the extent of the symptoms and of the constitutional disturbance. The patient becomes weak and emaciated, has an incessant irritating cough, and constantly brings up small quantities of thin muco-purulent sputum, frequently streaked with blood. The temperature is markedly irregular, and may rise several degrees.

The signs are generally found over the upper part of the lower lobe, where there is an area of dullness most marked in the centre, weakness of breath-sounds corresponding to the alteration of resonance, and fine crepitations best heard over the periphery of the affected regions. The picture, in short, so far as the symptoms are concerned, is that of a very advanced degree of pulmonary tuberculosis, while the physical signs are suggestive of an early lesion.

In the *Bull. et Mém. de la Soc. Méd. des Hopitaux de Paris*, for January 30th, 1913, there is a detailed description by Bensaude and Emery of such a case, with skiagrams.

Since the work done by Foulerton[40] on the streptothrices, we have to recognize the analogy of a streptothrix infection to tubercle bacteriologically as well as clinically. Actinomycosis is but one of the streptothrices, and therefore need not be considered separately.

These fungi are capable of producing two types of lesion :—

1. The acute miliary form.
2. A local induration with pus formation.

It is the latter type which concerns us here, because it can, in its earlier stages, be treated by surgical measures.

Karewski[41] divides the progress of the disease into three stages. In the first, the infection is localized to the lung itself. In the second, it spreads to and invades the pleura. In the third, the chest wall is attacked and the granuloma, breaking down, discharges externally.

Energetic treatment, viz., the excision of diseased portions of the lung and pleura and the scraping of sinuses, combined with the internal administration of iodides in massive doses, has produced a cure in a number of cases.

Penny[42] records four cases of pulmonary streptotrichosis treated with the most satisfactory results. The treatment consisted of operative intervention and the administration of potassium iodides in two cases, operative and vaccine treatment in one case, vaccine inoculation and potassium iodides in one case.

Primary Malignant Tumours of the Lung and Pleura.—It is a well-known fact that secondary tumours of the lung frequently produce symptoms long before physical signs. Although the same statement is true of primary growths, the importance of this seems not to be appreciated. Since in the earlier stages of some forms of pulmonary neoplasm, the growth can be entirely removed by operation, the paramount necessity of radiography in all cases with symptoms indicative or suggestive of a pulmonary lesion must once more be emphasized.

The author's case is a good instance of the value of this method of examination. The patient, a man aged 44, was sent to him as a case of bronchitis and emphysema, and as such possibly suitable for Freund's operation. He had suffered with chronic cough for many years. His bronchitis had been worse during the winter, and he had had some pain in the right side of the chest for four months. The patient had not got a rigid dilated thorax, but was radiologically examined as part of the routine investigation, and the tumour shown

in *Fig.* 116 was found. Although repeatedly examined by various experts, no physical signs other than those of bronchitis and emphysema could be discovered till three weeks later. A week after the radiological examination the patient brought up "prune-juice" sputum, and numerous large spherical cells with club- or tail-like projections, considered by Adler to be pathognomonic, were found in the expectoration.

The patient refused operation for two months. When operated on, the tumour was found to be confined to the lower lobe, except at one point where the

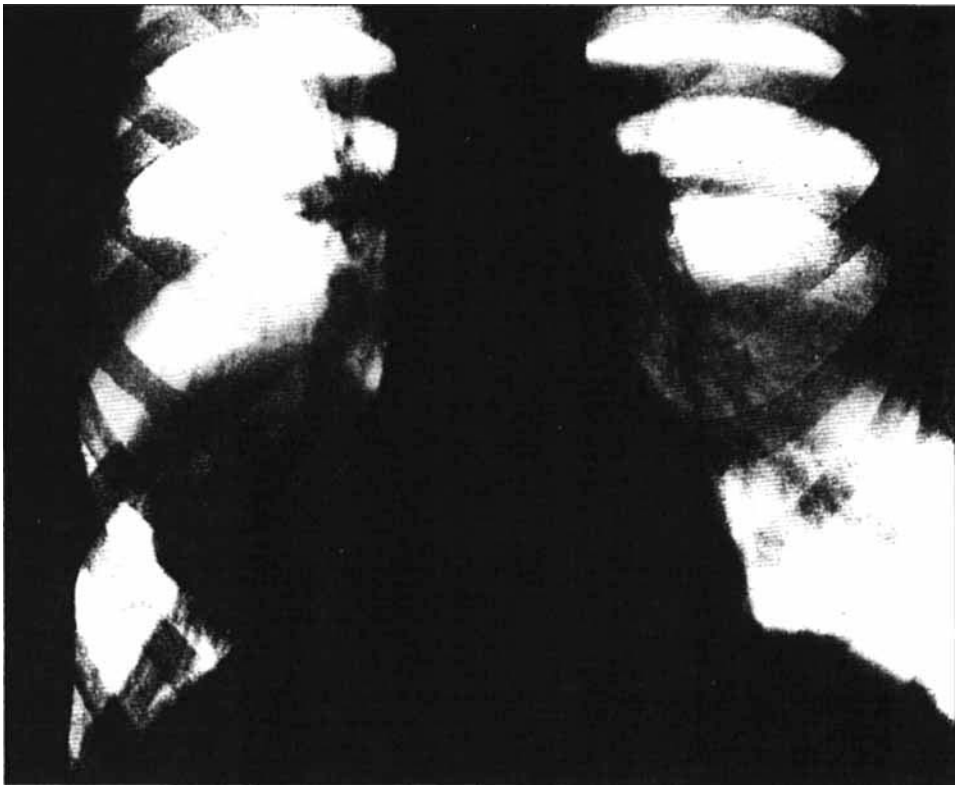

FIG. 116. PRIMARY BRONCHIAL CARCINOMA.

pleura was adherent. Access was obtained by slitting through the length of the sixth intercostal space (the patient being anæsthetized by infusion ether and the open pneumothorax compensated by the author's hyperatmospheric apparatus). The various structures at the pedicle of the lower lobe were ligated separately, and the lobe containing the growth, together with a portion of the parietal pleura, was removed (*Fig.* 117). The proximal end of the bronchus was stitched over and covered with an adjacent portion of lung. The patient's condition was quite good for the first six days; he then developed an empyema, and died on the eighth day. At the autopsy no evidence of leakage

FIG. 117.—PRIMARY BRONCHIAL CARCINOMA.
Half of the excised lower lobe and tumour.

from the bronchus could be obtained. Microscopic examination of sections from the hilum and adjacent glands failed to show any spread of the cancer from the primary focus. The tumour was a squamous-celled carcinoma of bronchial origin, and had broken down in the centre.

The author has found that in animals, the shock of handling the lung can be abolished by intrathoracic injection of the vagus with novocaine. The vagus was treated in this way in the case just described, and the patient experienced practically no shock after the operation.

Adler, in his admirable monograph on *Primary Malignant Growths of the Lungs and Bronchi*, 1912, has given a full description of the macroscopic and microscopic varieties of pulmonary carcinomata. He confirms the existence of primary neoplasms originating in the lung substance as distinct from the hilum, and concludes that " a cancer of the lung is, taken strictly, a bronchial carcinoma ; that, on the other hand, a carcinoma starting from lung tissue itself occurs, but is extremely rare, and is built up, not of flat but of cylindrical epithelium." The cylindrical carcinomata develop from the bronchial mucous glands, but when the growth originates in the surface epithelium it has an " alveolar structure with polymorphous and polyhedric cells that are, in the great majority of cases, flat."

Adler describes also various macroscopic types of carcinoma. They are : (1) Miliary carcinoma. Probably always secondary ; (2) Nodular forms with metastases scattered through the lung ; (3) Infiltrating type. This forms, " besides extensive pulmonary infiltrations, considerable masses of tumour at the root," leading to pressure and other changes in the lung ; (4) Localized infiltrating type. The tumour affects a portion of the lobe only, and " is sharply defined against the normal lung tissue, and is so dense that within the region of the tumour scarcely any lung tissue can be found." (See author's case.) Any of these tumours may undergo degeneration.

Sarcoma is less common, and tends to form large infiltrating tumours, invading, displacing, and obstructing the neighbouring structures. They are more often of the round-celled, but may be of the spindle-celled variety. Melanotic sarcoma is excessivly rare.

Clinically, pulmonary neoplasms present themselves as : (1) An acute pulmonary lesion resembling acute miliary tuberculosis ; (2) A pleuro-pulmonary lesion, with or without effusion ; (3) A mediastinal tumour, (4) A broncho-pulmonary lesion.

Cancer of the lung is in some of its varieties, and in its earlier stages, now accessible to surgical intervention and complete removal ; but until this fact is more fully recognized and all pulmonary cases are subjected to routine radiological examination, the growths will not be recognized until they have extended beyond the possibility of all treatment. In all doubtful cases, at least an exploratory thoracotomy should be undertaken.

Pleural tumours include simple and malignant varieties, and of the latter, the most interesting probably are the endotheliomata, which, as they increase in size, show a special tendency to invade the chest wall.[43]

The chief symptoms produced by pleural neoplasms are cough, pleurisy (dry or with effusion), and changes in the lung from pressure on the bronchus.

The endotheliomata in their earlier stages, and the myxo- and fibro-sarcomata, are accessible to surgical intervention.

Bronchitis and Emphysema.—Over fifty years ago, Freund[44, 45] drew attention to the fact that certain cases of bronchitis and emphysema were associated with a rigid and dilated thorax, and suggested that in these the changes in the chest wall were primary, and due to ossification in the costal cartilages, and that bronchitis and emphysema developed as a complication.

While the author agrees with Freund on the correlation of the pulmonary lesion with the fixation of the thorax in the position of extreme inspiration, he does not think that this is necessarily dependent on costal-cartilage ossification. This combination of pathological processes undoubtedly exists without the presence of any ossification in the cartilage, and benefits equally with the type described by Freund, from the operation of chondrectomy.

The operation consists in the removal of the second, third, fourth, and fifth costal cartilages on the right side through a vertical incision. Care must be taken not to perforate the pleura, which is of extreme thinness. Immediately after the cartilages have been cut away, the ribs are seen to approximate to the sternum and to move to and fro with respiration. The resection is done under regional anæsthesia.

The effects of the operation, in the author's experience, are immediate and startling. The dyspnœa and cyanosis disappear, and the patient is freed of the feeling of constriction in the chest, and can undergo exertions which previously were quite impossible.

The first twenty-four hours after the operation is a period of some anxiety, as the patient may refuse to cough owing to the pain, and the accumulation of secretion in the bronchial tubes may result in the development of broncho-pneumonia. The author has found, however, that in those cases in which the cough is inhibited, the anæsthetization of the intercostal nerves with novocaine at once abolishes the pain, and the patient brings up the sputum without difficulty.

Freund recommends that, in advanced cases, the left side be similarly dealt with at a later period.

REFERENCES.

[1] MURPHY, *Jour. Amer. Med. Assoc.*, 1898.
[2] MORRISTON DAVIES, *Lancet*, Dec. 1912.
[3] BRAUER, *Beitr. z. klinik d. Tuberkulose*, 1909.
[4] FORLANINI, *Deutsch. Med. Woch.*, 1911.
[5] GARRÉ UND QUINCKE, Lungen Chirurgie. Jena, 1912.
[6] MOLON, XIX Congresso di Medic. interna. ed all'Ordino del Sanitari di Venezia, 1909.
[7] TUFFIER ET HALLION, *Soc. de Biologie*, 1896.
[8] SAUERBRUCH, *Verhandl. d. Deutsch. Gesell. f. Chir.* 1904.
[9] BRAUER, *Ibid.*
[10] TIEGEL, *Beitr. z. klin. Chir.*, Bd. 64, 1909.
[11] LÖTSCH, *Archiv. für klin. Chir.*, Bd. 93.
[12] MORRISTON DAVIES, *Brit. Med. Jour.*, July, 1911.
[13] KAREWSKI, *Berl. klin. Woch.*, 1909.
[14] MELTZER, *Jour. Amer Med. Assoc.*, 1911.
[15] CRILE, *Lancet*, 1913.
[16] LAWROW, *Bruns. Beitr. z. klin. Chir.*, Bd. 83, 1913.

[17] TUFFIER, JARDRY ET GY, *Revue de Chir.*, 1903.
[18] SAUERBRUCH, *Beitr. z. klin. Chir.*, Bd. 60, 1908.
[19] MEOLA, *Giorn. Internaz. d. Soc. Med.*, 1879.
[20] REIDINGER, *Festschrift. der Alma Julia Maximiliana*, Würzburg, 1882.
[21] SAAR, *Verhandl. d. Deutsch. Gesell.*, 1912.
[22] TUFFIER, *Soc. de Chir.*, 1911.
[23] TIEGEL, *Beitr. z. klin. Chir.*, Bd., 66, 1910.
[24] TIEGEL, *Zentralbl. f. Chir.*, No. 12, 1911.
[25] LENORMANT, *III Congr. d. l. Soc. Intern. d. Chir.*, 1911.
[26] SAUERBRUCH, *XVII Intern. Cong. of Med.*, 1913.
[27] KILLIAN, *Zeitsch. f. Ohrenheilkunde*, Bd. 55, 1908.
[28] KISSLING, *Mitth. a. d. Hamburg. Staatskranken*, Bd. 6, 1906.
[29] PERTHES, *Verhandl. d. Deutsch. Gesell.*, 1908.
[30] FRAENKEL UND KÖRTE, *Berl. Med. Gesell.*, 1912.
[31] TUFFIER, *Soc. de Chir.*, 1910.
[32] SAUERBRUCH, Technik der Thoraxchirurgie. Berlin, 1911.
[33] FRIEDRICH, *III Congr. d. l. Soc. Intern. de Chir.*, 1911.
[34] SAUERBRUCH, *Münch. Med. Woch.*, Bd. 60, 1913.
[35] MACEWEN, *XVII Intern. Congr. de Med.*, 1913.
[36] WILMS, *Die Therapie der Gegenwart.*, Bd. 54, 1913.
[37] FREUND, *Münch. Med. Wocl.*, 1907.
[38] FREUND, *Verhandl. d. Deutsch. Gesell. f. Chir.*, 1910.
[39] MORRISTON DAVIES, *Brit. Jour. of Surg.*, 1913, No. 1.
[40] FOULERTON, The Streptotrichoses and Tuberculosis. London, 1910.
[41] KAREWSKI, *Verhandl. d. Deutsch. Gesell. f. Chir.*, 1907.
[42] PENNY, *Middlesex Hosp. Jour.*, 1912.
[43] MORRISTON DAVIES, *Clin. Jour.*, 1912.
[44] FREUND, *Breslau*, 1858.
[45] FREUND, *Erlangen*, 1859.