1932

Study of empyema thoracis, including treatment of the acute stage

Norval W. McKittrick
University of Nebraska Medical Center

A STUDY OF EMPYEMA THORACIS,

INCLUDING TREATMENT OF THE ACUTE STAGE

SENIOR THESIS

UNIVERSITY OF NEBRASKA

COLLEGE OF MEDICINE

NORVAL W. MCKITTRICK

1932

A STUDY OF EMPYEMA THORACIS, INCLUDING TREATMENT OF THE ACUTE STAGE.

Empyema Thoracis is a very old and controversial subject. Our first record of it comes from Hippocrates, the great Greek physician of about four hundred, B.C. He wrote a treatise on the subject which was as accurate in description of physical signs and clinical course as anything subsequently brought forward, up until nineteen-fifteen. He advocated intercostal incision and rib resection for drainage in cases of pleural effusion. However, because he knew nothing of asepsis, a large percentage of his patients died from prolonged supurative processes and the open operation was gradually discarded until, in the time of Celsus (150, A.D.) it was not done at all. The records of this latter time show a mortality of ninety percent, without operation.

With the revival of learning in the sixteenth century, beginning of post-mortem studies and renewal of interest in the works of Hippocrates, surgical intervention again came to the fore and has since been the leading recognized form of treatment.

Empyema came to be regarded as a surgical emergency that should be operated upon as soon as a diagnosis of fluid in the chest was confirmed by the aspirating needle. This remained the treatment up until nineteen-sixteen, in spite of mortality percentages in different series of as high as fifty and sixty percent.

The World War and the Influenza epidemic of nineteen-seventeen, eighteen and nineteen combined to bring about a study of Empyema such as it or any other disease had never been subject to before. Trained medical men, abundant facilities and a wealth of material, under control, small wonder that they learned more about Empyema in that short period than all their predecessors.

Because the work of the Army men was so far reaching in its scope and thoroughness, I have drawn heavily upon their records for my subject matter, with of course, due regard for the work of those men who have continued the advance.

The Influenza epidemic in American Army Camps, occured in two waves. The first began in the fall of nineteen-seventeen, when the camps were first established and ran into the early months of nineteen-eighteen. The second wave came in the late summer and fall of nineteen-eighteen and lasted till spring of nineteen-nineteen.

The first organized survey of the situation was made in nineteen-eighteen.[3] On February twenty-first, nineteen-eighteen, all base hospital in the united states were sent questionnaires from the office of the surgeon general, which were designed to secure particulars concerning this disease, the measures being taken to limit it and those being employed in caring for the cases. Because this questionnaire was designed especially for the study of

Empyema and because it covered the field so well, I will set it down here in full:

1. In measles cases, what prophylactic therapy is applied to the upper respiratory passages?
2. What measures have been taken to isolate and quaranteen Empyema patients?
3. Has X-ray been used in diagnosis, systematically and repeatedly?
4. What percentage of pneumonias developed Empyema?
5. What organisms have been found in pleuritic fluids in order of frequency?
6. Have blood cultures been made systematically and repeatedly?
7. What did the blood cultures show?
8. Has the administration of anti-streptococcic serum been part of the treatment?
9. If so, what method of administration has been used?
10. In your opinion has this treatment had any beneficial effect on the progress of the disease?
11. Is immediate operation advisable?
12. Thoracotomy or thoracostomy and costectomy?
13. General or local anesthesia?
14. Do you prefer early aspiration of the chest followed by operation after the pus has thickened?
15. Has Dakin's or any other solution been used for irrigation in patients operated upon?
16. If so, with what result?
17. Has continuous negative pressure been used postoperatively and with what results?
18. What has been the mortality in Empyema?
19. What percentage of Empyema cases have been operated?
20. What percentage of Empyema cases is followed by:
    - A. Empyema of opposite side?
    - B. Purulent Pericarditis?
    - C. General Peritonitis?
    - D. Pneumonia of opposite side?
    - E. Sinus Involvement?
    - F. Meningitis?
21. At autopsy, are pockets of pus found, particularly substernal or just internal to and behind the anterior flap of the lung?
22. Furnish other important autopsy findings.

As will be realized, this record was of most value in

acute cases which recovered. In the more protracted cases, when men were discharged from army service, follow-up letters were employed to check up on their progress and recurrences. This with only indifferent success.

Another fertile source of information open to the army investigators was the Bureau of War Risk Insurance because this bureau examined the discharged men to fix their disability and they compiled special charts for the Empyema cases.

Furthermore, the surgeon general's office received a monthly report on the progress of every empyema case in the army hospitals.

Because of the exceedingly high incidence and mortality of Empyema in the base hospitals, Empyema teams were appointed at each to make special studies. These teams included a surgeon, an internist and a labratory man.

By means of this efficient organization which I have described it was possible to gather all the data on Empyema cases, including history, treatment and follow-up letters and to arrange it in the form of a brief of each case. For the period, nineteen-seventeen-eighteen, two thousand, nine hundred and thirty-nine such briefs were made.

This brief outline of the army program serves to show that their work was thorough and far-reaching and that conclusions reached by the army medical men may well be accepted as being based on ample experience and study.

Empyema is nearly always secondary to infection elswhere in the body, primary empyema being very rare although in certain virulent streptococcal pneumonias, the pleural effusion is the first finding on physical examination and masks the consolidation areas. However, most empyemas are secondary. It follows lobar-pneumonia, Influenza, Measles, pelvic and abdominal infections, injuries, in short, any infection which can reach the pleura by the blood stream, lymphatics or by direct extension.

The organisms most frequently found are the pneumococcus, Streptococcus, Staphlococcus, more rarely the Influenza or Tubercle bacillus or Bacillus Mucosus Capsulatus. There are many instances of mixed infection. The pneumococcus is presnt in the lungs in the majority of cases of lobar pneumonia. Streptoccus is present particularly in cases of bronchial pneumonia. There are many healthy carriers of streptococci, they being lodged in the mucus membranes of the pharynx and larynx, without causing pathology other than a tonsilitis or pharyngitis. The army men found that the incidence of Empyema has a direct relation to that of upper respiratory infections. In singularly few instances did the curve representing incidence of Empyema fail to conform to that representing incidence of infections of the upper respiratory tract. Frequently the empyema curve was entirely interrupted when the curve for

the upper respiratory class of diseases approached its minimum. For instance, in several of the camps, this abscence of Empyema was first noted, when the admissions for upper respiratory disease dropped to ten per thousand or one percent and again appeared among men comming to the hospital, at a time when admissions for upper respiratory disease rose above one percent of the men in camp. If this parallelism was disturbed it was usually at a time of exceptionally high incidence of Influenza. If the influenza cases were mild, as shown by low mortality, the incidence of empyema was disproportionately low. When the mortality from influenza was greater, the incidence of empyema rose more rapidly in proportion to the incidence of upper respiratory disease.

So we conclude that the development of empyema is not directly dependent upon the influenza but rather upon associated infection of the upper respiratory tract, the effects of which are augmented by the influenza. It is therefore evident that study and control of these upper respiratory infections will be of importance in the future prevention of empyema.

Although this relation between incidence of upper respiratory disease and empyema was firmly established, it was not found that a fixed ratio existed between the two conditions, probably because of variations in infections of the upper respiratory tract, some being more prone to

further invasion or due to concomitant variations in environment in the different camps.

For example, compare camps Upton and Pike over a period of one month.[3] Upton had a ratio of Empyema to upper respiratory disease of one to forty-four. The same ratio at Pike was one to one hundred and nineteen. Although the incidence of upper respiratory disease was greater at Pike, it was not as virulent as at the other camp, there being no deaths due to this cause alone, while at Upton two and four tenths percent of deaths were due to upper respiratory disease. Evidently, because of the greater general severity of upper respiratory disease at camp Upton, complications were more likely to occur. Likewise the pneumonia at Upton showed a greater mortality (34% and 20.6%) Indicating a greater virulence. In the empyema cases, Upton had a mortality of 50% of 40 cases and Pike, 36% of 14 cases. So our contention that Empyema has a direct relation to incidence of upper respiratory infection is borne out, although no definate ratio can be sited because the ratio apparantly depends upon the severity of the upper respiratory disease, a highly variable factor. To my mind, this was the most important fact established by the epidemiological studies of the disease.

Other factors, effecting the incidence of Empyema, besides virulence of organisms are, general physical condition of the individual, exposure to inclement weather

or excessive fatigue, differences in race and previous mode of living.

In studying the pathology of the disease we find that streptococci (usually a hemolytic strain) or pneumococci are the organisms most commonly found in the pleuritic fluid.[5] Cases of staphlococci and influenza bacilli alone are rare. The two are usually associated with streptocci and appear to have little effect on the course. The most common portal of entry is the upper respiratory passages.

There are three routes by wich infection may reach the pleural cavity:

1. Throught the bronchial tree and alveoli, setting up and inflammation and exudate, extending to the alveolar tissues, underlying the pleural endothelium. This is called the alveolar route.

2. The interstitial route, throught lesions in the bronchial lining and thence by lymphatics to the pleural structures.

3. The blood stream route, by gaining entrance to the blood stream, circulating and setting up widely disseminated foci of infection where conditions are favorable to growth of the organisms.

Combinations of these routes are entirely possible and there may be others but the one which is most dominant will most effect the extent of infection and determine

its clinical course to a large degree.

In case of the alveolar route, the pneumonia is manifest before the empyema. The first pleural effect is an exudate, serous, fibrinous or sero-fibrinous in character and the initial damage is relatively mild in degree. The pneumonia is most likely to be lobular or bronchial. If only a single empyema cavity forms over an area of consolidation, it is due to organization of the serum and walling off of the pus cavity by granulations and adhesions of healthy pleural membrane at its periphery. The bacteria in such cases are invariably pneumococci. They frequently die and the pus becomes sterile. If evacuated, conditions for recovery are good because, the pneumonia will resolve and the lung will expand to normal. The pleural surfaces contact and permanent fibrous adhesions form.

If infection spreads by the interstitial route, the pleural effusion may be manifest before any consolidation occurs because the spread is so rapid through the loose interstitial tissue and lymphatics. Pleural pain may be the first symptom and by that time the effusion be sufficient to mask the signs of pneumonia. This type of empyema is most frequently the result of streptococcus infection and characterized by an abundant exudate. Adhesions occur only where the pleural surfaces are in contact, so that the pockets are usually lower than the area of adhesions because gravity carrys the exudate to the

most dependent portion of the sac. The spread of infection is aided by the respiratory process because it subjects the pulmonary lymphatics to periodic alterations in pressure. Infection may progress toward the hilus of the lung as well as peripherally, and there set up infection of the pericardium, mediastinal lymph nodes, alveolar tissue of the neck and parietal pleura.

In empyema by the blood stream route, the pneumococcus is most frequently the offender and there are foci of infection in distant areas, which can be explained on no other basis than a haemic distribution. Other structures frequently involved are, Pericardium, Peritoneum, Joints, Middle ear, Nasal sinuses and subcutaneous areolar tissue. At autopsy, many times, the extra pleural infections prove to be of greater importance than the empyema itself.

That the infection may spread by contiguity is shown by cases of subphrenic abscess, where the diaphragm has been invaded, however the commonest route for infection to spread is by the lymphatics and the mediastinal lymphatics seem to be the connecting link between, pleura, pericardium, peritoneum and areolar structures of the neck.

The complications of empyema in order of frequency of occurance are: Bilateral pneumonia and empyema of the opposite side, Pericarditis, Peritonitis, Mediastinitis, Infection of the neck. In cases with extension and complications,

the streptococcus is nearly always responsable.

From the pathological study, thus far, we conclude: that fatal cases of streptococcus empyema, die with a bilateral pneumonia and usually extensive infection of two or more of the serous cavities, but intra-thoracic complications being the most common; Pericarditis and peritonitis sometimes occur before the blood stream is infected (definate proof of lymphatic transmission); infection of the pericardium may occur through the mediastinum; and the blood stream is infected through the lymphatics rather than by direct contamination in the infected pleura.

Next, we shall consider the effect of the type of pneumonia upon the empyema. In acute interstitial bronchopneumonia, empyema is extremely frequent because the lymph channels offer easy routes of dissemination for the bacteria. In describing the lung picture, MacCallum says,[5]

> "The pneumonia lesions are in and about the bronchiols. The bronchiols themselves are densely infiltrated with mono-nuclear cells and markedly thickenend. In some cases, the whole bronchial lining is necrotic, constituting a dyphtheritic membrane. Bronchiectasis and atelectasis are frequent results due to rupture of bronchibls or obliteration of their lumen. Adjacent alveoli show infiltration of their walls and are filled with blood, dense fibrin and desquamated epithelial cells. Great numbers of streptococci are found in the lymph channels. The pleura itself and all the interlobular septa become edematous and permeated by a serofibrinous exudate with microorganisms and wandering cells. The effusion of fluid exudate takes place with extra-ordinary rapidity and compresses the lung to such

a degree as to complete the atelectasis."

This excellent description gives us a picture of the lung condition in those cases of bronchial-pneumonia which result in massive effusions, a type which Lillienthal calls total empyemas.

The lobular pneumonias are also associated with the hemolytic streptococcus but bronchial and peri-bronchial lesions are absent. The alveoli are the seat of infection, giving rise to consolidation and peripheral hemorrhage. It frequently results in multiple abscess formation. Rupture of these abscesses cause empyema and pleuro-bronchial fistulae.

Empyema with mixed types of pneumonia show features of both alveolar and interstitial routes of extension. In most cases it is evident that the invasion of streptococcus hemolyticus is secondary to some other infection, such as measles or influenza, which has lowered the individuals resistance.

In the typical lobar pneumonia, the pleural infection is prone to be confined to the area of consolidation and appears to start as a dry pleurisy, with hyperemia and a fibrinous exudate tending to agglutinate the pleural surfaces and restrict the pus, subsequently formed to a single empyema cavity. In uncomplicated cases, the infection is purely pneumococcal and the organism may die leaving the

pus sterile. The location of these empyema cavities is varied and they have been given descriptive names by Lillienthal such as: Parietal, Mesial, Supra-phrenic and Interlobar.

Conditions are quite different when infection of the pleura follows streptococcal pneumonia. The pleural infection may then be massive at the start and lead to abundant serous effusion, before fibrinous agglutinations are possible. Thus large empyemic cavities are formed, in some instances, including the greater part of the pleural cavity. In some cases of streptococcus pneumonia, sub-pleural or interlobar abscesses form. If one of these suddenly ruptures into the general pleural cavity, a massive infection of the pleural cavity results with rapid development of a large exudate. The exudate may in time be walled off because the inflammed pleural surfaces throw out granulation tissue and wherever this comes in contact, a permanent adhesion is formed.

Very few cases of empyema die of the empyema per se and it appears that caution in treatment and prognosis is especially important in the streptococcus cases. Therefore it is well to consider the findings in a streptococcus case. In the early stages of exudation, the pleural fluid is serous, straw colored, tawny, or pinkish from admixture of blood pigment and often slightly fluorescent, appearing

brownish by transmitted light and yellowish green by reflected light. Occasionally it appears quite clear but is usually somewhat cloudy due to the enormous number of organisms present. The amount formed in a few hours may be very large, as high as six liters being drawn off at a asingle aspiration and the daily accumulation running as high as a liter. Within from one to three days, fibrin and leukocytes appear in such quantity that on standing, a sediment is formed amounting to from one tenth to one fifth of the volume. The supernatent fluid is yellow, brownish or light pink in color. At this time the pleural surfaces are covered with a deposit of fibrin, which soon becomes abundantly infiltrated with leukocytes. The fluid, likewise carrys progressively more and more of these cells, turns sero-purulent, then purulent and finally is so charged with pus that only a thin layer of clear serum appears at the top after standing for several hours.

Next, we consider the dissemination of infection in the cases which survive. In a relatively small number only, of these, does the empyema become bilateral. Peritonitis as a complication in surviving cases is only mentioned in two cases of the army records. Pericarditis is also of low incidence in surviving cases, as a true infection of the Pericardium with abundant purulent exudate due to the streptococcus is almost invariably fatal.

A diagnosis of Empyema depends largely upon the three important factors of history, physical findings and x-ray studies, confirmed by aspiration. In streptococcus cases there is often a history of cough, headache and malaise for a few days preceding the onset of pneumonia. Epistaxis is a common prodromal symptom. In some the onset is sudden with intense pleural pain but Dunham says that there is always a history of predisposing respiratory disease. The pleural exudate develops early and in large quantities. The respiration is shallow and accelerated to between forty and sixty per minute. Allaccessory muscles are brought into play. There is expectoration of much frothy muco-purulent sputum, which may be blood tinged. The face is cyanotic. For the first two weeks, the temperature averages 102 to 104 and after the pneumonia is established, there are morning and evening variations of one or two degrees. The temperature drops two or three degrees after each aspiration. If the effusion is massive as is to be expected, the physical findings are those of a lobar pneumonia, however a crisis is not observed.

The empyema following lobar pneumonia, may obscure the crisis which is usually observed in that disease. The important thing is that the patient remains toxic and still runs a fever after ten to fourteen days. By that time, the physical signs of an exudate are found, limited usually to the effected lobe.

Additional aid in diagnosing an empyema may be obtained by referring to the list of physical signs given by Lillienthal[1]:

1. A distinct flattening of the effected side.
2. A depression of the shoulder on the effected side.
3. A scoliosis of the spine with its concavity toward the effected side.
4. Limitation of the respiratory excursion on the diseased side.
5. The obliquity of the ribs on the empyema side is exaggerated.
6. Vocal fremitus is increased if the exudate is very cellular.
7. Percussion is extremely important and brings out a flatness directly over the fluid.

It is important to search carefully for extra sacculations. These are especially elusive if between two lobes, between the diaphragm and the lower lobe or in the lower two thirds of the chest on the mediastinal side.

The x-ray is an extremely valuable aid in diagnosing empyema and should not be limited to diagnosis alone but should be used as a means for checking up, throughout the treatment of a case. It furnishes evidence of organic lesions, makes a permanent record, checks up on progress, saves time, aids the surgeon in operating and eliminates the personal equation to a large extent. The x-ray shadow of an empyema following lobar pneumonia is found, where the lung previously showed consolidation. Lobar pneumonia is most frequent in the lower lobes and the shadow of the subsequent empyema is usually most intense over the lower,

posterior or lateral pleural surfaces.

The fact that the effusion may be the first finding in a streptococcus infection has been alluded to before and this is found to be tru in x-ray studies of such cases. The signs of consolidation may be entirely obliterated at first by the effusion, although after the pneumonia is established, its progress can be followed by this means.

Then, of course, to make sure of a diagnosis of empyema, the aspirating needle is used and enought fluid ~~xixt~~ withdrawn to determine its character and bacteriology.

In treating cases of acute empyema, the following goal should be kept in mind: To avert any condition threatening life; to promote the well-being of the patient; and to reduce the ultimate disability to a minimum. The problem has always been surgical, changes in technique and time of operation being the important recent advances. Prior to the spring of 1918, all cases of empyema were treated as surgical emergencies and thoracotomy and rib resection was done as soon as the diagnosis of an effusion was established. Furthermore, this type of treatment made no distinction between an empyema following lobar pneumonia and an empyema accompanying streptococcus broncho-pneumonia. Now we know that there are vast differences between the two conditions. For instance, streptococcus broncho-

pneumonia continues over a course of several weeks, while the course of a lobar pneumonia is limited to a period of several days, terminating by crisis. After the crisis, the patient can be operated with much less danger because he is not called upon to withstand surgical shock while in a toxic and dyspneic condition. Furthermore, the streptococcus effusions are large and occur at the height of the pulmonary infection, while those due to pneumococcus are small, encapsulated and 80% diagnosed after the crisis.

The army men came to realize these differences and decided that, because of the severity of the infection in broncho-pneumonia, palliative measure would be best to bridge over the acute stage. It had been suggested by Keller, in 1917, that aspirations for several days would reduce the schock of operation and this was the routine finally adopted. Results were gratifying, mortality in the army camps falling from 40% to 5% almost immediately.

The treatment has remained the same with most surgeons since that time. In broncho-pneumonia with effusion, operation is deferred until the second or third week after the onset, aspirations being done, when necessary to relieve respiratory embarrassment, usually at two day intervals. These aspirations are done with a Potain apparatus, consisting of a vacuum jar, rubber tubing with a valve and the aspirating needle. After the third for fourth aspiration, the exudate, which is at first serous and

straw colored, becomes thick, creamy and purulent so that that at times, it cannot be drawn through the needle. The greatest quantity is usually obtained at the second or third aspiration. The amounts at successive aspirations vary greatly because of new adhesions and encapsulations which prevent complete emptying of the cavity.

I have indicated that these aspirations are merely palliative measure in the opinion of most surgeons, however, Dana advocates the treatment of empyema by aspiration and air replacement alone. He presents a series of thirty-five cases with two deaths, the others recovering completely. The technique is as follows:[1]

> By physical signs and x-ray locate the site of effusion. At a point in the intercostal space, corresp onding to the lowest part of the empyema cavity, infiltrate all the tissues from the pleura to the skin with ¼ ½% novocain solution. Attach a large size needle by rubber tubing to a 50 or 100 cc. Luer syringe and insert the needle at this point. Suck out fluid, empty the syringe and replace an equal amount of air. Repeat this operation until air comes through the needle on aspiration. Manipulate the patient and the needle so as to get at the bottom of the cavity and aspirate untill air comes again. Repeat aspirations as the pus accumulates on an average of once every six days. It is essential that the cavity be completely emptied at each aspiration. If the patient does not show immediate improvement, look for another cavity or other pathology. In the average case, all air is absorbed in three weeks.

In Dana's series of thirty-five cases, the average number of aspirations was three and in all the thirty-three patients who lived, there was complete recovery.

With the great majority of surgeons, it is still the practice to aspirate during the critical stage and drain when conditions are right. In this way they allow time for inflammatory infiltration of the pleura and especially the mediastinal pleura, thus rendering the cavity less elastic and reducing the shock and cardiac & respiratory embarrassment following drainage.

To determine the best time for drainage, the surgeon depends on the condition of the patient as shown by his temperature, respiration, pulse rate and character of the exudate. Operation is usually delayed until the exudate is no longer serous or sero-sanguinous but is purulent and contains numerous fibrin flakes. In pneumonia cases, the temperature is probably the best guide to toxicity of the patient as we find in the army records that the maximum mortality from surgical drainage and the peak of the temperature curve fall together on the seventh day after onset, while the lowest aferage temperatures occured on the fourteenth day after onset, when the mortality from operation was lowest.

Delaying the operation is usually not considered necessary in empyema complicating lobar pneumonia for the condition of these patients is such that they are usually good surgical risks when the diagnosis is made, however when the exudate is discovered before the crisis, preliminary aspiration is considered to be the logical treatment.

Before considering operative technique, it is well to have an understanding of the mechanics of the thorax in relation to early drainage. Too early drainage results in an open pneumothorax. This was formerly thought to have little effect on the other lung because of the wall formed by the mediastinal structures. But Graham and Bell, by direct experimental observation established the fact that in the normal thorax, the mediastinum offers so little resistance to changes in pressure that any change in one pleural cavity effects the other to practically the same extent. So, from the standpoint of pressure relationships, the normal thorax should be considered as one cavity instead of two. Immediately after making the drainage opening, there is a simultaneous change of pressure in the two pleural cavities from an entirely minus or negative phase to one which oscilates between a positive or plus and a negative phase. So we see that the mediastinum has a dangerous tendency to flutter. Other dangers of open pneumothorax are; loss of heat, danger of infection, and disturbance of circulation, resulting in a rise of venous pressure. However, fatal asphyxia, theoretically, should not occur until so large a portion of the lung capacity has been obliterated by the pneumothorax, that the individual's vital capacity equals his tidal air, or he loses his ability to compensate by increasing his respiratory effort. Toxemia may likewise produce asphyxia by an extraordinary demand for

oxygen.

Closed drainage has been used as a means to combat these dangers of pneumothorax. It is a means for obtaining drainage and at the same time maintain a negative pressure in the thorax. Of comparatively recent origin, it was advocated by Cresswell Hewett in 1876 and again by Bulau in 1891. Mozingo revived it again in the army epidemic and used it in conjunction with Dakin's solution irrigation, very successfully at Camp Pike. Many forms of apparatus have been devised for maintaining closed drainage, some of them complicated and cumbersome. In general, the simplest have proved to be the most efficient. A simple technique described by E.E. Mansur appeals to me:[13]

> A Wilson drainage tube, which resembles a spool, except that its inner flange has a lesser diameter than the outer, is prepared by fastening a piece of rubber dam material over its external opening. This is secured at its upper side only so that it forms a movable flap valve. The smaller internal flange is rolled up and held in a hemostat to facilitate introduction into the thoracic cavity. An appropriate site is selected, usually in the mid-axillary line. The skin and deep structures of the wall are infiltrated with novocain. The rib is cut down on with a parallel incision and a small section removed. A sponge is held in the left hand, while with the right, a blunt forceps is forced into the empyema cavity and its jaws opened sufficiently to make a 3/4 inch opening, which is instantly covered with the gauze sponge. Then the free hand introduces the valve into the wound, under the sponge. The operation of the valve may now be observed. The patient coughs slightly, increasing intra-

> thoracic pressure and quantities of pus and air rush out through the tube. When the wallscollapse and an intrathoracic vacuum is created, the rubber flap covers the opening and prevent entrance of air. That a constant intrathoracic vacuum is maintained is shown by the indentation of the rubber tissue covering the hole. Dressings can be applied and changed without interfering with the operation of the device.

Mansur claims that this technique provides more dependable lung expansion, minimum of scar tissue formation and a much shortened convalescence.

Another good type of closed drainage is obtained by the water-seal method as described by Lillienthal. In this the drainage tube leads into a pail of water on the floor at the side of the bed. Vacuum is maintained by the column of water which is drawn up into the tube on inspiration.

The open type of drainage can be used without fear of serious pneumothorax, if sufficient time has elapsed to insure adhesions. It is preferably done under local because voluntary movements of the patient may be desirable and if a broncho-pleural fistula is formed, coughing of pus will indicate the condition. A rib at the lower border of the cavity is usually chosen, but never lower than the nineth because of danger of injury to the diaphragm. Larger masses of fibrin may be removed manually but digital breaking up of adhesions is condemned. Most surgeons use drainage tubes and some irrigating solution in caring for

open drainage cases. In writing on the subject, Dr. Roeder says,[15]:

> "Drainage tube proccedures are simple, easily cared for and cause little distress. Disadvantages are that the drainage is profuse and prolonged and the lung flaps during respiration and frequently the pus pockets away from the drainage tube. I have used the gauze pack in cases requiring open drainage and when the lung was not permanently compressed by organized, thickened pleura, and intra-pulmonary scar tissue".

Advantages claimed for the gauze pack are:

1. It holds the lung steady after operation thus adding to the comfort of the patient.
2. It clears the exudate rapidly from the walls of the cavity.
3. It breaks up the numerous small abscesses in the periphery of the lung which are usually present.
4. It erradicates external purulent drainage almsot entirely after forty-eight hours.
5. It brings about obliteration of the cavity at least as rapidly as any other method.

Disadvantageous features are:

1. The gauze pack must be changed daily and the first dressing is distressful without light anesthesia.
2. The wound requires dressing for several weeks.

In packing the cavity, Dr. Roeder uses Bismuth Iodide gauze and a long curved dressing forceps so that every portion of the infected pleura is in contact with the gauze. The succeeding packs are less firm and the cavity each day admits less gauze. In six or seven days, further use of the gauze is unnecessary. Dr. Roeder reports several cases treated in this manner with good results.

Many types of irrigating solutions have been used in these open drainage cases:[6]

Formalin	Iodine
Cresol	Mercuric chloride
Dichloramine T.	Optochin
Bismuth	Potassium Permanganate
Boric acid	Iodoform
Chlorazine or Chloramine T.	Urotropin
Analine dyes.	50% Glucose
Silver nitrate	

In general, it may be said that the results have not encouraged the use of others than those belonging to the Chlorine group and of these, Dakin's neutral solution of sodium hypochlorite is undoubtedly the best. It is strongly germicidal in concentrations which do not injure living tissues. It effects an early sterilization of the cavity, thus shortening the time of closure. It has a chemical decorticising effect on the organized exudate, formed on the lung surface, and it reduces the liklihood of permanent disability.

Preparation of Dakin's solution is as follows:

1. 200 grams of chloride of lime (chlorinated) are dissolved in 5000 cc of water and left to stand for one hour.
2. 94 grams of dry sodium bicarbonate are dissolved in 5000 cc of cold water in a separate container.
3. The solutions are mixed and shaken thoroughly. When the granular calcium carbonate settles, the fluid is syphoned off and filtered. If alkaline to solid phenolphthalein, it is neutralized with boric acid.

The solution obtains the best results, when it is used with the full Carrel technique, although few surgeons

make such an elaborate instillation, simply running in fresh solution every hour and being sure that their supply is fresh daily.

During convelescence, expansion of the lung is best effected by deep breathing exercises and blowing on balloons or forcing water from one container to another. Check-up x-rays should be taken and the patient watched closely for recurrances.

In conclusion I will repeat three things which I believe are worthy of emphysis:.

1. The apparent connection between Empyema Thoracis and predisposing upper respiratory disease. Energetic treatment of these conditions may help to eliminate empyema.
2. The importance of delayed drainage in streptococcus pneumonia cases with empyema, using repeated aspirations to tide over the critical period.
3. The necessity for early sterilization of the empyema cavity with Dakin's or some other chlorine product, if there is to be recovery without permanent disability.

CASE REPORTS

#1. University Hospital # 25318. A boy, aged 15, had "flu" three weeks previously. On April 28, 1928, right 10'th rib resected and 650 cc of thin dirty-brown pneumococcic pus evacuated. Cavity packed with fluffed gauze and patient insisted on walking back to his bed because of the solid feeling in his chest. No purulent exudate visible ater the second day. No packing necessary after the 6th day.

This case illustrates very nicely, Dr Roeder's gauze pack method of treatment. Note the expression "solid feeling in the chest". The gause supports the lung and prevents it from flapping.

#2. University Hospital # . A boy, aged 7, entered the hospital March 22, 1928. One week before he had an upper respiratory infection. He was put to bed three days before entrance with a high fever and a tired feeling. At that time his complaints were, dyspnea, pain in the left side and he had a respiratory grunt. Physical examination on entrance showed the throat red and injected, all the heart sounds exaggereated, limited excursion on the left side, rales over the entire chest, friction rub on both sides and increased vocal and tactile fremitus on the right. The left chest had an area of repressed breathing and voice sounds, just medial and below the heart. A diagnosis of lobar pneumonia was made. Four days after entrance, the

temperature began to fall by lysis but did not reach normal and soon began to climb again. The lung findings at this time, including x -ray plates, suggested fluid in the left chest. On april second, 160 cc of fairly thick, greenish, cream colored pus containing pneumococci were aspirated from the left chest. On april fourth an open drainage was done and the wound packed with Bismuth Iodide gauze. The boy was able to rest and breath very comfortably immediately after the operation.

This case again illustrates the use of the Gause pack as advocated by Dr. Roeder and also supports the theory of predisposing upper respiratory infection as a factor in the production of Empyema.

#3. University Hospital #37860, male, aged 28. Admitted Fe9, 1932 with a diagnosis of lobar pneumonia of the left lower lobe. Four days before entrance he had worked all day, out of doors. That night had chills and aches and pains. On third day developed painful, rapid respiration and a dry unproductive cough. On entrance the tonsils and pharynx were found injected. The chest showed decreased excursion on the left side and breath sounds diminshed at the base, and these later became masked so that fluid was diagnosed. Thoracic paracentesis was done on February 20, 1932 and thin purulent pus obtained containing pneumococci. He was operated March second by simple incision and drainage in the post-axillary region of the seventh interspace.

About a liter of very thick, purulent materila, containing cheese like masses was obtained. Paroxysms of coughing make it necessary to close the wound at once, by retention sutures and leaving in three penrose drains. The drainage was profuse but by March 5th the temperature was down, he had no pain and was able to lie on his right side. Uneventful recovery.

#4. Douglas County Hospital, #10819, Male aged 53. He was admitted on January 6, 1932 with a diagnosis of lobar pneumonia of the right side. X-ray on the seventh showed increased density in the lower right lung field. The breathing was labored. There was some coughing and expectoration of a prune juice sputum. His temperature stayed up and the breathing became more labored. Thoracentesis done on January 16, obtained 140 cc of a reddish fluid, containing streptococci-like bacter. On January 15th, x-rays showed consolidation through the right upper and middle lobes and an elevation of the right diaphragm. The lower lobe and costo-phrenic angle were obscured. On January 19, under local, the sixth interspace in the mid-axillary line was opened and the intercostal muscle removed. 1000 cc of thin purulent material was removed and Dakin tubes inserted. Dakin's treatment was carried out methodically and by Feb 8th the patient was up and about. On Feb 27th, measurement of the cavity showed it reduced to 25 cc.

This case serves to illustrate the importance of early sterilization of the cavity in promoting healing and closure, and shows the efficacy of Dakin's solution for this purpose.

#5. University Hospital, #38051, Male aged 16. Entered on Feb. 27th. History 1. Chills and fever two weeks ago. 2. Anorexia. 3. Pain in the right chest, worse on deep breathing and coughing. 4. Some blood streaked sputum during the first week. 5. Rapid shallow breathing. Had been in bed the past 2 weeks with a temperature varying from 99 to 103. The right chest seemed smaller than the left and he favored it in breathing. Breath sounds and fremitus were marked in the right base. The x-ray showed a post pneumonia empyema of the right base, with displacemtn of the heart toward the left, and partial collapse of the right lung. Thoracostomy and drainage were sufficient to clear up his symptoms and the lung expanded to normal.

#6. University hospital #36997, male, aged 4½. Entered the hospital on October 3, 1931 with diagnosis of nasal polypi and scabies but he showed evidence of chronic draining ears and chronic mastoiditis. While in hospital he developed persistant vomiting and was operated for pyloric stenosis. Later, mastoidectomy and intra-nasal sinus drainage was done. On demcember 28th, 1931, he developed lobar pneumonia of lower left lobe. He developed

cyanosis on change of position and on January first, 250 cc of muddy colored fluid was apirated. The continued cyanosis made it necessary to use the oxygen tent at frequent intervals. On January 16th he was operated and tidal drainage instituted with Dakin's solution. The wound closed in a week but had to be reopened. On march 5th the drainage is cleared up but both ears are still drainaing and with this constantly maintained source of infection, it is likely that he will become one of the discouraging chronic empyema.

BIBLIOGRAPHY

(1) Dana, J.A., Treatment of Empyema by Aspiration and Air Replacement without Drainage; International Medicine and Surgery; 43; 128-134; 1930.

(2) Dana, J.A., Treatment of Empyema by Aspiration and Air Replacement without Drainage; Journal of the American Medical Association; 96; 1453-1458; 1931.

(3) Dunham, E.K., The Collection and Utilization of Special Data concerning Empyema in the Army within The United States; Medical Department of the United States Army in the World War; 2; Sec.2; 34-48; 1924

(4) Dunham, E.K., Epidemiology of Empyema; Medical Department of the United States Army in the World War; 2; Sec.2; 48-142; 1924.

(5) Dunham, E.K., Pathology of Empyema; Medical Department of the United States Army in the World War; 2; Sec.2; 142-170; 1924.

(6) Dunham, E.K., The Treatment of Empyema Cavities with Antiseptic Solutions; Medical Department of the United States Army in the World War; 2; Sec.2; 170-206; 1924.

(7) Graham, E.A., The Surgical Treatment of Empyema in the acute and chronic Stages; Medical Department of the United States Army in the World War; 2: Sec.2; 285-320; 1924.

(8) Hudson, H.W., Treatment of Acute Empyema Thoracis; New England Medical Journal; 202: 853-860; 1930.

(9) Irwin, E.L., The Treatment of Acute Empyema; New Orleans Medical and Surgical Journal; 78: 275-284; 1925.

(10) Keller, W.L., The Surgical Treatment of the Refractory Empyema Cavities; Medical Department of the United States Army in the World War; 2: Sec.2; 320-392; 1924.

(11) Lillienthal, H., Thoracic Surgery (Saunders); 1:; 619-666; 1925.

(12) Lockwood, A.L., Empyema, Acute and Chronic; Canadian Medical Association Journal; 14: 941-944; 1924.

(13) Mansur, E.E., Constant Vacuum Aspiration Treatment; Simple Device in creating Vacuum; Journal of Surgery, Gynecology and Obstetrics; 50: 1029-1033; 1930.

(14) Poorman, B.A., Empyema; Journal of the Missouri State Medical Association; 13: 160-164; 1916.

(15) Roeder, C.A., Gauze Pack in Empyema of Pleural Cavity; American Journal of Surgery; 8: 611-613; 1930.

(16) Stevens, F.A., The Role of the Roentgen-ray Laboratory in the study and Treatment of Empyema; Medical Department of the United States Army in the World War; 2; Sec.2; 206-261; 1924.