case; phenyl-hydrazine is perhaps contraindicated, since, by further destruction of erythrocytes, it might not only increase the jaundice but also favour the tendency to formation of bilirubin calculi, and possibly even produce hepatic cirrhosis.

My explanation of the whole morbid syndrome in the present case is therefore as follows. The primary "agent" is the erythraemia, which is an "idiopathic" increase of the total erythrocytes and erythroblastic bone marrow in the body—that is to say, an idiopathic increase of the "erythron," the term proposed by Professor A. E. Boycott in his recent presidential address before the Section of Pathology of the Royal Society of Medicine. If we regard the "erythron" as a tissue-organ or tissue-system (as we regard the reticulo-endothelial system and the total lymphadenoid tissue of the body), the increase in question must be of the nature of a primary diffuse but non-malignant neoplasm (a "neoplastic diffuse overgrowth"), and not of the nature of a secondary compensatory hypertrophy, such as we get in the polycythaemia of high altitudes, the polycythaemia of congenital heart diseases, and the polycythaemia connected with circulatory obstruction in the lungs—for example, in "Ayerza's disease." A true *neoplastic* overgrowth of the "erythron" is useless and harmful to the rest of the body, and in the present case a spontaneous compensatory reaction on the part of the spleen has taken place—namely, an increase of one of the splenic functions (a compensatory "hypersplenism"), with the object of destroying the superfluous erythrocytes. This in its turn gives rise to excess of the blood bilirubin and to a condition of acholuric jaundice, but is nevertheless insufficient to prevent the gradual further increase of the "erythron," which will have to be met by blood-letting. It is just possible that a diet qualitatively the reverse of that employed for pernicious anaemia may likewise be of some use.

SECONDARY COMPLICATIONS IN PATIENTS SUFFERING FROM EMPYEMA OF THE PLEURA.

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By an operation for empyema dangers which threaten life are avoided, but the *restitutio ad integrum* is seldom attained. On the contrary, prolonged suppuration often follows (with, sometimes, death due to exhaustion), and repeated operations may be required. At the least, disability, disfigurement, and marked pathological conditions ensue. The surgeon's life-saving intervention may be criticized by the patient's relatives, and therefore fall into discredit. Taking the view that the untoward consequences are due to the wide opening of the chest, Lister adopted a method of treatment which avoided this, while Wenckebach prefers the thoracic puncture, followed by substitution of the exudate by air. Many excellent results have been obtained by this method, especially in cases of tuberculous empyema; but not all cases of empyema can be treated in this manner. Hathaway has shown that coagulated fibrin in the form of blood clot is an excellent culture medium for pyogenic bacteria. The clot, therefore, must first be removed, and this is only possible with a widely opened pleural cavity.

Post-operative complications are to be found, however, whether the chest is widely opened or not. They may be classified in the following groups: (1) deformities, especially of the thorax; (2) functional troubles, including dyspnoea and disturbances of the circulation; (3) dangers to life, such as arise from the "pyothorax *ex vacuo*."

Massive adhesions, the result of insufficient resorption of the exudate, are generally believed to be the cause of the first group. Attempts were made, therefore, to empty the

effusion as thoroughly as possible; often, however, there are insurmountable difficulties to doing this completely, and even when all the effusion has been removed the patients suffer from the complaints already mentioned, sometimes in the highest degree. Those cases in which complete elimination of the exudate is attained by the Monzingo form of drainage show the greatest changes. Severe symptoms of breathlessness, oppression, and a peculiar type of dyspnoea are present, although the x-ray examination shows that the pleural space is entirely free from exudate.

FIG. 1.—Dislocation of the diaphragm by bending. ——— Position of the organ in a bending man. - - - - Position of the organ in a sitting man.

As soon as these patients try to bend sideways they experience a feeling of constriction in the chest, with pain and the sensation that they cannot get enough air. In many patients this symptom appears only when bending over to the diseased side; in others, when they bend to the sound side.

These complaints are comprehensible when it is remembered that they correlate with the presence of adhesions of the diaphragm to the bony wall and disappearance of the phrenico-costal angle. The condition becomes obvious when comparison is made with the normal displacement of the diaphragm following the bending of the body sideways. The lower part of the diaphragm is displaced upwards into the thoracic cavity, while the upper half descends into the abdominal cavity. The reason for this dislocation is that the intestines fall on the lower half of the diaphragm (Fig. 1); the abdominal pressure on this area becomes increased, therefore, and the upper part of the diaphragm is pulled downwards. The phrenico-costal angle opens on this latter side to its fullest extent.

The presence of scar tissue in the phrenico-costal angle interferes with its opening. The patient feels pain when

FIG. 2.—Pressure on a fixed midriff on bending. - - - - Position of the diaphragm in the sitting man. ——— Slope caused by the altered pressure in bending.

he inclines to the healthy side, because the scar tissue is stretched and pulled. These symptoms are more marked the more the patient inclines the upper part of his body to the horizontal position, because the dislocation of the intestines increases the pressure under the lower part of the diaphragm the more the body is bent. On the other hand, when fixed to the thoracic wall the diaphragm cannot follow the increased abdominal pressure when the patient bends his body to the diseased side; it becomes expanded (Fig. 2), and the patient feels pain owing to stretching of the adhesions and involvement of the nerves.

* I use the term (morbid) "agent" as something which provokes a compensatory or conservative "reaction" (compare my short paper, "A Note on Action and Reaction in Pathology and Therapeutics," *St. Bartholomew's Hospital Reports*, London, 1903, xxxix, p. 139).

These effects make the sick person avoid every bending of the body to the side, and especially the lateral sleeping position. This symptom of "clinophoby" (from κλίνειν, to bend, and φοβέιν, to fear) is not always developed in the same manner; it occurs in some patients when bending to the side, in others, while bending forwards or backwards. It is often absent in the beginning of the movement. The patient can lie for a short time on the side and even fall asleep in this position, but soon awakes with a feeling of pain or breathlessness, which compels him to sit erect or to turn while sleeping to the other side or the back.

The scars in the phrenico-costal angle are often not to be seen when only an x-ray plate is made. In such cases

FIG. 3.—Movements of the diaphragm in a bending man. The lower part executes great movements; the upper half very little at all. — J. = Inspiration. — E. = Expiration. — T.J. = Deep inspiration. — T.E. = Deep expiration. M. = Midline.

it is absolutely necessary to record the respiratory movements of the diaphragm on the x-ray screen, and to compare the inspiratory and expiratory forms of the diaphragm vault. The scar tissue produces a malformation of the diaphragm or a disappearance of the phrenico-costal angle. The systematic examination of these patients shows that a constant relation is to be found between the form of clinophoby and the seat of the adhesion; if pain arises when the patient inclines to the side, an adhesion is found at the side; if bending forwards or backwards produces the pain, the adhesion is either in the anterior or posterior part of the phrenico-costal slit. Further evidence of the truth of the statement that the adhesions cause the clinophoby is given by the results of the respiratory treatment of these complaints. First it must be noted that, not only is the position of the diaphragm altered by bending, but also the function: the respiratory movements of the organ are changed very distinctly thereby. The excursions of the two halves are not varied in the same manner (Fig. 3); the lower half is now moved much more extensively than in the standing position, while the upper half shows hardly any respiratory movements. This astonishing functional manifestation takes place in the examination of every healthy person.

After a puncture or an operation a portion of the exudate accumulates, mostly at the base of the pleural cavity. The diaphragm is pushed downwards, not only by the weight of the effusion, but by the diminution of the intrathoracic suction due to the resulting negative pressure. Fixation of the inspiratory position of the diaphragm results, and no movement can take place in consequence of the inspiratory contraction of its muscle fibres. This functional elimination of the respiratory movements brings about persistence of the effusion in the basal portions of the pleural cavity. Some time ago Grober was able to show by means of experimental studies that the respiratory movements of the chest wall are the most important factor, as regards absorption in the pleural space, not only of fluid but also of solid corpuscular elements. It can therefore be easily understood why an accumulation of scars in nearly all cases of pleurisy can be found at the end of treatment, especially in the basal parts. Also in our own cases marked remnants of the effusion were present in the supradiaphragmatic part of the pleural cavity.

The question arises whether it is possible to diminish the effusion by increasing the respiratory movements, especially

of the diaphragm. In order to stimulate the visible movements of the diaphragm it is necessary first to improve its position before the beginning of the inspiratory action of its muscle fibres. It must approach the normal expiratory elevation in the thoracic cavity. This elevation can be augmented by bending the body to the side (Fig. 1). The patients are told to lie down on the affected side several times a day for some length of time. In the beginning the pain necessitates a variation of this treatment. When the body is held vertically, leaning against a vertical support, the upper part of the body can make a rotation to the side without breathlessness or pain being felt. In this position the intestines barely press on the lower surface of the diaphragm, because they do not come directly in contact with it, but only with the side walls of the abdominal cavity. After a time the physician tries a slight bending of the body backwards before beginning this static exercise of bending sideways. The body is approached to the horizontal position until the patient, turning afterwards to the side, feels only a little unpleasantness. Stronger traction on the scar tissue, and especially any risk of rupturing it, must be avoided absolutely. At first the patient remains in this position only a few minutes, but later the period is increased. He soon feels quite at ease in this position, and can continue to rest comfortably in it for a long time. Then the vertical standing support is brought a little nearer to the horizontal position; the back of the patient is therefore approximated to the horizontal, and the rotation of the body to the side is repeated. By means of this treatment in all cases it was possible slowly to enable the patients to lie permanently on both sides without pain or discomfort, and to sleep on the side through the entire night.

These exercises hasten the gradual return of the diaphragm to the normal position; the force of its muscle fibres also assists the respiratory movements. X-ray examinations during treatment reveal a definite increase in the respiratory excursion, an effect which becomes greater when the physiologically active expiratory forces, the abdominal muscles, assist in strengthening this action. This may be obtained by certain respiratory exercises, especially by humming exercises. In this way the attention of the sick person is concentrated on the expirations because they are controlled by the ear; he learns to lengthen and strengthen the expiratory action, and also to avoid the perilous "pressing expiration." At the end of the humming the abdomen sinks in more and more, and the abdominal wall becomes firm from the progressive exercising of its muscles. The following inspiration allows the abdomen to return to its primitive form with relaxed walls; this takes place passively, the muscular contraction ceasing. At the end of the exercise the abdomen is pushed forward actively, the diaphragmatic muscle fibres contract during the inspiration, and push the intestines downwards; thereby the abdominal walls are compelled to go forwards. In this way the respiratory action of the diaphragm shows a gradual improvement.

The same process is necessary for the bony parts of the thorax. Strong masses of scar tissue are often to be found, and there are always adhesions which are attached to the ribs and hinder their respiratory movements. The return to normal is accomplished in the following manner. The patient learns a combination of the humming exercise with arm movements; the hand of the healthy side embraces the chest during inspiration to avoid, by pressure against it, any increase in the "vicarious emphysema" on the sound side; the diseased side is thus compelled to make greater respiratory movements. The arm of this same side is stretched and lifted up to the vertical position (Fig. 4b) to strengthen the action of the inspiratory muscles. During the humming expiration the arm descends until it touches the hip (Fig. 4a). In the beginning too energetic action

FIG. 4.—Humming exercise combined with arm movement. a = In the beginning of the inspiration. b = After a full inspiration.

must be avoided, especially if pain is produced. The full development of these respiratory exercises proceeds very slowly; the complete treatment considerably influences the adhesions and scars in the pleural space, the effusion and its consequences often disappearing entirely (Figs. 5 and 6).

Special attention was given to the secondary deformities produced in the trunk, inasmuch as very different alterations may develop after pleural effusions. There may be a

muscles causes pain, because the elevation of the thoracic wall produces an opening of the split between the diaphragm and the costal pleura. The patient will therefore avoid every action of these muscles, the tonus becomes diminished, and a dropping of the shoulder appears, which is often associated with a curvature of the vertebral column. The concavity to the affected side must occur, because the tonus of the back muscles is there diminished.

FIG. 5.—The pathological state following a right empyema two years after the surgical treatment.

FIG. 6.—The same patient as in Fig. 5 after the respiratory treatment.

lower or higher position of the shoulder on the diseased side (Fig. 7); a scoliosis, curving either to the sound or to the affected side, may originate in consequence of an empyema. The pathogenesis of these morbid changes is difficult to determine, and "post-empyema scoliosis," though it has been studied for a long time, is not yet definitely understood. In the majority of the cases the convexity of the vertebral column bends to the healthy side, but in the minority the reverse is to be seen, the concavity being turned to the sound side. The systematic study of our own cases shows a constant relationship between the behaviour of the diaphragm and the vertebral column; malformation of the diaphragm was always accompanied with a convexity of the spine towards the healthy side, combined with a descent of the shoulder on the diseased side. When the diaphragm moved freely, or when a thick mass filled the widely opened phrenico-costal angle, the concavity of the vertebral column was seen towards the healthy side, associated with an ascent of the shoulder on the affected side. These deformities were definitely benefited by the previously mentioned exercises. Depending on the reactivation of the diaphragmatic respiratory action the crookedness of the trunk proportionally disappears.

All our observations support an explanation of the pathogenesis of these deformities on the following lines. A *defense musculaire* is originated by the inflammatory irritation of the pleura—that is, by the pains resulting from the respiratory movements. If only the upper parts are irritated the back muscles are contracted; ascent of the shoulder and convexity of the vertebral column on the affected side develop in consequence of this, but the latter only if the contracture is stronger and the pain due to respiration is longer lasting. These consequences are only possible in such cases where the irritation of the upper parts is not accompanied with involvement of the pleura in the phrenico-costal angle; for if there is a fixation of the diaphragm on the ribs the contracture of the back

Besides these secondary troubles there are to be found more serious complications in some cases, and especially long-lasting suppuration, the "pyothorax *ex vacuo*," which often leads to death from amyloid disease, even though the patient may be operated upon several times. It is suggested that the suppuration is only the consequence of the existence of free air spaces between the visceral and parietal pleura; plastic operations are performed, therefore, to bring the two serous membranes together. The results of animal experiments and of clinical experience show that the filling of the lungs with air depends on their respiratory action; it is diminished in the lobes adjoining the effusion, but later increases with respiratory activation (Figs. 5 and 6). The retraction of the pulmonary tissue from the thoracic wall is effected by the diminished respiratory function; it can be paralysed in some cases by respiratory reactivation. Although excellent results were frequently obtained, failures were seen in some cases. The cause of the delay in recovery in such cases must be sought and can nearly always be found. In the majority of cases the suppuration is caused by foreign bodies

resting in the pleural cavity, especially pieces of rubber broken off from a drainage tube or a clot of fibrin, these being breeding places for the pyogenic bacteria.

CONCLUSION.

All the secondary morbid manifestations after empyema are caused by disturbances of the respiratory function. They can be divided into subjective symptoms, such as dyspnoea, and into organic crippling malformation of the trunk. Proof of the correctness of this view is afforded by their successful treatment with systematic breathing exercises, which bring about their complete disappearance.

LITERATURE.

Hathaway: *British Medical Journal*, 1918, i, 718; and 1920, i, 734.
Hofbauer: *Atmungsphysiologie*, Berlin, 1921. J. Springer.
Wenckebach: *Mittel. a. d. Grenzgeb.*, Tome 19, p. 842.

FIG. 7.—Post-empyema scoliosis. a = Curved to the sound side. b = Curved to the affected side.