The orthopaedic aspects of the condition concern us very acutely, especially since industrial insurance and workmen's compensation cases have become so numerous.⁷⁹ The therapeutic indications are the same as in other types of the condition: attention to general health and free elimination, physiotherapy, protection of the affected portion of the spine by a Thomas collar, a spinal brace or jacket, and an attempt to neutralize or correct the faulty spinal curves and bring about a normal weight-bearing alignment. Conceivably a spinal fusion operation might be a rational procedure in an occasional case. Relief from less radical measures is ordinarily easy to obtain, and for this, in the commonly met cases exhibiting low back pain and sciatica, the low short back brace with an abdominal supporting pad devised by Goldthwait has been a sheet anchor which has held. If rest of the affected part, diminution of intra-articular friction, and free elimination can be provided, we may expect symptomatic relief.

SUMMARY.

1. Rheumatoid arthritis is a disease in which no specific organism has been found which can be held constantly responsible for its causation. Probably many different types of organisms and many other factors play etiologic parts in its onset and course.

2. In the early stages of rheumatoid arthritis, if these organisms and if the other factors can be overcome, complete recovery is possible. In the later stages, if the factors inimical to normal vitality can be eliminated and the essentials for normal body mechanics can be satisfied, arrest of the disease and great functional betterment may be expected. In this stage the simple eradication of a possible surgical focus of infection will rarely be successful in controlling the progress of the disease.

3. Osteo-arthritis is a disease in which no specific organism has been conclusively proved to be responsible for its causation. On the basis of the present evidence, its manifestations may occur unassociated with any demonstrable remote or local focus of infection.

4. In the early stages of osteo-arthritis, if a faulty body chemistry and a faulty body mechanics can be corrected and intra-articular friction can be lessened, almost complete relief of the subjective symptoms is possible. In the later stages, if intelligent physiotherapy, protective appliances, and well conceived surgery be added to these measures, relief of discomfort and greatly improved function may be expected.

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PHRENIC EVULSION AS AN AID IN THE TREATMENT OF PULMONARY TUBERCULOSIS AND BRONCHIECTASIS.

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(With Special Plate.)

In pulmonary tuberculosis it is quite common to find by radiological examination a reduction of the range of movement, or a delay, or, occasionally, complete immobility of one or both domes of the diaphragm. This reduction in the mobility of the diaphragm is not of the nature of a paresis or paralysis, but rather of a tonic contraction, exercising probably the same type of protective function as is seen in the rigidity of the muscles of the back in cases of pulmonary tuberculosis, or of the abdominal muscles in intra-abdominal lesions. The rigid diaphragm will, in chronic fibrotic cases, become drawn up somewhat into the thorax and so aid slightly in reducing its volume. In the upward displacement, if the base of the lung is adherent to the muscle, distortion will be added to the upward displacement. This tonic spasm becomes an added factor in disturbing the normal reflexes of respiration, and is therefore a contributory agent in the production of dyspnoea. Briscoe has stated that when the phrenic nerve is involved by pressure due to neoplasms, etc., dyspnoea is at first one of the striking features of the clinical picture; later, when doubtless the irritation of the pressure has given way to paralysis, the dyspnoea subsides.

When the phrenic nerve is paralysed by severance of the nerve supply the condition, as seen by radiological exam-

ination, is very different. There is complete loss of tone of the muscle, and the dome (when one half is paralysed) occupies a higher position in the thorax. On the right side the elevation may be from 4 to 8 cm.; on the left side it is less—from 2 to 4 cm. The maximum rise is not seen at once; the initial change in position is increased during the ensuing weeks as the muscle atrophies. The rise is due partly to the pull of the intrathoracic negative pressure, but mainly to the upward pushing force exercised from the abdomen by the abdominal muscles. During ordinary respiratory movements the paralysed dome is immobile. In most cases, but not in all, paradoxical movements can be observed during deep respirations—that is, the paralysed dome will rise still further into the thorax during inspiration and will sink back during expiration. These movements, according to Landé, are especially noticeable with Bittorf's method (that is, inspiration with closed nose and mouth).

The effect of the paralysis is twofold: it prevents the diaphragm pulling on the lung and expanding the lower lobe; it also does what is of such value in the treatment of certain types of disease—it produces a partial collapse of the base of the lung. Such collapse varies considerably in different cases, depending probably on the absence or the extent of the adhesions in the costo-phrenic sulcus. As there is rest of the lung and collapse of the base, benefit is derived from the diminution in the outpouring of toxins into the lymph stream. The realization of these facts aids the appreciation of the value of unilateral diaphragmatic paralysis in the treatment of certain pulmonary diseases, especially when localized at the base.

So much disappointment was experienced by the repeated failure of simple phrenicotomy that the operation fell into comparative disuse. Willy Felix published in 1922 a paper giving the results of his anatomical, experimental, and clinical researches on the phrenic nerve and the innervation of the diaphragm. His work explained the previous failures, which, until then, had been somewhat vaguely attributed to the existence of additional nerve fibres to the diaphragm said to run with the nerve to the subclavius.

Briefly, Felix's findings are as follows. The main nerve supply to the diaphragm is the phrenic nerve; the last intercostal nerve does send some filaments to the muscle, but these are of no consequence. The important point is that the phrenic nerve when it reaches the diaphragm does not always consist only of the fibres of the phrenic nerve as found in the neck. It may receive fibres from the nerve to the subclavius muscle; it may also receive them from the hypoglossal, the spinal accessory, the vagus, or the suprascapular nerves, either directly or through the ansa hypoglossi. But of much greater importance is the fact that the phrenic nerve is often duplicated in the neck. In such cases, the true phrenic occupies the usual course, traversing the scalenus anticus muscle from without inwards and entering the thorax *behind* the subclavian vein. The accessory phrenic, when present, lies at first some 3 cm. lateral to the true phrenic. It originates from the fifth cervical and frequently runs in close contact with the nerve to the subclavius muscle, leaving it just before that nerve enters the muscle. The accessory phrenic then enters the thorax *in front* of the subclavian vein, crossing the scalenus anticus at its point of insertion into the first rib. Either at this spot, on the inner side of the muscle, or behind the innominate vein, or even at some lower

point in the thorax, the accessory joins up with the true phrenic. This double phrenic occurs in at least 20 or 25 per cent. of people, according to Felix. Goetze, who has also examined a series of bodies, found that in 68 per cent. of them there were accessory branches to the main nerve. In one case the accessory phrenic joined the true phrenic at a point 3 cm. only above the diaphragm. Ruheman, in his examination of 17 bodies, found some abnormality—that is, a condition other than that of a single phrenic nerve—in 11 of them. In 4 there was a bilateral accessory phrenic; in 3 the accessory phrenic ran with the nerve to the subclavius.

It is only necessary to appreciate how frequently the main phrenic nerve is supplemented by fibres reaching it during some part of its course (usually in the thorax) to understand why the old operation of phrenicotomies—that is, simple section of the nerve in the neck—is almost more likely to fail in producing the required result than it is to succeed.

Two operations have been devised to ensure complete paralysis of one dome of the diaphragm. (1) The radical operation of Goetze. Goetze makes a long incision along the posterior border of the sternomastoid muscle. Through the lower end of this he exposes the phrenic nerve and divides it as low as possible, so as to cut off the sympathetic fibres from the inferior cervical ganglion. Then, through the upper part of the incision, he exposes the fifth cervical root, identifies the nerve to the subclavius muscle, and divides this. This operation has not found favour. (2) Phrenic evulsion (phrenic exairesis) suggested by Thiersch, and first done by Willy Felix; the phrenic nerve is divided in the neck and the peripheral end is twisted and pulled out of the thorax. When complete evulsion is obtained the various terminal branches are plucked out of the diaphragm; frequently, however, the nerve breaks at some point in its intrathoracic course.

The theoretical objections to phrenic evulsion are:

1. The phrenic nerve may rupture at a point above that at which the main stem is joined by the accessory.
 2. Bleeding may occur from the pericardio-phrenic artery, which accompanies the nerve in its intrathoracic course. In one case Sauerbruch had to open the chest after evulsion and evacuate 2 litres of blood.
 3. The phrenic nerve entering the thorax behind the subclavian vein, while the accessory enters in front of it, means that when the former nerve bundle has strong traction exerted on it the vein is caught in the loop and dragged on. Theoretically the vein might rupture before the nerve bundles give way. This has never occurred.
 4. Changes in the pleura in the neighbourhood of the nerve have led to the implication and inclusion of the nerve, which becomes embedded in the organized lymph deposit. Traction on the nerve trunk may lead to rupture of it proximal to its point of fixation; on the other hand, the thickened pleura round the nerve may get torn away and expose the mediastinum to infection from pus, if such is present in the pleural cavity. Similarly, the nerve may have become attached to the surface of the lung or to a gland, and rupture of either of these may occur, with resulting pneumothorax or pyo-pneumothorax.
- Experience, which now includes many hundreds of cases, shows that these dangers are more hypothetical than real. One other danger must be mentioned, but chiefly as a warning: on four occasions the vagus nerve has been mistaken for the phrenic, with fatal results each time.

FIG. 1.—Diagram illustrating the phrenic nerve occupying a normal position in relation to the scalenus anticus muscle, and entering the thorax deep to the subclavian vein. The commonest variety of the accessory phrenic is also shown. It arises from the upper trunk of the brachial plexus, which it crosses superficially, to reach and enter the thorax, passing superficial to the subclavian vein. The intrathoracic juncture of the phrenic and accessory phrenic nerves is shown by dotted lines.

The bleeding from cut veins may be merely "troublesome," but there is also the danger of air embolism, which has occurred on more than one occasion. Zadek has on two occasions seen haemoptysis during the operation; he and Felix have both seen temporary cardiac failure. Reflex cardiac and respiratory phenomena have been reported by H. Alexander. J. Alexander says: "Dyspnoea, rapid or slow, weak and irregular pulse are usual during the actual twisting of the nerve." Morone has seen one case of dyspnoea following the operation. This hitherto has not been my experience, except in so far that during traction when the nerve parts company with the diaphragm the sudden rebound which occurs at that moment usually causes a momentary gasp and an acceleration of the pulse rate. I have observed the pulse weaken and a feeling of faintness come over the patient temporarily on three or four occasions, but there has been nothing to indicate that this is a direct reflex due to traction on the nerve as opposed to the mental strain associated with any operation done under a local anaesthetic.

INDICATIONS FOR PHRENIC EVULSION.

1. *As a means of arresting disease in cases of basal tuberculosis and bronchiectasis.* It must be understood that, wide as is the range over which unilateral paralysis of the diaphragm can be regarded as efficacious, its value is chiefly as an accessory to other forms of treatment, as a means of controlling symptoms, or as an intermediate measure to enable other lines of treatment to be more complete or more successful or to be adopted after an interval of time. Only when the disease is strictly limited to the lower lobes can complete arrest be expected by phrenic evulsion as the sole method of treatment. The case of bronchiectasis given in detail later on (Case 1) is an illustration of the very successful results which can be hoped for, especially on the right side. Rist also quotes a case of bronchiectasis healed by phrenic evulsion.

2. *Phrenic evulsion in association with local thoracoplasty* is applicable to such cases as those described above but in which the disease is somewhat more extensive.

3. *To assist in controlling the disease in more generally extensive or more advanced or more acute cases of pulmonary tuberculosis.* Fischer, discussing radical phrenicotomy, says that the infiltrating, rapidly progressive, disintegrating forms of pulmonary tuberculosis, which so often give bad results with thoracoplasty, are exactly the type of case which give favourable results with phrenicotomy. Bacmeister, with an experience of 38 cases, states that even those of the acute exudative type, which have resisted treatment, have been improved. Goetze states that phrenicotomy constitutes, with pneumothorax and thoracoplasty, a third useful operative method of treatment for pulmonary tuberculosis, and resembles pneumothorax in its freedom from danger. It has the advantage over pneumothorax in that it is a single operation with progressive efficiency. Sultau is in agreement with Sauerbruch rather than with Goetze; he considers that phrenic evulsion as the sole method of treatment should be used in exceptional cases only. J. Alexander states that phrenic evulsion has produced some startling results in acute, highly febrile, progressive, predominantly caseous types of the disease.

In the advanced type of case an amelioration only of the symptoms should be expected. In severe unilateral cases phrenic evulsion may be done when pneumothorax has failed, in the hope that sufficient improvement will occur to admit a thoracoplasty being done at some later time. In bilateral cases hemidiaphragmatic paralysis may be produced on the more affected side so as to obtain for the patient some diminution of the cough and sputum and some reduction of temperature. Landgraf has done phrenic evulsion on the more affected side in 20 cases with bilateral disease. Of these 4 were uninfluenced and 16 improved (in 3 there was disappearance of pyrexia and in 5 of sputum).

4. *As an accessory to artificial pneumothorax treatment.* Sauerbruch, Brunner, Zadek, Goetze, Sultau, Baer, Ziegler, and Schulte-Tigges are all greatly in favour of the combination of phrenic evulsion with artificial pneumothorax. When adhesions are present between the base of the lung

and the diaphragm, and are interfering with the pneumothorax, and are responsible for definite symptoms such as cough, etc., considerable improvement and relief may result from paralysing the dome. There is a general consensus of opinions that effusions are less frequent if the diaphragm has been paralysed, and that there is less rapid absorption of the gas, with the result that the intervals between the refills can be lengthened. Zadek estimates that the interval can be lengthened by 25 to 33 per cent. According to Sauerbruch, the interval can be doubled or even trebled. It is suggested that the diminution of movement is responsible for both these benefits; possibly also the removal of the drag on adhesions, when such are present, is also beneficial. Lastly, in conjunction with artificial pneumothorax, it is of great advantage to paralyse the dome of the diaphragm before permitting a lung, long collapsed, to re-expand. As J. Alexander says:

"To release an artificial pneumothorax and permit a scarred, shrunken lung to re-expand in an attempt to meet the chest wall is a hazardous procedure, and not rarely followed by emphysema, mediastinal displacement, dyspnoea, pain, unfolding of cavities, lighting up of infirmly encapsuled foci, and reactivation of the tuberculous disease. The narrowing of the chest, caused by the mounting of the diaphragm, largely compensates for the disproportion in volume between the unchanged capacity of the hemithorax and the diminished volume of the shrunken, fibrotic lung."

So valuable and helpful has the combination been found to be that it has been recommended as a routine procedure. Zadek does the phrenic evulsion before starting the pneumothorax; Goetze after.

5. *Phrenic evulsion for the treatment of symptoms.* Sauerbruch considers diaphragmatic paralysis of special value in that it makes coughing easier; this leads to freer expectoration and prevents stagnation of secretions. The beneficial effects are in turn seen in the reduction of pyrexia and the improvement in the general condition. In my experience this is undoubtedly the case. The value of hemidiaphragmatic paralysis in easing the cough needs even greater emphasis than is given to it by Sauerbruch, Brunner, and others. When the base of the lung is adherent to the diaphragm there is set up at times an intolerable irritating cough, which is dry and incessant. The slightest movement, even talking and laughing, may start it, and it is some minutes before it subsides. I have done phrenicotomy for the relief of this condition since 1914. Whenever the diaphragm was paralysed and raised into the thorax by the section of the nerve, the result was always most gratifying; now, with the substitution of evulsion for section, the much greater certainty of success makes one unhesitatingly advocate this method of easing a very distressing symptom. In three of the cases detailed later this reiterating cough was one of the main reasons for recommending phrenic evulsion. It is not only this type of cough which is benefited; the act of coughing, in general, is aided by the paralysis of the diaphragm. Cases have been recorded of the cessation of haemoptysis after phrenic evulsion (Morelli). It is more likely to be successful when the bleeding comes from the lower lobe. In such cases phrenic evulsion should undoubtedly be done if artificial pneumothorax is impossible or incomplete. The pumping action of the diaphragm on the stomach frequently leads to the association of vomiting with the morning bout of coughing, especially if this comes on during or immediately after breakfast. The same may occur after other meals. In two of the cases of my series this vomiting was one of the symptoms indicating the operation (see Cases 5 and 8). Sauerbruch has treated hiccup by bilateral diaphragmatic paralysis. The results have been successful, and have not been accompanied by any ill effects. It is astonishing what complete freedom from all unpleasant sensations there is after one dome of the diaphragm has been paralysed. Most patients are quite unconscious of any change in the region of the muscle, except one of relief. When there has been constant coughing, complaint may be made of intense soreness, aching, and even pain round the costal margin; these sensations will disappear completely after the muscle is paralysed. Two patients noticed a "hollow feeling" below the costal margin after the

operation. Usually there is a diminution of cough and sputum (there may be increase for the first day or two); a feeling of greater ease and freedom in breathing; dyspnoea is lessened; with it all there is the feeling of greater well-being.

6. As a preliminary to thoracoplasty: (a) As a test of the ability of the sounder lung to stand up to the increased work which will be imposed on it by the major operation; (b) as an aid in improving the general condition of the patient; (c) to prevent the development of catarrhal signs in the lower lobe.

7. As a preliminary to radical treatment of a tuberculous empyema. Sauerbruch and Brunner recommend that unilateral diaphragmatic paralysis should be produced before doing a thoracoplasty in cases of tuberculous empyema. The object is to reduce as far as possible the size of the pleural cavity so as to lessen the extensiveness of the subsequent operation.

8. After imperfect resolution of pneumonia. Pneumonia, when it subsides completely, leaves little, if any, trace; when resolution is imperfect fibrosis takes place and the volume of the lobe or lung shrinks. Following this, and as a natural consequence of it, bronchiectatic changes appear and progress. In from two to four years after the pneumonia the patient exhibits the complete picture of bronchiectasis. If the lung is allowed to contract freely during the early post-pneumonic fibrotic stage the bronchiectatic changes will not develop. Phrenic evulsion, by paralyzing the dome of the diaphragm and allowing it to rise into the thorax, will give to the affected lobe or lung the freedom to shrink in response to the contraction associated with the active changes of fibrosis.

9. In order to free the heart from embarrassment. In cases of extreme fibrosis of a lung there is very considerable displacement of the heart. This in itself may embarrass the heart's action. Such embarrassment is likely to be increased if there has been much pleuro-pericardial thickening. After phrenic evulsion the rise in the position of the diaphragm will allow some return of the heart towards its normal position and so tend to relieve the symptoms.

TECHNIQUE OF PHRENIC EVULSION.

The operation is done under local analgesia. Novocain 1 per cent. is used with adrenaline hydrochloride; 12 c.cm. should be sufficient completely to anaesthetize the field of operation. The patient is given also an injection of omnopon gr. 1/3, or morphine gr. 1/4.

The skin incision is either oblique along the lateral border of the sterno-mastoid muscle, 5 cm. long, the centre being 5 or 6 cm. above the clavicle; or transverse, 5 to 6 cm. above the clavicle, two-thirds being lateral and one-third mesial to the lateral border of the sterno-mastoid muscle. The skin, platysma, and fascia are divided and the lateral border of the sterno-mastoid is defined and exposed, and is then retracted mesially. The next landmark is the omo-hyoid muscle crossing the wound downwards and laterally. This is retracted downwards. The scalenus anticus muscle with the phrenic nerve crossing it is still concealed from view by fat, glands, and the deep cervical fascia. The dissection must be carried down through these and the muscle exposed. If the nerve is running a normal course it will now be seen crossing obliquely from above downwards and mesially across the surface of the muscle. Care must be taken not to displace the nerve to one side with the fascia. During the deeper dissection the internal jugular vein will be seen on the mesial aspect of the wound, and must be drawn to one side. The superficial cervical and suprascapular vessels can be seen running across the lower end of the wound.

It must be remembered that the course of the phrenic nerve is not constant; it may not come on to the anterior

surface of the scalenus anticus till low down in the neck; it may cross to the mesial margin high up; at times it may run through the substance of the muscle. When the nerve is pinched with a pair of forceps the commonest sensation is one of pain referred to the shoulder or to the upper part of the arm. Sometimes a fluttering sensation is felt in the region of the costal margin, or a definite sharp contraction of the dome of the diaphragm can be both seen and felt.

The nerve is divided at the highest exposed point, and the cut peripheral end is seized in a pair of forceps. Traction is now applied, and as each successive length of nerve appears a Spencer Wells forceps is applied to it. This is to retain a hold on the nerve should it rupture immediately below the upper forceps through which the traction force is exerted. When some 10 cm. of the nerve has been slowly drawn out from the wound, an extra pull will probably rupture the filaments from the diaphragm and the whole nerve comes away. At the moment when the break occurs the patient usually experiences a sudden jerk at the base of the chest. The operation is now concluded by stitching together the divided deep fascia, the superficial fascia and platysma, and the skin.

If the whole of the peripheral part of the nerve has been evulsed, the part extracted will be found to consist of the trunk and the main terminal branches. The trunk of one nerve so evulsed was 30 cm. long, while the main branch was an additional 10 cm., making a total length of 40 cm. Another similarly complete evulsion from a small woman gave a total length of 24 cm. These have been the extremes in the cases recorded here.* It is generally held that if a total length of 11 to 12 cm. of the nerve has been evulsed this, in the great majority of cases, will have necessitated rupture of the accessory phrenic, if present.

In three of my cases I have abandoned the attempt at complete evulsion, because in each the same phenomenon was observed, and I decided that discretion was the wiser course. After the first 6 cm. or so of nerve had appeared, instead of the diaphragmatic pull one usually feels, I obtained arterial pulsation. The stronger the force used the greater became the pulsation. In these cases, therefore, I divided the nerve as low down as possible. In each case the diaphragm was found afterwards to be paralysed on the side of the operation and to be raised up into the thorax; in two of the cases there were paradoxical movements. Most Continental surgeons exercise a torsion force as well as a traction force, giving the nerve not more than one complete turn a minute round its long axis.

Perret, Piguet, and Giraud, summarizing the results of phrenic evulsion, say:

"The results obtained in the most successful cases, as a result of phrenic exaeresis, can be likened to those of the other plastic operations, though they are rarely as complete. Between the successful and the unsuccessful there is room for the whole range of partial successes characterized by the improvement of such and such a symptom, physical, functional, or general. . . . The inconstancy of the results must, in our opinion, be attributed to two principal causes: (1) incomplete evulsion of the phrenic and its anastomoses; and (2) cases wrongly selected."

I have now done phrenic evulsion twenty times.† The cases come under the aforementioned groups as follows:

1. For the purpose of arresting disease ...	3
2. In conjunction with local thoracoplasty ...	0
3. To assist in controlling disease ...	4
4. As an accessory during artificial pneumothorax treatment ...	5
5. For the treatment of symptoms ...	2
6. As a preliminary to thoracoplasty ...	4
7. As a preliminary to the radical treatment of a tuberculous empyema ...	2
8. After imperfect resolution of pneumonia ...	0
9. To free the heart from embarrassment ...	0

* In a later series I have evulsed a nerve the trunk of which was 29 cm. long and the terminal ramifications 17 cm.—total 46 cm.

† I have since done phrenic evulsion an additional fourteen times.

FIG. 2.—Drawing of an evulsed phrenic nerve, showing the main trunk (not in its entirety) and the terminal ramifications.

FIG. 3.—Case 1, before operative treatment. The semicircular wire shadows mark the nipples. The shrapnel can be seen immediately above the right dome of the diaphragm.

FIG. 4.—Case 1, ten days after evulsion of the right phrenic nerve.

FIG. 5.—Case 2. Skiagram taken the day before phrenic evulsion. Partial pneumothorax on the left side.

FIG. 6.—Case 2. Skiagram taken seven days after evulsion of the right phrenic nerve.

FIG. 7.—Case 3. Skiagram taken eight days after evulsion of the right phrenic nerve.

FIG. 8.—Case 8. Skiagram taken about seven weeks after evulsion of the right phrenic nerve.

FIG. 9.—Case 8. Skiagram taken five months later to show the increase in the heightened position of the right dome of the diaphragm and the greater collapse of the right lung.

FIG. 10.—Case 14. Skiagram taken before phrenic evulsion.

FIG. 11.—Case 14. Skiagram taken six months after evulsion of the left phrenic nerve.

The following is a synopsis of the cases. With the exception of Case 1 the operations were all done under local anaesthesia.

Case 1 (Group 1).—E. M., aged 39. (V.C.S.*) In 1918 gunshot wound right side of the neck. Division of the recurrent laryngeal nerve. Subsequent operation in the front of the neck, and posteriorly, with removal of sequestrum from body of fourth dorsal vertebra. Drainage tube passed down posterior mediastinum. Cough and sputum started immediately after injury and gradually became worse. Sputum at times extremely offensive. Admitted October, 1924. Incessant cough and the expectoration of some 4 ounces of offensive sputum per diem. Breath offensive. Some shortness of breath. Radiograms showed the presence of three pieces of shrapnel in the base of the right lung, and bronchiectasis, chiefly of the right lower lobe. In December, 1924, the right phrenic nerve was evulsed. The operation was very difficult because of the great distension of all veins. The phrenic nerve was apparently caught in scar tissue, and traction on it caused considerable pain; a little chloroform was therefore given. The nerve ruptured and 11 cm. were evulsed. The irritating cough disappeared at once, while the sputum diminished rapidly and lost all offensive odour. Radiograms showed that the right dome of the diaphragm had been raised 7.5 cm. above its original position (this is the highest immediate rise I have seen), while the foreign body had been shifted 5.5 cm. Paradoxical movements were present on deep respirations; no movement of the right dome during shallow respiration. In April, apart from an occasional spit first thing in the morning, he was untroubled by cough, sputum, offensive odour, or dyspnoea. This patient was sent to me by Dr. E. A. Peters, London.

Case 2 (Group 1).—Mrs. Ch., aged 27. (V.C.S.) On admission left lung only involved. Artificial pneumothorax started September, 1921. Kept very well till November, 1923. In January, 1924, artificial pneumothorax was started on the right side also, that on the left being maintained, but to a less degree. Again, the patient responded well to treatment and became free from symptoms. In April, 1925, the patient was extremely well, but in May there was again a relapse, due to extension of the disease to the uncollapsed lower lobe of the right lung. The artificial pneumothorax on the right side was abandoned. In June, 1925, the right phrenic nerve was evulsed, 11 cm. of nerve being extracted. The sputum was at first increased and then diminished. Screen examination showed that the right dome of the diaphragm was paralysed and raised into the thorax; there were no paradoxical movements. On August 30th, 1925, she was much improved; there was considerable lessening of cough, sputum, and dyspnoea. January, 1926: There are practically no symptoms.

Case 3 (Group 1).—Mrs. B., aged 31. (N.W.S.) Clinical and radiological evidence of tuberculous involvement of right lower lobe. On May 4th, 1925, right phrenic evulsion was performed, 10 cm. of the nerve being extracted. The nerve lay on the lateral side of the scalenus anticus muscle, which it crossed just above the insertion into the first rib. With it ran another nerve, the two being closely connected in the upper part of their course. This second nerve left the phrenic in the lower part of the neck and turned outwards across the posterior triangle. The appearance of these two nerves suggests that the normal phrenic was absent and that the whole of the nerve supply to the diaphragm was in the accessory phrenic which ran with the suprascapular nerve.† Seen six weeks after the operation, the diaphragm was found to be raised and immobile. There was no paradoxical movement. The cough and sputum had ceased except for a very occasional dry single cough and a spit once or twice in the week.

Case 4 (Group 3).—E. L., aged 23. (P.P.) A long history of very chronic pulmonary tuberculosis involving the left lung, but mainly the lower part. In June, 1925, the symptoms had increased; the cough was troublesome and there were 2 ounces of sputum per diem. He had pain and discomfort over the left base and was unable to lie on that side. On June 12th left phrenic evulsion was performed. In this case the nerve did not give way, but was cut after the first stage of the evulsion owing to the strong pulsation felt on continuing the traction; 8.5 cm. only were excised. A week later the cough and sputum were reduced to three or four coughs and spits in the twenty-four hours. The patient had lost the sensation of dragging at the base of the lung, was much more comfortable, and could lie on the left side. Screen examination showed that the left dome was raised and was immobile during quiet respiration, but that it became tilted during deep inspiration owing to the pull of the central tendon of the diaphragm.

Case 5 (Group 3).—Miss M. H., aged 28. (N.W.S.) Left lower lobe extensively diseased and very retracted; involvement of the left upper lobe also, but to a less degree. On July 15th, 1925, the left phrenic nerve was evulsed. The nerve was 21 cm. long. Screen examination showed that the left dome of the diaphragm was raised and that paradoxical movements were present. Left dome 2 cm. above right on shallow inspiration; 4 cm. above on deep inspiration. On August 31st the cough was still troublesome; sputum diminished in amount; temperature a degree lower.

* Explanations of abbreviations: V.C.S. denotes Vale of Clwyd Sanatorium. N.W.S. denotes North Wales Sanatorium, belonging to the Welsh National Memorial Association. These patients were under the care of Dr. Powell, medical superintendent, and Dr. Emrys Jones. P.P. denotes private patient under the care of Dr. Cropper, Ruthin.

† In a later series I have had two other cases with identically the same arrangement of the nerves.

Case 6 (Group 3).—M. W., aged 55. (V.C.S.) Extensive fibrotic and bronchiectatic changes in the right lung. On August 27th, 1925, the right phrenic nerve was evulsed. Total length 36.25 cm. (main trunk 25 cm.; terminal ramifications 11.25 cm.). Screen examination showed that the right dome had been raised 5 cm. There were slight paradoxical movements.

Case 7 (Group 3).—Miss V., aged 47. (V.C.S.) About 3 ounces of sputum per diem; constant reiterating cough disturbing sleep. Clinical signs mainly in the right lower lobe, but fine râles on the left also. X rays confirmed main changes in the right lower lobe. On September 19th, 1925, evulsion of the right phrenic nerve was performed. Very great traction force was required, the nerve finally breaking; 10 cm. extracted. September 23rd, 1925: Very little cough or expectoration since operation. Night's rest unbroken by cough. Right dome raised 3 cm. above pre-operative position. This patient was sent by Dr. Elkington, Newport, Salop.

Case 8 (Group 4).—A. S., aged 32. (N.W.S.; transferred from the South Wales Sanatorium by Dr. Watson for the operation.) Artificial pneumothorax started on the right side in September, 1924. Collapse greatly interfered with adhesions. Mesial half of the base of the lung fixed to the diaphragm. In January, 1925, the right phrenic nerve was evulsed; 18 cm. of nerve extracted. The dome was only slightly raised into the thorax; it was immobile during quiet respirations, but showed paradoxical movements on deep respirations. By July, however, radiograms showed that the dome had risen into the thorax a further 2.25 cm. Dr. Watson, writing to me on July 1st, said: "Though it may be little, I think he has made some improvement." Since the evulsion it has been found possible to double the interval between the refills.

Case 9 (Group 4).—Mrs. C., aged 35. (V.C.S.) Admitted May, 1923, with extensive activity and fibrosis all over the left lung and slight involvement of the root of the right lung. Artificial pneumothorax started on the left side in June, 1923. Condition greatly improved by the end of October, when she returned home. In September, 1924, signs of activity present in right upper lobe; the left lower lobe was beginning to creep out. There was also a constant purposeless cough. On February 5th, 1925, left phrenic evulsion was performed; 40 cm. of nerve evulsed; the last 10 cm. consisted of the terminal branches plucked out from the diaphragm. A week later screen examination showed the left dome raised and immobile, except on deep inspirations, when paradoxical movements were present. The purposeless cough disappeared, and the coughing was reduced 75 per cent. Unlike the last case, in this the evulsion has made no difference between the length of the refills. In neither of them has any obvious alteration in the intrapleural pressures been noticed.

Case 10 (Group 4).—Miss D. R., aged 26. (N.W.S.) Admitted with pleural effusion over the lateral surface of the left lung. Effusion aspirated and replaced by air. The lung fixed in a position of partial collapse by thickened pleura. On June 15th, 1925, phrenic evulsion was done on the right side as the effusion kept recurring; 13.5 cm. of nerve evulsed. On July 31st she felt much better; was eating and sleeping better. Dull ache in side gone, but dyspnoea practically unchanged. Very slow reaccumulation of liquid. Right dome raised 3 cm. above left; no paradoxical movements.

Case 11 (Group 4).—Mrs. S., aged 25. (V.C.S.) Bronchiectasis of right lower lobe. Admitted February, 1925. Artificial pneumothorax done, but partial collapse of base only obtained. On July 18th, 1925, evulsion of the right phrenic nerve attempted. During traction on the nerve the patient experienced pain referred to the right shoulder, and became very restless. The evulsion was therefore abandoned and the nerve was cut as low as possible, 3.5 cm. being excised. On July 25th the right dome was seen to be slightly raised and to show paradoxical movements. A month later, however, the muscle had recovered, and although the movements of the right dome were considerably less than those of the left they were synchronous.

Case 12 (Group 5).—Miss D. E., aged 33. (V.C.S.) Readmitted October, 1924. Evening temperature 102° (rectal). Involvement of all five lobes, the disease on the left side being considerably worse than on the right. General condition bad; thin, emaciated, dyspnoeic. Constant hard "barking" cough, which seemed to shake the left side; vomiting associated with the cough after most meals. An attempt to produce a partial pneumothorax on the left side failed. On December 16th, 1924, left phrenic evulsion was done; 10 cm. of nerve extracted. The incessant barking cough disappeared completely. Moreover, vomiting ceased, except as an occasional feature. On screen examination a raised dome was seen on the left side, immobile during quiet breathing, but showing paradoxical movements on deep respirations. The treatment in this case was not done in the hope of preventing the ultimate end-result of the disease, but to give the patient relief from two most distressing symptoms. In this it was and still is successful. Such relief must necessarily influence greatly both the mental and the physical state of the patient.

Case 13 (Group 5).—T. A. M., aged 50. (V.C.S.) The chief symptom was the almost incessant cough, day and night, except when under the influence of drugs. Artificial pneumothorax was attempted but abandoned. On December 19th, 1924, evulsion of the right phrenic nerve was performed; 26.5 cm. of nerve extracted. The patient's condition before the operation was feeble; a close watch was kept on his pulse during the evulsion, but no change in the rate or quality was observed at any stage.

A large quantity of sputum was brought up in the ensuing twenty-four hours; after this the cough subsided and the incessant distressing character of it disappeared. A month later the cough had diminished so greatly that there was a bout of coughing about every eight hours, at which time the sputum was brought up; in between there was no cough or expectoration. The temperature was a degree lower. In this case also the object of the operation was attained, in that he was afforded peace from the incessant cough. The arrest of the disease was of a temporary nature only; the patient died in July, 1925.

Case 14 (Group 5).—Miss T., aged 25. (N.W.S.) Symptoms started with dry pleurisy on the left side in December, 1922. Artificial pneumothorax was begun on the left side in August, 1923. Adhesions prevented more than a moderate collapse. Vomiting started in March, 1924. In December, 1924, owing to the severity of the vomiting, the artificial pneumothorax was given up and a phrenic evulsion was done on the left side; 9 cm. of nerve were extracted. The dome was paralysed, but was not much raised. Paradoxical movements were present with deep respirations. She wrote in July that she was in business, and felt "famous."

Cases 15, 16, 17, 18 (Group 6).—In these four cases the phrenic evulsion was done as a preliminary to thoracoplasty. Lengths of nerves evulsed: 11.5 cm., 24 cm., 16.5 cm., and 32 cm.

Cases 19 and 20 (Group 7).—Phrenic evulsion done as a preliminary to thoracoplasty for tuberculous empyema. Lengths of nerves evulsed: 35.5 cm. and 23 cm.

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FULL-TIME OVARIAN FOETATION.

BY

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(With Special Plate.)

A CASE of ovarian foetation is sufficiently rare to merit report. The literature of the recorded cases from 1910 to 1917 has been reviewed by Lockyer in vol. 10 of the *Proceedings of the Royal Society of Medicine*; he says that of the 33 cases quoted in the German statistics only 8 were full-time pregnancies. An American authority, however, questions the authenticity of some of these; 17 further cases he classed as highly probable, of which 8 had proceeded to term. The case which is now reported was seen in November, 1924, and the conditions found at the subsequent operation lead to the conclusion that it was a case of full-time ovarian foetation. The patient was submitted to x-ray examination and several excellent skiagrams were obtained of the unborn foetus a few weeks prior to operation.

Report by L. ERNEST ACOMB.

The patient was a married woman, aged 33, of rather slight and small build; she had a normal menstrual history. Though married for six years or so she had not hitherto become pregnant. On November 30th I was of opinion that she was about eight and a half months pregnant. To the best of her recollection her last period occurred at the latter end of January. She complained of distension and considerable pain in the left groin. She found it uncomfortable to lie flat in bed and had to be propped up.

The abdomen was tense but symmetrical and presented the appearance of a normal pregnancy of about eight and a half months' gestation. A narrow crescentic projection could be palpated in the left groin. This projection was slightly movable, but immediately returned to its former position, and I could not decide the anatomical part of the foetus to which this corresponded.

On vaginal examination the cervix was small and considerably harder than is usually the case in pregnancy at this stage. It was high in position and displaced laterally. The os was closed. I was unable to determine the nature of the presentation, and decided to make a further examination under an anaesthetic. Again neither the presenting part nor the lie of the baby could be definitely ascertained. It was certainly not a head presentation and all efforts to perform version were unsuccessful.

I referred the patient to Dr. Candy for x-ray examination with a view to obtaining some definite information upon the position and presentation of the foetus. The unusually interesting series of skiagrams which he obtained accompany this report, and his observations upon them are given below. The projection, the anatomical nature of which I had been unable to determine, was found to be due to the acutely flexed cervical spine.

In consequence of the abnormal x-ray findings it was decided to perform Caesarean section. On opening the abdomen (December 29th) I found the foetal membranes lying towards the right side. The uterus itself was in the pelvis and was slightly enlarged, but not much larger than the non-pregnant uterus. The right Fallopian tube was flattened and stretched over the sac, and the tissue of the right ovary was thinned out, constituting the outer layer of the sac. The latter lay above the broad ligament.

A full-time male child, weighing 7½ lb., lying in dark-stained liquor amnii was extracted without difficulty. The skin was soft and slightly macerated. The child appeared to have been dead for two or three weeks. Large vessels coursed between the walls of the sac. There was no difficulty in removing the placenta, but had the child been alive no doubt extensive haemorrhage would have been met with. The sac and the tube on the right side were removed and the abdomen closed. The patient made an uneventful recovery.

Observations upon the X-ray Examination by

T. I. CANDY.

Skiagrams were taken in the following three positions: (1) dorso-ventrally (abdomen nearest film); (2) ventro-dorsally (back nearest film); (3) laterally (profile view). These showed a fully developed foetal skeleton of about eight to eight and a half months' gestation which was lying in an extremely irregular position. The head was above the pelvis and acutely flexed upon the chest. The cervical spine formed an acute projection against the abdominal wall of the mother. The skeleton of the foetus as a whole was observed, from the lateral view, to lie in a much more ventral position than normal. As it could be seen that