EMPYEMA OF THE PLEURAL CAVITY*

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There are certain conditions which we must attempt to meet if we are to satisfactorily treat empyema of the pleural cavity. They are:

1. An early recognition of the disease, whether we intend immediate surgical treatment or not.

2. A low mortality.

3. The prevention of chronicity, *i.e.*, the development of chronic from acute empyema.

4. The shortest possible convalescence.

5. The restoration of the functional capacity of the lung of the involved side to as nearly a normal condition as possible.

6. The certain cure of chronic empyema should it develop; and with a low mortality.

How can we meet these conditions? Obviously one way of approach is by the study of a fairly large, carefully followed series made with the purpose of discovering the factors which have contributed toward or prevented their realization. We have made such a study of 455 cases of empyema, 425 of which occurred in the Johns Hopkins Hospital series and 30 in the Cincinnati General Hospital series the past year; and we shall consider the above conditions in the light of these studies.

1. *Early Recognition of Empyema.*—This from a surgical viewpoint is a difficult condition to meet, for the early diagnosis of empyema will remain in the majority of instances in the hands of the internist and general practitioner, and therefore largely out of our control. But we may as surgeons emphasize the importance of early diagnosis and early surgical consultation, for a study of our cases seems to show the evil effects of tardy recognition of the disease. That empyema has frequently been recognized late in the past and is still recognized late in many instances has been our experience. Of the 425 cases in the Johns Hopkins Hospital series 213 had symptoms of empyema for 1 to 4 weeks before entering the hospital, only 1 of which had been operated upon; 81 had symptoms of empyema for 1 to 3 months, only 4 of which had been operated upon; 40 had symptoms for 3 to 6 months, only 14 of which had been operated upon; and 21 had symptoms for 6 to 12 months, of which 11 had been operated upon. Fifty per cent. of the total series of cases therefore had been rather promptly recognized, while the other 50 per cent. had either not been promptly recognized or, if so, had not been promptly treated. The harmful effects of such tardy recognition of the disease cannot be dogmatically stated, for there are factors concerned which

* Paper read before the Ohio State Medical Association, May 2, 1923.

are difficult to interpret. Yet our studies show, I think, that tardy recognition and late treatment contribute (a) toward the development of serious complications, (b) to a higher mortality, and (c) to prolonged convalescence and chronicity. At the time of their admission to the hospital with empyema, 20 cases in our series had pulmonary abscesses or gangrene, 8 had septicæmia (confirmed by blood culture), 4 had general peritonitis, 3 had suppurative pericarditis, 3 had meningitis or endocarditis and 9 had bronchial fistula due to the rupture of the empyema into a bronchus. Forty-seven cases therefore (10 per cent. of the entire series) had very serious complications in addition to empyema, and our records show that three-fourths of the total mortality in the entire series occurred in the group of cases with the above complicating conditions. I will grant that it is difficult to say that in the above cases with serious complications the empyema was primary, the complicating conditions secondary; for such complications may be manifestations of a general infection of which empyema is one. But I feel sure that a certain proportion of these complicating conditions follow acute empyema if left untreated, a view which is abundantly supported by our experience with infected thoracic war-wounds in France. Not only then is the danger of serious complications and thereby the mortality increased by tardy recognition, but the convalescence in empyema is prolonged and the tendency toward chronicity increased. In the Johns Hopkins Hospital series, 67 patients were admitted with chronic empyema and draining sinuses the result of operations performed elsewhere; and 20 cases operated upon primarily at the Johns Hopkins Hospital became cases of chronic empyema. In the Cincinnati General Hospital series of 30 cases admitted in the past year 7 were cases of chronic empyema. Ninety-four cases therefore (exclusive of the cases of tuberculous empyema) in a series of 455, or 20.7 per cent., were on admission cases of chronic empyema or subsequently became cases of chronic empyema. When we review the histories of these cases we find that in the large majority, operation was performed late—after weeks or months of evident empyema. When we compare with these the period of convalescence and the percentage tendency to chronicity of acute cases promptly recognized and treated, we feel sure that delayed recognition and late treatment of empyema is one of the causes of prolonged convalescence and chronic empyema.

2. *A Low Mortality.*—In order to attain as low a mortality as possible in the treatment of empyema, we must know the factors which contribute to the mortality in this disease. They are many and varied; and, while practically several of them may, in a given case, be operative, we shall for the moment treat them separately.

(a) *Age.*—When we study the mortality of empyema according to age periods, we find that in infants under two years of age the mortality is 39 per cent., that it drops in children from 2 to 5 years to 16.4 per cent., and reaches its lowest level (1.6 per cent.) in children from 5 to 10 years of age. It rises from this period, being 11 per cent. in young adults from 11 to 20 years of age; 16 per cent. in adults from 21 to 30 years, 17 per

cent. from 31 to 40 years, and 34.8 per cent. from 41 to 50 years. From this second high peak it again drops to 7.7 per cent. in adults over 50 years of age. The highest mortality in empyema therefore according to our records occurs in infants under two years of age and in adults between 40 and 50 years of age; the lowest mortality occurs in children from 5 to 10 years of age.

(b) *Etiology of the Disease.*—Studied from the standpoint of etiology the mortality in post-pneumonic empyema was 10.9 per cent., in tuberculous empyema was 42.8 per cent., in post-operative empyema was 41 per cent., in post-traumatic empyema was 33 per cent. and in empyema due to a miscellaneous group of infections 40.5 per cent. Etiologically, therefore, the highest mortality occurs in the tuberculous empyema, the lowest in the post-pneumonic empyema.

(c) *Type of Infecting Organism.*—Studied from the standpoint of bacteriology the pneumococcus empyema showed a mortality of 9 per cent., the streptococcus pyogenes empyema of 22.5 per cent., the streptococcus hæmolyticus empyema of 15.5 per cent., the staphylococcus empyema of 17 per cent. and the influenza bacillus empyema of 16 per cent. In this series streptococcus pyogenes empyema shows the highest mortality; pneumococcus empyema the lowest mortality.

(d) *Presence of Complicating Conditions.*—As above noted by complicating conditions, I refer to acute or unresolved pneumonia, either unilateral or bilateral, pulmonary abscess, pericarditis, peritonitis, meningitis, septicæmia, etc. Studied from the standpoint of the presence or absence of complicating conditions at the time of admission for empyema, we find that the mortality of empyema when such complications are present is 48 to 50 per cent.; in the absence of such complications is 6.5 per cent.

(e) *The Duration of Symptoms before Operation.*—Studied from the standpoint of the duration of symptoms of empyema before operation was performed, the mortality in the 213 cases with symptoms of empyema of 1 to 4 weeks' duration was 20.6 per cent.; in the 81 patients with symptoms of 1 to 3 months' duration was 9.8 per cent.; in the 40 patients with symptoms of 3 to 6 months' duration was 10 per cent.; and in the 67 patients with symptoms of over 6 months' duration was 9 per cent. The comparatively low mortality in patients with symptoms of long duration is to be expected and has no bearing on my remarks concerning the value of early diagnosis and prompt surgical consultation; for the majority of patients who have survived the first four weeks of empyema are those who have escaped the serious complicating conditions to which I have just referred. But that they have not entirely escaped and that they have suffered from the lack of prompt treatment is indicated by a study of the autopsy records of those dying. Of the 28 deaths which occurred in those with symptoms of more than 1 month's duration 14, or 50 per cent., showed at autopsy some serious complicating condition such as lung abscess, pericarditis, septicæmia, meningitis and bronchopneumonia.

(f) *The Kind of Anæsthesia.*—It is indeed difficult in this series to form any certain estimate of the influence of the various forms of anæsthesia upon the mortality. Ether, chloroform, nitrous oxide-oxygen and local anæsthesia were all used. Naturally local anæsthesia was the anæsthetic of choice in the most dangerously ill patients and therefore judged purely from the standpoint of anæsthesia the mortality is highest in this series following operations under local anæsthesia. This we know is incorrect, for the deaths were not anæsthetic deaths but deaths due to serious complicating conditions. On the other hand, we have some evidence of the harmful effects of general anæsthesia. A careful analysis of the deaths in this series shows that 3 patients apparently free from the condition before operation developed an acute bronchopneumonia which was at least the immediate cause of death; one patient died upon the operating table from the aspiration of pus through a bronchial fistula—a death which might have been averted—and one patient died upon the operating table either from anæsthesia or pleural reflex or acute surgical pneumothorax, it is not clear which. We have evidence therefore that the kind of anæsthesia is a contributing factor in the mortality, although of slight importance as compared with the others we have enumerated; and that local anæsthesia is the safest and therefore the best whenever it can be used.

(g) *The Kind of Operation.*—For the present we shall speak only of the operations for acute empyema; leaving the subject of chronic empyema to be discussed later. They are commonly three in number, *i.e.*, aspiration drainage, meaning by that the establishment of continuous air-tight suction drainage without the production of pneumothorax; intercostal incision with drainage, and rib resection with drainage. A study of our cases shows that in a certain and relatively large group of cases, *i.e.*, those not seriously ill in which the empyema is localized in the sense that the visceral and parietal pleuræ have become adherent about the empyemic cavity, the kind of operation has little influence upon the mortality. On the other hand, the kind of operation performed becomes a factor of great importance in the mortality in two groups of cases—those which are dangerously, acutely ill with marked toxæmia; and those with unilateral or bilateral pneumonia. In both groups the least possible operation which will suffice alone is permissible; in the latter group especially surgical pneumothorax must be prevented. We have noted a striking improvement in our mortality rate, especially in children, since we have substituted aspiration drainage for rib resection; and due, we believe, to the lessening of the seriousness of the operation and to the prevention of surgical pneumothorax.

(h) *The Kind of Post-operative Treatment.*—It is obviously difficult to form any just estimate of the influence of the post-operative treatment upon the mortality. So many factors come into play, namely the age of the patient, the etiology of the disease, the presence of complicating conditions, etc. In the Johns Hopkins Hospital series the operation (rib resection and drainage) was practically a constant, the post-operative treatment a variable.

Among 221 cases with no special post-operative treatment the mortality was 20 per cent.; in 65 cases treated with boric acid, weak bichloride and other irrigations, the mortality was 9.2 per cent.; in 50 cases treated by the Carrel-Dakin method the mortality was 4 per cent. It is perfectly clear that these mortality rates cannot be attributed to the kind of post-operative treatment; for an analysis of the first group, for example (those without any special post-operative treatment; mortality 20 per cent.), shows that a fairly large percentage died within 24 to 48 hours after operation before any form of post-operative treatment could have had any marked influence upon the course of the disease. Yet when we survey our experience we feel sure that the kind of post-operative treatment does influence the mortality and by quickly overcoming the toxæmia, by promptly controlling the infection and therefore the development of serious complications and by shortening the convalescence and therefore avoiding chronicity. Undoubtedly in our own experience the post-operative treatment of empyema by the Carrel-Dakin method has contributed to our results.

These, then, are the factors which a study of our cases has shown contribute to the mortality in empyema, and to which we must direct our attention if we are to attain a low mortality in the treatment of the disease. Which of them are of prime importance, which of lesser importance may be gathered from a closer study of our deaths. When we study the *factor of age,* which has so large an influence upon the mortality, we find the following:

In infants under two years of age the mortality in the Johns Hopkins Hospital series, as previously noted, was 39 per cent. Of the 16 deaths which occurred, autopsies were obtained in 10; and in these death was not due to simple empyema but due to the serious complications which I have previously enumerated. In 6 cases autopsies were not obtained and the exact condition is not known. In children from 2 to 5 years of age there were 13 deaths (mortality 16.4 per cent.), 12 of which were due to serious complicating conditions, either in the lungs or elsewhere. In children from 5 to 10 years of age, there was 1 death (mortality 1.6 per cent.), and that due to pericarditis. It is clear that in the last group the low mortality was due to two factors, *i.e.,* to the fact that the empyemas were post-pneumonic and that the disease was not associated with serious complications. When we examine the deaths in the succeeding age groups we find again that they are due to serious complications associated with empyema and to the introduction of other factors, such as traumatic conditions, post-operative complications and tuberculosis. We see therefore that age is a factor in the mortality only insofar as it predisposes to or is associated with serious complicating conditions. In infants the mortality is high because of the serious nature of the pulmonary infection which precedes and accompanies empyema. Infants stand infection badly, they are prone to develop bilateral pneumonia, bilateral empyema, multiple pulmonary abscesses, septicæmia and the complications of systemic infection. In children from 5 to 10 years of age, the mortality is low because perhaps of the less serious nature of the

primary pulmonary infection and certainly because of the absence of serious complications. In adult life the mortality again rises, due in part to the complications which accompany the empyema but due in part also to the introduction of new factors which become operative in adult life, *i.e.*, traumata, surgical operations, unusual infections and tuberculosis. In the aged the mortality again drops because the empyemata are post-pneumonic and unassociated with serious complications.

Similarly, when we study *the factor of the kind of infecting organism,* we find that the mortality in pneumococcus empyema is low, because proportionally it is less frequently associated with serious complicating conditions; that the mortality in streptococcus and tuberculous empyema is high, due in part to the graver toxæmia but in greater part to the proportionally higher incidence of serious associated complicating conditions.

In the light of these studies it becomes evident that the factor which contributes in largest measure to the mortality in empyema is the presence of serious complicating conditions. In order to attain a low mortality in the disease we must aim to make an early diagnosis, to recognize by physical, X-ray and other examinations the presence of complicating conditions; and our treatment must be directed toward supporting the strength of the patient, toward avoiding all unnecessary trauma by operative measures, toward preserving the greatest possible function of the lungs by avoiding surgical pneumothorax, and toward lessening and controlling infection by appropriate post-operative measures.

3. *The Prevention of Chronicity.*—An examination of the reports from various hospitals shows but few accurate statements regarding the incidence of chronic empyema. Wilensky, reporting the cases of empyema at the Mt. Sinai Hospital between 1903–1915, found that 23 per cent. of the cases developed chronic empyema. Other statistics are not so clear, but it is evident that in any large series of cases the incidence of chronic empyema has in the past been relatively high. In the above series of 455 cases, 94, or 20 per cent., either were chronic on admission or were acute and became chronic following treatment. It was this fact which originally stimulated us to study empyema in the hope of reducing the incidence of chronic empyema.

We shall reserve for a subsequent paragraph some remarks upon the pathology of chronic empyema and confine our attention here to the factors which clinically seem to be responsible for the development of chronic empyema. A study of the cases admitted with chronic empyema and of those admitted with acute empyema, which subsequently became chronic, shows that the factors involved are (a) delayed operation—by that meaning the presence of empyema for weeks or months before drainage is instituted, (b) the failure to produce adequate drainage, (c) the failure to overcome the infection of the pleura, and (d) the failure of constant supervision in post-operative care until it has been proven by physical and X-ray examinations that the lung has completely expanded and the empyemic cavity has thereby been obliterated. All these factors when closely examined show the impor-

tance of infection in the causation of chronic empyema and the necessity of overcoming it in preventing chronicity. The constant finding in chronic empyema is thickened pleura, the parietal pleura being always much thicker than the visceral. It is caused by infection, for we have proven that so soon as the infection is removed the thickened pleura disappears. It is the cause of the failure of the lung to expand and the reason for the persistence of the cavity. Delayed operation by causing thickened pleura, inadequate drainage, the presence of pockets, and foreign bodies and the results of inadequate post-operative supervision are factors dependent upon infection. In the prevention of chronicity, therefore, we must direct our attention particularly toward overcoming or providing conditions so that nature may overcome the intrapleural infection. It may be accomplished in various ways. J. M. Flint and B. Douglas, working in the Yale Clinic at New Haven in a series of 102 cases of acute empyema which will be reported, have not had a single case of chronic empyema develop. Their procedure has been rib resection with constant suction tube drainage. They have not made use of irrigations nor the Carrel-Dakin method. We, using aspiration drainage or rib resection with air-tight suction drainage depending upon the condition of the patient and making use of the Carrel-Dakin method in the post-operative treatment, have had no case of chronic empyema develop from an acute empyema in the past four years. Other methods may be as adequate, providing they are employed reasonably early and ensure the prompt elimination of the intrapleural infection. The criteria for satisfactory progress in the post-operative course are the rapid disappearance of toxic symptoms; the rapid fall of the temperature to normal, the decrease in the amount of the discharge and the constant progressive diminution in the size of the intrapleural cavity as determined by periodic X-rays and actual measurements. No patient with acute empyema should in our opinion be discharged from the hospital until it has been proven that the lung has completely expanded and the cavity has been entirely obliterated; for only under these conditions may we be sure that the condition is cured.

4. *The Shortest Possible Convalescence.*—Our remarks upon this subject form a corollary to those we have made in the preceding paragraph. Prolonged convalescence is a manifestation of chronicity and therefore in attaining the shortest convalescence we must study the factors which contribute to chronicity. As previously noted they include (a) delayed operation, (b) inadequate drainage, (c) the failure to overcome the intrapleural infection, and (d) the failure of adequate post-operative treatment. The first three of these factors require no further discussion, the fourth—the failure of adequate, constant post-operative supervision—should perhaps be discussed more fully. In the Johns Hopkins Hospital series we have studied the late results from various viewpoints, one of which has been the period of convalescence following various forms of post-operative treatment. With an average hospitalization period of 36 days, 12.2 per cent. of the cases receiving *no special post-operative treatment* were discharged with their empyema cured, 67.8 per

cent. with draining sinuses; 10.7 per cent. of the cases treated after operation with *boric acid or other irrigations* were discharged cured, 80 per cent. with draining sinuses; and 45 per cent. of the cases treated after operation by *the Carrel-Dakin method* were discharged cured, 55 per cent. with draining sinuses. The great increase in the percentage of cures in a 36-day interval following the Carrel-Dakin treatment is a striking commentary upon the value of adequate post-operative treatment. Now when we follow the after-history of patients discharged from the hospital, we find that those discharged with their empyemic cavities obliterated and their sinuses healed remain well practically without exception. Of those discharged from the hospital with cavities unobliterated and with draining sinuses, 80 per cent. eventually heal and get well while 11 per cent. fail to heal. Thus a fairly large proportion of cases do get well, but when we study the period of convalescence of those discharged from the hospital with draining sinuses, we find that over 75 per cent. require over three months for healing and many six months or a year; while as above noted 11 per cent. entirely fail to heal. These findings indicate that the shortest possible convalescence can be obtained only by continuous hospital treatment; and if this treatment is adequate our records and those of Flint and Douglas show that the large proportion of cases of acute empyema can be cured in 40 days, by cured meaning the obliteration of the cavity and the healing of the sinuses. So important has this matter seemed to us that we have in the past three or four years, in cases under our personal supervision, refused to discharge a patient with acute empyema from the hospital until he has been cured.

5. *The Restoration of the Functional Capacity of the Lung of the Involved Side.*—From a study of our end results the restoration of the functional capacity of the lung upon the involved side would seem to depend upon two factors: (a) upon the time after the development of the disease at which primary treatment is instituted and (b) upon the period of post-operative convalescence. Our records show that patients admitted for primary treatment from one to six months after the development of empyema have retraction of the thorax, thickening of the pleura, obliteration of the costo-diaphragmatic sulcus and fixation of the diaphragm; and therefore diminished functional capacity of the lung; that patients admitted for primary treatment early in the disease are less prone to these conditions. I have examined by physical methods, by the fluoroscope, by X-ray plates and by functional capacity tests about 130 patients in the above series—and anywhere from two months to several years after their primary treatment. The results of these examinations show that when obliteration of the cavity and healing of the sinus takes place promptly there is no retraction of the chest, no drooping of the shoulder, no scoliosis, no thickening of the pleura, and in rare instances only, any fixation of the diaphragm; and no diminution in the functional capacity of the lungs; in other words, restoration to the normal is complete. On the other hand, when convalescence has been prolonged, *i.e.*, when the obliteration of the cavity and the healing of the sinus has required months,

retraction of the chest, thickening of the pleura, fixation of the diaphragm and diminished functional capacity of the lung have been relatively common. It seems clear therefore that in order to restore the involved side to normal we should aim at early primary treatment and prompt cure.

6. *The Certain Cure of Chronic Empyema with a Low Mortality.*—Our previous remarks show the enormous advantages of preventing chronic empyema from the standpoints of mortality, prolonged convalescence and disability. Our experience and that of others moreover shows that with proper methods chronic empyema may be almost entirely prevented. It is not unreasonable to hope that chronic empyema will disappear as a surgical disease; but that time has not yet come, and those interested in thoracic surgery still see a distressingly large number of cases. It is indeed a difficult surgical condition to treat; and a study of the literature shows that the results of various methods of treatment are none too brilliant and the mortality attending them relatively high. It is well worth while therefore to study the condition as it presents itself and to devise and attempt procedures which may cure it.

A study of the pathology of chronic empyema shows an intrapleural cavity surrounded by an *infected thickened* pleura. The cavity may be single and is usually ovoid; or it may be irregular, longer or shorter prolongations (pockets) extending from the main cavity in various directions. The pleura is invariably infected; not only its presenting surface, but often also, as microscopic sections and cultural studies show, its sub-surface deeper portions. Of the two pleural leaves the parietal pleura is in my experience always thicker than the visceral. That is the usual picture; but there may in addition be one of several bronchial fistulæ communicating with the cavity, or a chronic suppurative focus in the lung or a foreign body or a focus of infection in a rib.

In answer to the question why does the condition persist, there are two chief factors to be taken into consideration. (1) The failure of the lung to expand and (2) the continuance of the infection.

(a) *The Failure of the Lung to Expand and Obliterate the Cavity.*—The causes assigned for the failure of the lung to expand have been chiefly three: (1) The shortening of the trabeculæ of the lung the result of prolonged collapse of the lung combined perhaps with infection (*i.e.*, pulmonary fibrosis), (2) adhesions at the point of junction of visceral and parietal pleuræ and (3) thickened pleura. It is well known, as shown by our experiments upon animals, that a normal lung covered by a normal pleura will expand indefinitely to fill any space within the pleura, provided the thoracic cavity is closed. It is also known that in the human subject a relatively normal lung with nearly a normal pleura will spontaneously expand and obliterate a cavity, even in the presence of an open pneumothorax, the result of a rib resection. Quite different conditions obtain in chronic empyema. Even in cases with simple ovoid cavities (without pockets, etc.), observed with the thoracic cavity widely opened so that any movements of the lung may be seen, the greatest force exerted by the patient in forced expiration is often incapable of expanding the lung in the slightest. There is

therefore a powerful resistance to the expansion of the lung in chronic empyema. It has been clearly shown that the shortening of the trabeculæ of the lung is a rare and insignificant factor in this; for the removal of the other factors enumerated allows in the great majority of cases the satisfactory expansion of the lung. We must look therefore to other factors for the failure of the lung to expand, and we find them I think in the adhesions or union between the visceral and parietal pleuræ at the margins of the cavity and in the thickened, resistant, inelastic pleura. A cross-section of a chronic empyema cavity will usually have in our experience an oval shape but differing from an exact oval in that one side—the visceral or lung side—is shorter than the parietal. The thickened visceral pleura has, then, become shortened and bears somewhat the same relation to the chest wall and parietal pleura as a cord subtending an arc. It is firmly held by its union with the thickened rigid parietal pleura. So long as this union persists the shortened visceral pleura cannot meet the parietal pleura and therefore the lung cannot expand to obliterate the cavity. That this is very largely the explanation for the failure of the lung to expand is shown by the success of three procedures: (1) The Fowler-Delorme, which removes the visceral pleura, thus removing the cord subtending the arc, (2) the excision of the parietal pleura described by myself,† which severs the union between visceral and parietal pleuræ and thereby allows the expansion of the lung and (3) the sterilization of the infected pleura which is followed by the absorption of the thickened pleura.

(b) *The Continuance of the Infection.*—Infection is the cause of the thickened pleura, the thickened pleura is, as we have just shown, the cause of the failure of the lung to expand and obliterate the cavity, the persistence of the cavity is most commonly the cause of the continuance of the infection. There is established therefore a vicious cycle which continues until either the cavity is surgically obliterated or the infection overcome. That infection is the fundamental cause for the persistence of chronic empyema was first completely demonstrated by us in 1913; for after the complete sterilization of a chronic empyemic cavity we allowed the sinus to close, leaving within the thorax a large intrapleural cavity. Subsequent cases showed that this experience was not unique and in 1920 we reported 7 cases‡ in which we succeeded in sterilizing chronic empyemic cavities. In all we closed the sinus, leaving within the thorax an unobliterated cavity; and found that the patients remained well, that the thickened pleura disappeared and the cavities were sooner or later spontaneously obliterated. The cure of the infection will alone therefore result in the cure of chronic empyema; for with the disappearance of the infection the thickened pleura is absorbed, allowing the expansion of the lung and the obliteration of the cavity.

The treatment of chronic empyema to be adequate must consider the above factors. The Estlander and Schede operations are designed to obliterate the cavity by bringing the thoracic wall in contact with the lung. The Fowler-

† ANNALS OF SURGERY, July, 1920.

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Delorme operation is designed to obliterate the cavity by allowing the lung to expand to meet the thoracic wall. In both groups of procedures the obliteration of the cavity is the primary object, the control of infection a secondary consideration. The excision of the parietal pleura, combined with the Carrel-Dakin treatment as practiced by us, was designed both to aid in the obliteration of the cavity and to control the infection; and it has been shown that complete sterilization of the cavity with closure of the sinus may precede obliteration of the cavity. The simple sterilization of the cavity and the wide exposure of the cavity combined with sterilization (the latter so far as I know first practiced by M. R. Reid in Baltimore and later brilliantly carried out by W. L. Keller) are procedures primarily designed to control the infection, the obliteration of the cavity being the secondary consideration—and occurring spontaneously so soon as the infection is controlled. In a consideration of these various procedures account must be taken of the mortality, of the certainty of cure, of the mutilation and of the resultant functional disability of the lung. Personally we have employed the Estlander or Schede operation in only two cases, for the mortality, the mutilation and the functional disability of the lung have seemed to us great disadvantages. We have made use of three procedures, the simple sterilization of the empyemic cavity with subsequent closure of the sinus; the excision of the parietal pleura combined with sterilization of the cavity and the wide exposure of the cavity by rib division followed by sterilization of the cavity and secondary closure. The two former procedures are applicable in the relatively small simple cavities; the latter in the large complicated cavities. The results we have obtained by the use of these procedures will be given in our summary.

Summary.—From a study of all the foregoing factors we may attempt to outline methods of treatment which in our experience most nearly meet the conditions enumerated in our opening paragraph.

1. Early diagnosis in acute empyema is desirable for failure to make an early diagnosis and institute prompt treatment favors the development of serious complications, increases the mortality and predisposes to prolonged convalescence and chronicity.

2. An early surgical consultation having been obtained, the most careful physical and X-ray examinations should be made for the purpose of determining the presence or absence of complicating conditions. It has been shown that the presence of bronchopneumonia in the lung of the affected or the contra-lateral side, the presence of bilateral empyema, lung abscess, pericarditis, peritonitis, etc., affect profoundly the prognosis and often determine the kind of surgical procedure. The intra-pleural fluid should be examined to determine its character and the kind of infecting organism. It is not clear to us that aspiration drainage has any disadvantages if done without the production of a pneumothorax and under local anæsthesia over simple aspiration, and we can see no good reason for waiting, if a fluid is not purulent but contains many leucocytes and organisms, for frank pus to develop.

3. In infants and young children, in adults very ill with grave toxæmia, and in all cases in which physical and X-ray examinations show or suggest the presence of pneumonia, either lobar or lobular, in the lung of the affected or contra-lateral side or other pulmonary complications, aspiration drainage promptly done under local anæsthesia and without the production of surgical pneumothorax is in our opinion the procedure of choice. Its advantages are that it causes the least possible trauma, it avoids surgical pneumothorax which in the presence of pulmonary complications is a grave condition, and it permits continuous, air-tight, gentle suction drainage and sterilization of the cavity. Its one disadvantage is that the presence of fibrin clots which fail to pass readily through the tube sometimes makes the post-operative management troublesome; yet we can say from a fairly large experience that this difficulty can be overcome, and without the necessity of further operative procedures. It has materially reduced the mortality in the dangerously ill of all age groups, but particularly in infants and young children, as we shall presently show.

4. In adolescents and adults not desperately ill and with empyema localized in the sense that adhesions between visceral and parietal pleuræ have formed of sufficient strength to prevent the ill effects of open surgical pneumothorax, aspiration drainage need not be insisted upon and rib resection may be performed. But if rib resection is performed, provision should be made for immediate continuous air-tight suction drainage. In the past year we have had one fatality due clearly to acute surgical pneumothorax, the result of an open sucking wound following a rib resection.

5. The proper post-operative management of acute empyema is of great importance. Air-tight suction drainage, sterilization of the empyemic cavity, continuous hospital treatment until it has been proven that the empyemic cavity is obliterated and proper pulmonary gymnastics will result in a lowered mortality, in a short convalescence, in a lessened tendency to chronicity and in less functional disability.

Let me conclude this paper with a statement of the results obtained by myself and my associates, Drs. M. R. Reid and B. N. Carter, in the treatment of empyema. The total number of cases treated was 125, of which 83 were acute empyema and 42 chronic empyema. One hundred and twenty-five cases were operated upon with 19 deaths, a mortality of 15 per cent.

An examination of our mortality shows the following:

1 age 30, died the day of operation. No autopsy.
1 age 49, died the day after operation. Autopsy. Bilateral bronchopneumonia; purulent pericarditis.
1 age 5 weeks, died 10 days after operation. Autopsy. Septicæmia. (Proven.)
1 age 32, died 3 days after operation. Autopsy. Bilateral bronchopneumonia.
1 age 36, died 30 days after operation. Autopsy. Lung abscess opposite side.
1 age 42, died ? days after operation. Autopsy. Primary carcinoma of lung.
1 age 47, died 21 days after operation. Autopsy. Embolism, infarction, gangrene lung—following repair arteriovenous fistula.

1 age 20, died ? days after operation. Autopsy. Bilateral empyema, bilateral lung abscesses.
1 age 1–½, died 10 days after operation. No autopsy. Symptoms of pulmonary embolism.
1 age 5/6, died 35 days after operation. No autopsy. Bilateral bronchopneumonia.
1 age 2, died 30 days after operation. No autopsy. Cause unknown.
1 age 2, died 12 days after operation. No autopsy. Cause unknown.
1 age 2, died 27 days after operation. No autopsy. Bilateral pneumonia; septicæmia. (Proven)
1 age ⅔, died 61 days after operation. No autopsy. Cause unknown.
1 age 23, died ? days after operation. No autopsy. Septicæmia. (Proven)
1 age 33, died 4 days after operation. Autopsy. Bilateral bronchopneumonia.
1 age ⅔, died 16 days after operation. No autopsy. Cause unknown.
1 age 40, died immediately after operation. No autopsy. Shock following extensive Schede operation.
1 age 31, died ? days after operation. No autopsy. Septicæmia; (Proven) acute surgical pneumothorax.

Two deaths in this series (carcinoma of lung; gangrene of lung) should be excluded.

The above data include our total experience. When we compare with them our statistics since we have become interested in the subject we find that our results have vastly improved in at least three directions: (a) In lowering the mortality in all age groups, but especially in children under five. As previously noted, the mortality of the entire series for this group was 24 per cent. In our recent series (15 cases) the mortality has been 6.6 per cent. This reduction in the mortality has been due we believe in large part at least to more careful examination before operation, to the substitution of aspiration drainage with local anæsthesia for rib resection and to more careful post-operative supervision. We are, however, aware that the lowered mortality may in part be due to the less frequent presence of complicating conditions. (b) In preventing the development of chronic empyema. Since we have insisted in the past three years that no patient leave the hospital until he is cured, we have had no instance of chronic empyema develop from an acute empyema which we have treated. This we can say after a careful study of the late results in our cases. The criteria for a cure must be rigid. The lung must be proven by physical and X-ray examinations to have completely expanded, and the cavity therefore completely obliterated and the sinus tract healed. Under these conditions we have never yet observed the recurrence of the condition. (c) In the cure of chronic empyema with a low mortality. In our personal series of 42 cases of chronic empyema there have been 35 cases of non-tuberculous chronic empyema and 7 cases of proven tuberculous empyema. Of the 35 cases of non-tuberculous chronic empyema 30 have been operated upon, the operation consisting of either (1) rib resection and sterilization of the cavity, (2) of excision of the parietal pleura followed by sterilization and (3) of wide exposure of the cavity by rib division, sterilization and secondary suture. Five have not been operated upon, the treatment consisting of the sterilization of the cavity through the

original sinus tract. In these 35 cases there has been no mortality. The results in all are known. Twenty-nine have been healed and are well from 1 to 6 years after operation, 2 are healed and well less than 1 year after operation, 4 are still under treatment in the hospital and will undoubtedly be cured. Our experience is far different in the cases of tuberculous empyema. Of the 7 cases in our series all were operated upon, the operations consisting of rib resection with attempts at sterilization in 5, and extensive Schede operations in 2. Following operation 6 patients recovered; 1 died of shock following a Schede operation. Of the six patients who recovered 1 was living and greatly improved in health 2 years after operation, but continued to have a discharging sinus, 4 are known to have died from 6 months to 2 years after operation and one has not been heard from. In none of these had the sinus healed at the time of death. It would appear therefore that the cure of non-tuberculous chronic empyema is quite possible and with a low mortality; the cure of tuberculous empyema remains a problem which still requires serious study.