Remarks

ON

THE TREATMENT OF EMPYEMA.*

BY

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If we study the statistics of empyema we cannot help being impressed by the fact that it is a very serious disease. Thus, of 1,310 cases in the London Hospital in fifteen years (1909-23) the total mortality was 23.9 per cent.¹ Of 499 cases treated at St. Bartholomew's Hospital the mortality was 28.2 per cent. In infancy the disease is peculiarly fatal. Most observers agree that during the first year the mortality is about 75 per cent., and during the second to fourth year anything from 40 to 60 per cent. Holt puts the mortality during the first year as high as 90 per cent.² In older children and in young adult life the mortality is much less, 6 to 20 per cent., but in older people the figures rise again, the London Hospital figures being 31 per cent. at 40 to 50 years of age; 39.4 per cent. at 50 to 60; and 38.4 per cent. at 60 to 70.³

The percentage of deaths from empyema among soldiers in 1918-19 during the epidemic of influenza was appallingly heavy. The Surgeon-General's statistics in America showed the average mortality to be about 30 per cent., and in some of the military camps it rose as high as 70 per cent.

When we regard these extremely high figures of mortality, and when we consider, moreover, how many cases which recover for the time being are left with chronic empyema which renders them permanent invalids, and possibly leads to death some few years later, we cannot help wondering whether it should not be possible, by a better understanding of the principles of treatment, or the adoption of a more suitable technique, to obtain more satisfactory results than have hitherto been possible. As the result of the heavy mortality in the military camps in America in 1918, a special commission was set up to study this question, and certain definite principles were enunciated which, it was claimed, made an enormous difference in the results obtained.

Before going on to discuss methods of treatment I should like to remind you of certain facts concerning the physiology of respiration and the physics of pleural effusion and pneumothorax. In a normal healthy adult the average vital capacity—that is, the maximum amount of air that can be expired after a full inspiration—is about 3,700 c.cm. During ordinary quiet respiration, however, the amount of air taken in during each inspiratory effort, the so-called tidal air, is only about 500 c.cm.—rather less than one-seventh of the maximum vital capacity. In the case of a patient with a pleural effusion, or a closed pneumothorax, it follows that though the maximum vital capacity is diminished in proportion to the size of the effusion, the patient is able to carry on quite comfortably so long as he is at rest, provided the effusion is not large enough to prevent the inhalation of some 500 c.cm. of air during each inspiration. Directly he begins to move about, however, and the normal tidal air is not sufficient to provide for his increased need of oxygen, he becomes very short of breath.

Now the usual conception of the physics of a pleural effusion implies that the mediastinum, though subject to more or less displacement according to the size of the effusion, does, as a matter of fact, impose some barrier between the two sides of the chest, so that, although one side may be almost full of fluid and the lung almost entirely thrown out of action, the lung on the other side is able to carry on in virtue of being shut off by the mediastinum.

Now Dr. E. A. Graham⁴ and the other members of the U.S.A. Empyema Commission appear to have proved by a series of experiments that this conception of the physics of pleural effusion is fundamentally wrong. By introducing a water manometer into each side of the pleura, both in

animals, and in patients recently dead from diseases not affecting the thorax, Graham showed that injection of air into the pleura of one side affects the intrapleural pressure on the other side to an equal degree. By injecting the trachea with plaster-of-Paris and then removing the lungs he was also able to demonstrate that the density of the two lungs was equal. In other words, the compression induced in one lung by injection of air into the pleura on that side was accurately reflected in the compression induced in the lung on the contralateral side.

Now so long as we are dealing with a pleural effusion or a pneumothorax, in a closed chest, it is not a matter of very vital importance whether the mediastinum imposes an effective barrier between the two sides or not. So long as there is sufficient space left in the thorax for the patient to inhale some 500 c.cm. of air every time he breathes, it does not much matter whether he inhales it into one lung or both; but when we convert a closed pleural effusion into an open pneumothorax, which is what we virtually do when we treat an empyema by resection of a rib and open drainage, the question of the imposition of an effective barrier by the mediastinum between one side of the chest and the other becomes one of the utmost urgency. If at each effort of inspiration air is sucked into the pleural cavity by way of a large open drainage tube, at the same time as it is sucked into the lung by way of the trachea, the amount of air which enters the thorax by these two routes respectively is governed entirely by the resistance offered by the trachea and bronchial tubes on the one hand, and by the open drainage tube on the other; and if, as Graham asserts, and I think asserts truly, there is no effective barrier between one side of the chest and the other—if, in other words, we must regard the thorax as a single cavity and not as two separate cavities—it is possible, by increasing the size of the opening in the chest wall, to produce a condition in which all the air enters into the pleura and none into the lung. In other words, to produce sudden asphyxia and immediate death; and as a matter of fact this is what actually does happen, provided the opening in the thoracic wall is sufficiently large. Short of this it is found experimentally that an attempt is made, by means of forced respiratory efforts, to overcome the disability induced by the open pneumothorax. Inspiration becomes very much deeper, and results in partial compensation. The intrapleural pressure becomes negative during the height of inspiration, and so enables the animal to inhale a sufficiency of air to keep it alive. If the pneumothorax is temporarily closed the animal experiences immediate relief, and by the end of about five or six minutes the negative pressure in the pleura has attained its normal range during the whole respiratory cycle. Owing to the partial compensation effected by forced inspiration it is possible to sustain life with a much larger opening in the chest than would otherwise be the case, and Graham has worked it out on mathematical principles that the largest opening compatible with life in an average healthy adult man is about 8 sq. in. (2 in. by 4 in.).

In a patient suffering from empyema, however, the additional embarrassment of respiration produced by an open pneumothorax is a much more serious matter. One lung at least is partly thrown out of action by consolidation, and in streptococcal broncho-pneumonic cases both lungs are involved—and this at a time when more oxygen than normal is required to keep pace with the increased metabolism of fever. The muscles of forced inspiration have already been brought into play, and, owing to the patient's general toxæmia and weakness, they are in no condition to make any sustained effort of compensation to counteract the effects of an open pneumothorax. We can readily appreciate, therefore, that an open resection, followed by the introduction of a large drainage tube, in a patient already desperately ill, may easily give an adverse turn to the balance between life and death.

In order to test the effect of open drainage, Graham performed an interesting series of experiments on animals. After some difficulty he was able to isolate a strain of streptococci which produced empyema when injected into the pleura of dogs. Ten pairs of dogs, carefully graded as regards weight and general condition, were inoculated, and

* An address given to the Trowbridge Division of the British Medical Association, November, 1928.

twenty-four hours later a stiff open drainage tube, 1/4 in. in diameter, was inserted into the thorax of one of each pair. Of the ten drained dogs all died except one which tore out the tube, and was found later, when killed, to have had an empyema which had healed. Of the undrained dogs seven died, one as the result of injuries by fighting with another dog, and three recovered. When both dogs of a pair died, the one that had been drained died sooner than the other in every case. So far as they go, then, these experiments show that open drainage, instead of being of value, was attended by greater mortality and earlier death.

The statement that treatment of an empyema by open drainage imposes an additional handicap by further embarrassment of respiration only applies, of course, to cases in which there are no adhesions. In those patients in whom the empyema is sealed off from the rest of the thoracic cavity by dense adhesions between the visceral and parietal layers of the pleura it is a matter of little or no importance, as far as the physics of respiration are concerned, whether the cavity is closed or open, and whether it is filled with pus or atmospheric air.

It is necessary, therefore, to distinguish clearly between two classes of empyema—those in which the pus is lying free in the cavity of the thorax, and those in which it is shut off by adhesions. Now the formation of adhesions is entirely a matter of time. In cases of ordinary lobar pneumonia, where there is always a certain amount of pleurisy as well, an empyema is usually a comparatively late manifestation. It develops gradually as the pneumonia begins to subside, and by the time it is diagnosed it is usually cut off entirely from the rest of the thorax by the formation of thick masses of adhesive fibrin. On the other hand, in the case of streptococcal empyema associated with broncho-pneumonia the condition is just the reverse. The invasion of the pleura by infective organisms takes place quite early in the illness. An empyema develops almost at the same time as the broncho-pneumonic changes in the lung, and it may appear so rapidly as to constitute almost a primary manifestation of the illness. In such cases there has been no time for adhesions to form, and the empyema is lying perfectly free in the cavity of the thorax. Such cases, which are specially common in infancy, are always severe, and the patient, especially if a very young child, is usually desperately ill, and any elaborate or immediate operative intervention, especially if it involves even a temporary open pneumothorax, is much more likely to kill it than to save its life. If it is determined to apply open drainage at all to a case of this type it is absolutely essential to temporize, and to be content with aspiration, to evacuate the pus, till such time as adhesions have had time to form and seal off the cavity from the rest of the thorax. Aspiration itself is a somewhat painful and distressing procedure, and to perform with success a second or even a third aspiration on a desperately ill and probably terrified child is not necessarily as easy or satisfactory as it might at first sight appear. It is in such cases especially that the performance of continuous suction drainage, by the introduction of a soft self-retaining catheter attached to a water-pump, appears to offer such enormous advantages over other methods of treatment. The introduction of the catheter itself is a very trivial affair, and entails very much less shock than any more elaborate surgical intervention, and since it avoids the risk attached to the induction of an open pneumothorax this method may be employed at the earliest moment, even in streptococcal cases, in which no adhesions may be expected to have formed.

Whatever method is adopted to drain an empyema there is one important principle to be observed in the after-treatment, and that is the paramount necessity of sterilizing the cavity at the earliest possible moment and of preventing any secondary infection through the opening made in the chest.

Bacteriological examinations seem to show that secondary infection of the cavity during the period of drainage is largely responsible for delay in the recovery of a great many patients. Prolonged inflammation of the pleura, whether it results from the primary infecting organism or from some secondary infection, causes the ordinary endothelium of the pleura to be replaced by fibrous connective

tissue, with the result that the lung is firmly bound down and prevented, possibly for ever, from completely expanding to fill up the chest. A permanent thick-walled cavity may thus be formed, and a chronic empyema result, with all its attendant risks to health and even to life. The sooner, therefore, that we are able to disinfect the cavity in the thorax, and the more successful we are in preventing the introduction of fresh organisms from without, the more likely we are to prevent the formation of a chronic empyema.

As a general principle, therefore, it may be said that an empyema cavity should be rendered sterile at the earliest opportunity, and in order to do this, frequent irrigation with some suitable antiseptic is of very great assistance. Of all antiseptics chlorine solution seems to be the most efficient and suitable. During the last two years of the war, when I was chiefly concerned with the treatment of some hundreds of patients with penetrating and, in many cases, heavily infected chest wounds, I found, in common with others, that frequent irrigation with Dakin's solution was of the utmost value. In the first place, it is non-toxic, and can be freely used without any fear of ill effects; and, secondly, it appears to have a special action in softening and breaking down those large masses of fibrinous exudate which so often make efficient drainage a matter of great difficulty.

There is one point in connexion with the disinfection of an empyema cavity that is of some practical importance, and that is, that the upper part of the cavity seems less easy to render sterile than the lower part. This is probably because the rounded surfaces of the lower part of the cavity are more accessible to the antiseptic than the narrow sinus between the expanding surface of the lung and the upper part of the chest wall. Whatever the explanation may be, it is found in practice that it is more satisfactory to make the opening in the chest wall near the upper limit of the cavity rather than, as one would naturally expect, at the most dependent part.

Though I have directed my remarks chiefly to the principles which it appears ought to be observed if the treatment of empyema is to be satisfactorily carried out, I may perhaps be allowed to make a few remarks about the methods by which these principles would appear to me to be best put into practice. Before doing so, however, it may be as well to recapitulate shortly what those principles are. The principles to which any ideal form of treatment should conform are:

1. Operative procedure should be such as involves the minimum of time and the minimum of shock.
2. If it is necessary to employ the method of open drainage, this should never be performed until it is reasonably certain that the empyema cavity has become sealed off from the rest of the thorax by adhesions.
3. In connexion with the last it is imperative to distinguish between pneumococcal empyema, in which adhesions are usually formed by the time the empyema is diagnosed, and streptococcal empyema, where adhesions are not usually formed till later.
4. In order to minimize the risk of secondary infection the opening in the chest wall should be no larger than is sufficient to admit a suitable drainage tube, and should fit closely around the tube when it is placed in position.
5. The cavity should be sterilized as early as possible by frequent irrigation with some suitable antiseptic, to prevent the formation of dense fibrous adhesions, which prevent the expansion of the lung and the early closure of the cavity.
6. The lung should be encouraged to expand by ensuring a negative pressure in the pleural cavity throughout the period of drainage.
7. Convalescence should be assisted by giving plenty of nourishing food, and, whenever possible, by treating the patient entirely in the open air.

The method of treatment which would appear to fulfil these principles more completely than any other is that of closed continuous-suction drainage. This method is, of course, by no means new. It has been tried by various people and in different hospitals for a good many years. For certain reasons, however, it does not seem to have attained that measure of popularity which I venture to think it deserves. The technique usually employed, of introducing a stretched rubber tube through a metal cannula, which is allowed to remain in position, presents

a very real disadvantage in the fact that the cannula is very apt to become displaced, especially in a restless child, and come out of the chest, pulling the drainage tube with it. This difficulty is entirely obviated by using a self-retaining rubber catheter, which is either introduced direct through a very small incision into the chest, or through a cannula, which is withdrawn immediately the drainage tube has been inserted. I have had an oval trocar and cannula specially made to enable a larger catheter to be introduced between the ribs than would otherwise be possible, but I am not sure that this method presents any material advantage over the method of direct introduction through a small incision in the chest wall. Two other disadvantages have been cited against this form of treatment—namely, that it is difficult to ensure adequate drainage, and that after-treatment requires almost continuous supervision by specially trained nurses. With regard to efficiency of drainage, we have not found the difficulties so great as would be thought. Irrigation of the cavity by Dakin's solution, two or three times a day, seems to soften or disintegrate those large masses of fibrin which so often impede the free passage through the tube. If the latter appears to be blocked it is detached from the suction apparatus, and, by means of a glass syringe, Dakin's solution is alternately forced gently through the tube and sucked out again. By doing this a large amount of fibrin can often be removed, and when the suction apparatus is replaced drainage is found to proceed quite satisfactorily. The last objection to continuous suction, that it requires unremitting attention, is only partially true. Once it is satisfactorily started very little attention is required, unless the tube gets blocked and requires syringing out, as it occasionally does. Irrigation with Dakin's or some other antiseptic ought to be carried out at least two or three times a day, no matter what method of drainage is adopted, and it is much easier to detach the suction pump and irrigate through the catheter than it is to remove the messy dressings from a patient's chest and irrigate through an ordinary open tube. One way and another, I do not think that this method requires more attention than can easily be given in the ordinary routine way in a hospital ward or a nursing home.

During the last eighteen months I have treated all cases of empyema coming under my care, twelve in all, by this method. Of these twelve cases, one, a man of 35, who had a large chronic empyema of some five months' duration, died as the result of multiple cerebral abscesses three weeks after admission, and while the empyema was still draining. The other eleven cases have all done uniformly well.

After removal of the catheter I have, in all cases, put a fine tube into the sinus to drain the small cavity remaining. The sinus is usually healed completely after three or four days, but in four of my patients the wound, after closing up, has broken down again, and a small abscess has discharged, after which the sinus has again closed up and given no further trouble. This is perhaps due to the wall of the sinus itself being infected, and can probably be obviated by treating the latter with flavine or some similar preparation. In all cases except one the cure has, I believe, been complete, and, so far as one can tell, permanent. One patient, who originally had a very large staphylococcal empyema of ten weeks' duration, returned to his work as a miner some six weeks after discharge, and came back to hospital two months later with an abscess pointing over the old sinus; some six ounces of pus were evacuated from the cavity, which rapidly healed and has not, so far, recurred. Another patient had a double empyema, both sides being drained simultaneously, and closing on the seventeenth and eighteenth days respectively. This patient has remained fit ever since, and I am informed he has been for some months working about his farm as usual.

The average period during which drainage has been required has been nineteen days. One particularly satisfactory feature in all has been the rapid expansion of the lung, as shown by the amplitude of respiratory movements on the affected side, and the return of breath sounds at the base.

The ages of the eleven patients still living ranged from 4 to 50 years; the organism isolated was the pneumococcus

in eight cases, combined in one instance with the streptococcus and the tubercle bacillus; in two cases the staphylococcus; and in one case the *Bacillus coli*.

The advantages that I think one can justly claim for treatment by continuous suction drainage are:

1. Introduction of the catheter is rapid and easy, and entails virtually no shock.
2. Anaesthesia is correspondingly brief, and, if necessary, the operation could be done, except perhaps in infants, with a local injection of novocain.
3. The tube causes little or no pain.
4. Nursing of the patient is much easier and cleaner.
5. The risk of secondary infection of the empyema is very much diminished.
6. The wound closes quicker than by open drainage.
7. Re-expansion of the lung is more rapid and complete.

REFERENCES.

- ¹ *British Medical Journal*, 1925, ii, p. 333. ² *Diseases of Children*.
³ *British Medical Journal*, 1925, ii, p. 354. ⁴ *Empyema Thoracis*, 1925.

THE PROGNOSIS AND TREATMENT OF ECLAMPSIA AND ALBUMINURIA:

WITH SPECIAL REFERENCE TO THE RISK OF RECURRENCE IN SUBSEQUENT PREGNANCIES.*

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It is in some ways remarkable that, despite the close study which the clinical features of the toxæmias of late pregnancy have received, we should now be discovering, not only that there are still a few fields left for us to explore, but that some of our teaching on the basic clinical facts has proved to be incomplete and in certain respects actually unsound. Take, for example, eclampsia. It has been almost a commonplace in our teaching that a woman who has suffered from this condition is little likely to suffer in any similar way in her next pregnancies. A study of such cases proves this to be incorrect. At the British Congress of Obstetrics and Gynaecology in 1927 I³ showed that in 47 consecutive cases of eclampsia in parous women admitted to the Edinburgh Royal Maternity Hospital eclampsia occurred six times in a previous pregnancy and "albuminuria" nine times. This gave a total recurrence figure of 31.9 per cent. Adding to this six cases, in which there had been abortion, accidental haemorrhage, premature or stillbirth without toxæmia in the previous gestations, we got a total recurrence of abnormality of 44.7 per cent.

Dr. Jessie C. B. Sym has since carried out a similar investigation of the subsequent obstetric history of the surviving cases of eclampsia treated in the hospital from 1919 to 1926, and in a total of 67 cases which were traced she found that 42 had become pregnant again, with a total of 60 completed gestations. Of these, 3 had developed eclampsia for the second time, with a fatal result in one case, whilst in 15 of the other pregnancies "albuminuria" occurred, giving a total of 18 out of 60 subsequent pregnancies which were toxæmic, or 30 per cent. Adding to this 6 more, in which abortion, etc., took place, we get 24 abnormal pregnancies out of a total of 60, or 40 per cent., a figure which emphasizes the risk which is run by an eclamptic patient should she become pregnant again.

A similarly sinister record is revealed when the "albuminuria" cases are studied. In the paper to which I have already referred I recorded a recurrence of toxæmia, and of abortion, etc., without toxæmia, in 42 out of a total of 118 studied—that is, in 35.6 per cent. These figures referred to the previous pregnancies in parous women admitted to the hospital with "albuminuria." By following the surviving cases into their subsequent obstetric life we have found that 51 out of 81 cases subsequently became pregnant again, and had between them 84 completed pregnancies. Of these, 44 had "albuminuria" (this diagnosis was based on clinical evidence supplied by the patient in 5)—that is, 52 per cent. In 14 of the other pregnancies there occurred abortion, accidental haemorrhage, etc.,

* A paper read before the Section of Obstetrics of the Royal Society of Medicine, November 16th, 1928.