Remarks

ON

EMPYEMA THORACIS*

BY

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Empyema is of particular interest because, after hundreds of years of relative stagnation, progress has at last been made. It is to the work done by Evarts Graham and the other members of the Empyema Commission¹ that we are indebted for the realization of the mistakes of the past, and for the very definite knowledge which constitutes an enormous advance in science and forms the basis of our technique to-day. To Evarts Graham and his colleagues we owe a greatly reduced mortality—a death rate which has been brought down in cases of streptococcal empyema from about 25 per cent. to a little over 4 per cent., and also a large decrease in the number of cases of chronic empyema, which are a very serious trial to the surgeon, a bugbear to the general practitioner, and a curse to the unfortunate patient.

Before the war little attempt was made to distinguish between an empyema caused by a pneumococcus and one caused by a streptococcus. Cases with pus in the chest were grouped into those due to tubercle, which it was generally realized should not be opened, and those due to pneumonia, which must be opened and drained. Operative procedure entailed controversial points of minor importance only, such as rib resection as against intercostal drainage, and vertical incision as against oblique incision. If the patient lived, it was creditable; if he died, it was fate.

It was the appalling mortality in some of the American Army camps during the epidemic of 1917-18, which averaged over 30 per cent. and in some camps was as high as 70 per cent., that led to the setting up of the Empyema Commission at Camp Lee, Va. As a result of the very efficient work of this commission the pathology of the disease, the physiology of open pneumothorax, and, in consequence, the modern line of treatment, were established. The application of the cardinal principles was followed immediately by the reduction of the mortality to 4.3 per cent.

PHYSIOLOGY OF OPEN PNEUMOTHORAX

To appreciate the rationale of modern treatment it is necessary to understand the physiology of open pneumothorax. It is of the first importance to realize the fact that the mediastinum, which seems to be a stout median partition between the two lungs, is not a rigid structure in the healthy chest, and can be regarded as of no greater resistant value than a dividing veil.

Under normal conditions there is a negative pressure, at the height of expiration as well as during inspiration, in both pleural cavities. If an opening is made into one pleural cavity the alterations in pressure in that side are immediately reproduced to an almost similar extent in the opposite side. The negative pressure changes to a positive pressure, except only at the height of inspiration. This positive pressure on the surface of the lung prevents the suction of air down the trachea into the lungs. An attempt is made almost immediately to overcome this difficulty by an increase in the amplitude

(not necessarily the rate) of the respirations. The success of this compensation depends on the capacity of the individual to make the exertion and on the size of the opening into the pleural cavity. Failure means death by asphyxia. At the best, if the opening into the pleural cavity is no bigger than that of the glottis, the intrapleural pressures will remain positive during expiration but become negative during inspiration; that is to say, there is compression of *both* lungs during expiration and incomplete expansion during inspiration.

A perfectly healthy individual can withstand for a short space of time a considerably larger opening, compensating for it by a big increase in amplitude of respiration. There are, however, other factors which come into action, greatly increasing the seriousness of the situation. With inspiration and expiration the mediastinum flaps to and fro, causing great cardiac embarrassment; there is stasis of the venous system owing to loss of aspiration by the heart of the venous blood; there is great loss of heat from the exposed pleural cavity, and there is the danger of suction of infection into the pleural cavity.

To pass for a moment from the healthy chest to an extreme case of chronic empyema, quite a different picture is presented. In such a case, not only the lung, but the mediastinum, is so bound down by adhesions that no admission of air by however big an opening can affect the tissues beyond the barrier of thickened pleura: the open pleura has all the characteristics of an extrathoracic cavity. The only considerations in connexion with the opening are sepsis and loss of heat.

NATURE OF THE INFECTION

Once these facts are understood it is possible to consider the problem of empyema. There are, however, certain other factors associated with the nature of the infection which have to be grasped. In all pneumonias there is a very great loss of functionable lung tissue owing partly to the pneumonic consolidation and partly to the effusion. This loss seriously reduces the vital capacity. Vital capacity can be defined as the maximum amount of air which can be expired after a maximum inspiration. A pneumococcal pneumonia differs essentially from a haemolytic streptococcal pneumonia in that the reduction of the vital capacity in the former is very much less than in the latter, as can be seen by the comparative absence of dyspnoea and cyanosis in the pneumococcal type and the seriousness of these symptoms in the streptococcal. In the pneumococcal cases the extent of lung area put out of action is usually localized. In the streptococcal pneumonias it is more widespread: the bronchioles and bronchi are involved, and there is extensive interstitial infiltration, blockage of alveoli, and atelectasis. If, therefore, an individual with healthy lungs and a good vital capacity experiences embarrassment by an opening into the pleural cavity, how much more serious an effect must such an opening have in the case of a patient suffering from pneumonia, and especially if that pneumonia is due to a streptococcal infection—always supposing that the mediastinum is equally mobile in both cases.

Now, there is also a big difference between a pneumococcal and a streptococcal empyema. An empyema due to the pneumococcus is a comparatively late manifestation in the course of the disease. It is therefore termed "meta-pneumonic," because it is rarely diagnosed until the pneumonia has passed the acute stage, when resolution is taking place; by this time the vital capacity is again increasing and the rate of metabolism is diminishing. Moreover, from the onset, the pus is rich in fibrin, forming a deposit on the pleura and fixing the lung and

* A British Medical Association Lecture delivered at Harrogate.

mediastinum. The dangers associated with making an opening into the pleural cavity are therefore *comparatively* small.

A haemolytic streptococcal empyema, on the other hand, is syn-pneumonic. So early does it start in the course of the illness that it is thought it might at times actually precede the interstitial broncho-pneumonic change in the lung. At first the effusion is a thin greenish-brown turbid fluid, and it is not till two or three weeks later that it becomes a frankly purulent effusion, and that efficient adhesions have formed to fix the lung and mediastinum. An opening made, therefore, in the earlier stages exposes the patient to all the dangers of an open pneumothorax, at a time when vital capacity, toxæmia, and increased metabolism make him least able to tolerate it. If, however, this intensely toxic fluid swarming with streptococci is left pent up in the chest, there is the probability that the patient will die from toxæmia, if he does not die first from anoxæmia and heart failure produced by the compression effects of the fluid.

TREATMENT BY ASPIRATION

In aspiration, and preferably in oxygen replacement of the effusion, we have a simple means of removing the fluid from the thorax and, temporarily at any rate, of diminishing the toxæmia and preventing the disasters of excessive compression of the lungs. This should therefore be the first line of treatment in any empyema. It relieves the symptoms and allows time for the investigation of the pus and the identification of the causative organism.

It is most important to recognize from the very beginning that repeated puncture of the chest wall may be necessary. For this reason every care must be taken at the first exploration to cause so little pain or distress that later interventions are tolerated with equanimity. The preliminary puncture serves two purposes: it confirms the presence of pus and it enables a specimen to be obtained for bacteriological examination. The site chosen is the sixth or seventh interspace in the axilla. With a 1 c.cm. syringe and a moderately long but fine hypodermic needle the skin at the selected site is anaesthetized with 1 per cent. novocain. Through the centre of this area, through the intercostal space and the parietal pleura, the needle is driven, the anaesthetic being expressed from the syringe in a steady stream so that the whole track is completely anaesthetized. It is generally quite easy to detect the change in resistance as the needle enters the pleural cavity. Before the needle is withdrawn an attempt is made to aspirate some of the effusion into the syringe; if successful, this sample is saved for bacteriological examination. It is quite possible that the pus may be too thick to enter the needle, in which case the needle is withdrawn and another with a larger bore is fitted to the syringe and pushed through the chest wall along the anaesthetized track. When pus has been found this needle is withdrawn, the centre of the anaesthetized skin is punctured with a fine double-edged tenotome, and a trocar and cannula connected with a Potain's aspirator* is slowly driven into the pleural cavity. A most necessary precaution to ensure the proper working of the apparatus is the production of a negative pressure in the bottle and the testing of the apparatus by aspirating some sterile water immediately before use.

By simple aspiration there is a limit to the amount of fluid that can be withdrawn. The amount varies according to the size of the effusion, the amount of displacement of the intrathoracic organs, the degree to

which these are fixed by adhesions, and the expansile capacity of the affected lobe or lung. The onset of cough, of discomfort, or of pain in the chest is an indication that the limit of safe withdrawal of fluid has been reached. If it is exceeded, great distress can be caused to the patient, and there is even the danger of acute oedema of the lungs and death. The whole of a small effusion can be withdrawn without the appearance of symptoms, but if the effusion is large, symptoms may occur when not more than two-thirds has been aspirated; while if there is much thickening of the pleura, discomfort can be experienced when about a half only, or less, has been withdrawn.

It is possible to overcome this disadvantage by replacing the fluid, whenever symptoms of excessive intrapleural negative pressure appear, with air, or, better still, with oxygen. When a Potain's trocar and cannula is used for the aspiration, a fine pneumothorax needle connected with a pneumothorax apparatus is inserted into the pleural cavity through a higher interspace. Through this, air or oxygen can be run in as required. Unless the effusion is very thick I prefer aspirating and replacing through a single needle with a bore of 1 mm. and having two connexions, each controlled by a tap. One connexion is for the Potain's aspirator and the other for the pneumothorax apparatus. This saves the patient having two areas anaesthetized and two punctures. In an emergency, when the Potain's apparatus only is being used, if too high a negative pressure has been produced, the tap can be turned off and the Potain's tube disconnected from the needle. A pad of sterile wool is placed over the outer opening. The tap is then reopened, when, by reason of the intrapleural negative pressure, air will be drawn into the pleural cavity through the wool, which sterilizes it.

The application of this method of treatment has proved sufficient in itself to effect a cure in some cases of pneumococcal empyema.* "There is, moreover, the additional fact that experience has shown that a small proportion of these streptococcus cases will recover merely by aspiration. This number amounted to 13 per cent. of the cases observed by the Empyema Commission."² Graham, however, goes on to point out the danger of repeated aspirations owing to the risk of the needle penetrating the lung, when the pleural cavity becomes reduced in size, and causing a lung abscess. Empyema due to the staphylococcus is rare, but serious. It must be treated on the same principle as a streptococcal infection.

In the majority of cases further measures are needed, but an open pneumothorax must not be produced until frank pus is present: even then it is not advisable if there is a chance that the empyema can be cured by some other method which offers fewer possibilities of secondary infection—for example, by siphon or suction drainage through an air-tight opening.

SUCTION DRAINAGE

The principle of suction drainage is the introduction through an intercostal space of a catheter connected with a tube which opens about 10 cm. below the level of an antiseptic fluid in a Woulfe's bottle under the bed. By this means the intrathoracic fluid is carried off as formed, no air can enter the pleural cavity, and a constant intrapleural negative pressure is maintained.

The following is the ideal method of effecting air-tight drainage. The skin and underlying tissues of the seventh

* Any other efficient aspirator can be used instead of a Potain, if preferred.

* Prior to the great war, following success in the treatment of effusions by replacement by oxygen (*Lancet*, 1912, ii, 1774), I tried this method in pneumococcal empyemata. The cases were then too few in number and the results too inconstant to justify more than a private hope.

intercostal space in the posterior axillary line are anaesthetized with novocain as previously described. Before the needle is withdrawn pus is sucked into the syringe to confirm its presence at this point. With a fine-bladed knife a skin incision is made sufficient only to admit a large trocar and cannula, which is driven through the chest wall. The trocar is withdrawn and a catheter, in size sufficient to fit tightly into the cannula (size of outside bore preferably not less than 8 mm.), stretched on a rigid stylet, is passed through the cannula so as to project fully two inches into the pleural cavity. It is advisable, before starting, to mark the catheter at two points—the one three inches from the distal opening, and the other the length of the cannula proximal to the first point. The cannula is now withdrawn and the catheter is left *in situ*, fitting tightly in the wound.

Some arrangement must be made for irrigating the pleural cavity. The ideal method is to insert a second fine tube through the intercostal space immediately above the drainage tube. A gauze pad is then placed round the tubes, and over this a sheet of rubber, which is firmly fixed in place by strapping. During the insertion each tube must be kept closed; the larger is not opened till it has been connected up with the Woulfe's bottle, and the smaller one till connected with the irrigation solution.

As an alternative to the second opening for irrigation, a Y connexion can be inserted in the length of rubber tubing passing from the catheter to the bottle. To the third limb of the Y a short length of tubing is attached. This is kept closed with a clip when not needed for irrigation. A second clip must also be fixed on the rubber tube between the bottle and the Y connexion, so that this can be closed when the irrigating fluid is being run into the pleural cavity.

It is possible to introduce a catheter through an air-tight opening simply with a narrow-bladed knife and a pair of sinus forceps. This should not be attempted except in emergency, as it is not easy, and there is considerable risk of injuring the intercostal vessels unless the knife is kept close along the upper edge of the lower rib of the interspace.

Irrigation is not so much indicated in the early acute phase of the empyema as at the later period, when a deposit of flakes of lymph and fibrin is occurring. Carrel-Dakin's solution is the best, as in addition to its antiseptic action it has a solvent effect on the fibrinous deposit. It soon loses its efficiency in contact with the albuminous content, and must therefore be constantly renewed.

The most recent method advocated is that known as "tidal drainage." For this the catheter is connected by a short length of tubing to a bottle half filled with Dakin's solution, the bottle being placed just below the level of the chest. With each inspiration the solution is drawn into the pleural cavity and expelled with expiration. The solution requires to be changed frequently.

There are two objections to air-tight suction drainage: the tissues gradually lose their close apposition to the tube which excludes the air, but by that time the more serious risks of an open pneumothorax have disappeared, owing to the formation of adhesions. The second objection is that restless or delirious patients, and especially children, may pull the catheter out of the wound at a time when it is still essential to exclude the possibility of exposing the pleural cavity to the air. In treating such patients aspiration is very much safer.

OPERATIVE PROCEDURES

By the time the effusion has become really purulent, the pleural membranes are thickened and the lung and mediastinum are immobilized; then, for the first time, the question of open operation can be considered. This,

however, does not arise in that small percentage of cases in which aspiration is succeeding in arresting the effusion and obliterating the pleural cavity, nor in the somewhat larger number in which success is attending air-tight drainage. There are many cases, however, which need further treatment, either because aspiration is not a sufficiently continuous method of drainage, or because the catheter in suction drainage is becoming continuously plugged by lymph. The first question to decide is whether open drainage shall be through an intercostal space or by rib resection. Each procedure has its own advantages and disadvantages. The disadvantages of rib resection are that it takes slightly longer and is somewhat more of a strain for a patient who is seriously debilitated. Either operation is done under a local anaesthetic; this means the anaesthetization of two intercostal spaces for the rib resection and of one only for the intercostal incision. After rib resection there is the danger of fragments of bone getting into the pleural cavity and of rib necrosis, causing delay in healing. To prevent the latter the cut ends of the ribs should be plugged with sterile wax before they are exposed to infection. Rib resection does, however, afford adequate drainage, and gives room not only for the drainage tube, but also for an accessory tube alongside for irrigation. Intercostal drainage may not be possible if the ribs are too close together. Occasionally, when the tube fits tightly in the space, necrosis of a rib from pressure of the tube may occur.

The tube must be inserted at such a level that it drains the lowest part of the empyema cavity. This varies according as to whether there is an empyema of the whole cavity or a local one. It is advisable to explore first with a syringe and medium-sized hypodermic needle, after anaesthetization of the track through two or more interspaces, so as to ensure correct location. When the whole pleural cavity is involved the best position is usually through the seventh intercostal space, or by resection of part of the eighth rib in the posterior axillary line. Normally the pleural cavity extends lower than this into the costo-phrenic sulcus, but when an empyema is drained, and even before, this sulcus becomes obliterated by the organization of lymph and cellular deposit, and by the adherence of the lateral part of the diaphragm to the chest wall. If then the costo-phrenic sulcus is traversed by the drainage tube, the subsequent closure of the tissues round the tube leads to inefficient drainage, sinus formation, and irritation of the diaphragm. Cough from such irritation of the diaphragm may also be caused by the pressure of too long a tube inserted at a higher level. The tube, therefore, must not be too long. A projection of two inches within the cavity is ample to prevent its slipping out, if adequately secured. The tube should be of a wide bore, from 1.5 to 2 cm. It is a wise policy to insert a second much finer tube or a No. 10 catheter alongside the tube for purposes of irrigation.

The oblique and vertical incisions through the skin and superficial tissues have their respective advantages and disadvantages. The oblique incision requires less extensive anaesthetization of the tissues. The great objection to it is that if the arm is raised during the operation, when brought back to the side, it will be found that the cutaneous and subcutaneous incision is considerably below the level of the intercostal opening and tends, therefore, to distort the tube. While such a valve-like effect may be advantageous when instituting air-tight drainage, it is quite otherwise for open drainage. As a general rule the vertical incision through the skin and subcutaneous tissues with an oblique incision over the rib or through the intercostal space is preferable.

The value of Carrel-Dakin's solution for irrigation has already been referred to. One of the causes of chronic empyema is the organization of lymph so that it forms a sheath over the lung, preventing its re-expansion. Unless the visceral pleura is sufficiently supple reapposition with the parietal pleura cannot take place. If, on the other hand, the cause of incomplete expansion of the lung is due to fibrotic changes in the lung itself, approximation of the pleural membranes may still be possible owing to displacement of the mediastinum. Dakin's solution, by virtue of its solvent action, can often so free the pathological deposit from the pleura that the lung is again mobilized and capable of re-expansion. This action of Dakin's solution may liberate the plug closing a bronchial fistula, the existence of which was unknown. In such a case the use of the solution must be discontinued on account of the irritating cough it produces, and the risk of inspiration into the lung.

It is sometimes difficult to decide when to remove the drainage tube. A tube left in too long is apt to be responsible for a chronic sinus. This, unless of long standing, will clear up by the simple expedient of taking the tube out. A drainage tube is a source of irritation and therefore of reinfection, and must be removed as early as possible. The indication is the character of the discharge and the re-expansion of the lung as shown by *x* rays. If the lung is showing itself capable of expanding again, the tube should be omitted as soon as the discharge has ceased to be purulent, and is sterile.

It is essential from start to finish to treat the wound and empyema cavity with every aseptic precaution. A patient discharged from hospital while there is still a cavity or a sinus may, for the want of an additional week or two weeks' rigid supervision and care, be condemned to further operations, or to years of drainage, or even to a premature death from chronic sepsis or cerebral abscess.

DIET AND EXERCISES

The importance of nutrition was indicated by Bell of the Empyema Commission. He found that unless the diet contained a large amount of calories a day (from 3,300 to 3,500), an adverse nitrogen balance was produced, which meant a serious loss of weight. Graham recommends lactose, which is easily disguised by fruit juices, and also the subcutaneous administration of a 2 to 3 per cent. solution of glucose. Water should be given in considerable quantities during the febrile stage.

After the acute phase is over, breathing and blowing exercises should be started to increase the inflation and expansion of the lung so as to aid in the obliteration of the cavity.

CHRONIC EMPYEMA

The causes of chronicity can be divided into two groups—(a) cases in which chronic empyema could have been prevented, and (b) cases in which healing is very difficult owing to the primary cause or to unavoidable complication. The first group unfortunately is considerably the larger. It includes empyemata either not recognized or not treated until the pleura has become a rigid membrane by organization changes; those in which drainage has been inefficient owing to the opening being too high or too small; those in which reinfection has occurred; those in which irrigation with Dakin's solution has not been done and was necessary to remove the deposited lymph in order to prevent organization or to arrest persistent infection. Finally in this group of preventable cases are those in which the chronic cavity is maintained by the presence of a foreign body, such as a drainage tube, or fragments of rib, or on account of osteomyelitis of the divided rib.

The second group, in which the chronic empyema is due to unavoidable complications, includes those cases with bronchial fistula, with associated fibrosis of the lung, or in which the primary cause was tuberculosis or actinomycosis.

The first line of treatment is directed to rectify, when possible, the original fault. Efficient and dependent drainage must be instituted, preferably by enlarging and extending the original opening, if that is practicable; if not, by making a new opening. Foreign bodies should be looked for and removed. Frequent irrigation with Dakin's solution will help to sterilize the cavity and may even effect a decortication of the pleural surface, separating off the organized lymph. Dakin's solution should not be used, however, if the case is tuberculous, or, as has previously been stated, if there is a bronchial fistula.

It is only when these measures have been given a full trial that the major operative procedures are indicated. The object of these is to mobilize the chest wall by denuding it of the ribs over the affected area, and at the same time mobilizing the lung by decortication—that is, stripping the organized lymph off the lung and pleura. When dealing with a cavity of any size, mobilization of the chest wall alone or of the lung alone is rarely adequate. The operations must be performed in a series of stages, and it is most important that approximation should start at the apex and that apposition should be secured over the upper area before an attempt is made to obliterate the lower segment. In cases of very large empyemata it may be necessary to dissect away the whole of the parietal pleura, together with the periosteum of the ribs and the intercostal muscles.

Bronchial fistulae may clear up spontaneously after free drainage has been instituted. If not, the opening should be cauterized. To obliterate a large chronic fistula the bronchus must be freed, the end cauterized and closed by sutures, and the lung mobilized so as to bring it into apposition with the chest wall.

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- ² Idem: *Empyema Thoracis*, p. 63.

THE EFFICIENCY OF ANTISEPTICS USED IN MIDWIFERY

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Early last year it was pointed out in the correspondence columns of the *British Medical Journal*¹ that doubts had been raised of the utility of lysol as an antiseptic for obstetric use. A memorandum circulated by the London County Council, and reissued by the Central Midwives Board, gave particulars of tests which indicated that only comparatively strong solutions of lysol were capable of killing *Streptococcus pyogenes*, and, further, that different brands of lysol varied considerably in their bactericidal potency. It was not unnaturally asked what antiseptic should be substituted for lysol in midwifery, and this question has not until now, so far as I am aware, received an answer, either in the medical press or in the pronouncement of any public health authority. Meanwhile the Central Midwives Board has recommended the continued use of lysol by midwives, provided that it conforms to a certain chemical standard—namely, a 50 per cent. cresol content.