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THE TREATMENT OF ACUTE EMPYEMA

FLOYD C. NELSON

SENIOR THESIS CLASS OF '32
We do not know or have any knowledge today when or where empyema was first recognized and how it was treated, if treated it was at all. However it is generally thought to have first been treated by the wandering physicians among the Arabians. These physicians left no records of their works and we only know of them from the writings of later historians. We know of the school of Alexandria; and the first definite knowledge we have of any one treating empyema is that of Paulus of Aegina who is thought to be of this school. Some historians claim that he lived in the fourth century and others say the seventh century. Evidence seems to support the latter belief. Knowledge of his work is limited but he is thought to have been a wandering physician, traveling from country to country, and we know that he employed the actual cautery in treatment of empyema, and we also know that this was the favorite method of treatment for various ailments among the Arabians.

In the centuries following, we have no record until the thirteenth century when Sailiceto of Milon revised the use of the knife instead of the cautery. As to his application of the knife to empyema we have no records but we do know that his pupil, Lan
Franchi of Milon revived the use of the cautery and used it in opening empyema. We do not know, however, with what success they met in treating this condition.

Records also show that Vesalius, 1514-1564, performed a successful operation for empyema on Don Carlos of Aragon in 1562. Historians do not tell us what method he used but at this time the actual cautery seems to have been in vogue and so we can assume he used this method.

In the latter part of the eighteenth century, Le Dran gives us quite a detailed account of how he operated for empyema. He used the knife and made an incision about three inches long between the ribs at "the point of election," which he locates at the eighth interspace in the mid axillary line, and which he considered the most dependent portion. He allowed the pus to escape and he sometimes used injections, but only a few at most; he considered this as being a little dangerous. He then dressed the wound with what he called a tent, for the collection of the pus.

Hewitt in 1876 described his plan of "continuous aspiration" as follows. Paracentesis being performed with an ordinary trocar and canula, a rubber tube is placed through the canula, into the empyema cavity; the canula is then extracted and the outer end of the tube is attached to a glass tube, piercing the cork and reaching to the bottom of the vessel containing a
weak antiseptic solution. By gently raising and lowering the bottle, the cavity is washed out, and by changing bottles the cavity is evacuated of pus and filled with antiseptic fluid. The cavity becomes smaller and smaller and fluid less by lowering the bottle a little more each day to increase the amount of siphonage.

In 1891 Buller proposed a method almost identical with that of Hewitt except that he recommended irrigation with lime water through the tube.

In the latter part of the nineteenth century, Bryant used free drainage. He made an opening with the scalpel or with a large trocar and canula and the subsequent introduction of a drainage tube or elastic catheter into the thorax either through the canula or otherwise; and either daily washings of the cavity with a solution of iodine; (he cites a case in which this method was employed and four months were necessary for complete healing), or by subaqueous drainage which he describes as being carried out in the following manner. Several feet of india rubber tubing is used and one end introduced thru a canula about four or five inches into the chest, and as pus comes out through the end of the tube it is placed under water
The idea of this is for the tube to act as a siphon. However he goes on to state that out of thirty cases so treated, eighteen imperfect drainages were recorded. He does not tell us what happened to those eighteen cases, and how they were subsequently treated, nor does he tell us the mortality of these cases, but I assume to believe that these eighteen cases either became chronic or resulted fatally.

Lilienthal in 1900 tells us that emptying the chest by aspiration should not be attempted, since by the suction, the displaced heart is forced back too quickly into its normal position and sudden death from embolism by this motion are not by any means unknown. He goes on to say that an incision which admits air to take the place of the pus which has been withdrawn allows the heart to return very gradually with the healing of the wound, to its proper position and renders embolism a far less likely occurrence. His method of operating is as follows. An incision four inches long is made directly down over the rib in the region of the posterior axillary line. If there is space between the ribs, the pleura is then incised but if not then a section of the rib
is removed. Adhesions which would prevent the lung from coming down were loosened and after the escape of pus, the cavity was irrigated with warm 5% carbolic solution and immediately rinsed with saline solution. Two large caliber drainage tubes were then placed with their ends just far enough in the cavity to insure actual drainage. The tubes were then surrounded with gauze and covered with a dressing. He did not believe in subsequent irrigations as it broke up adhesions which formed between the visceral and parietal pleura and which would hold the lung in position.

Five years later, 1905, Joseph D. Bryant comes out and in contradiction to Lilienthal says that irrigation was dangerous and ought not to be practiced except occasionally for the relief of foul discharges, and then with great caution, and when it did become necessary, to use normal saline and boric acid solution. He did not regard simple incision with drainage with favor as it tended to close and hinder drainage, however he recommended the use of a non collapsable tube into the incision. He also recommended rib resection and some of his results are as follows.

Incision and drainage, a death rate of 33%.
Primary excision, a death rate of 20%. And in a series of 467 cases treated by either method the average mortality was 26%. He also conducted a series of cases of empyema in childhood and his results are as follows.

1. Simple aspiration  
   No. cases: 9  
   Recoveries: 2  
   Deaths: 7

2. Incision with drainage  
   No. cases: 98  
   Recoveries: 64  
   Deaths: 14

3. Same after unsuccessful asp.  
   No. cases: 9  
   Recoveries: 8  
   Deaths: 1

4. Primary exsection  
   No. cases: 2  
   Recoveries: 2  
   Deaths: 0

5. Secondary  
   No. cases: 5  
   Recoveries: 5  
   Deaths: 0

This gives an average mortality of 17% but tends to support his claim that primary exsection (rib resection) gave the best results. However we cannot judge accurately from these figures as the no. of cases of exsection were comparatively small as compared to those of simple incision and drainage.

Following these experiments Dr. Bryant devised a method of aspiration combined with drainage and at the time of publishing his work in 1905 had used successfully upon the first patient to which it was applied. This consisted of an apparatus as shown below.
The end of the tube projecting beneath the cushion (a) is passed into the cavity a proper distance and the cushion is placed in contact with the chest wall. The end of the tube is then placed on a syringe and the liquid withdrawn and followed by sufficient exhaustion of air to cause the rubber cushion to fit closely enough to the wall of the chest to prevent passage of air into the pleural cavity. The stop cock is then closed and the syringe removed. The nozzle of the rubber bag (b) while fully collapsed is inserted into the open end of the tube and the stop cock reversed. In this manner aspiration is maintained as long as the bag is expanding. When the bag is nearly distended it is removed and cleaned and the procedure is repeated. This method he considered to be safer than other vigorous methods but as unsuited for use in cases in which there was gangrene of lung or abundant fibrinous deposits. Also by this method one can determine the presence of minute lung perforations as the bag will not then stay collapsed and a vacuum maintained. Consequently this method is suited for only certain types of cases.

Even though we find such men as Hewitt in 1876 and Bulau in 1891 and Bryant in 1905 advocating
closed drainage, we find that open operation (rib resection) became the routine type of operation up until the time of the war, and prior to 1915 nearly every series of cases of empyema reported showed a mortality of over 20%.

In most of the army camps of the United States during the early part of the influenza epidemic of 1917-18, practically all cases of empyema were treated by the then conventional method of operation; i.e., open drainage as soon as the diagnosis was made of the presence of infected fluid in either one or both of the pleural cavities. However the associated mortality was so high that it was apparent that the current ideas of treatment needed modification. Answers to a questionnaire which was sent out to the various camps by the surgeon general were compiled in March 1918, and an average mortality of 30.2% was reported in the cases diagnosed as empyema. In some of the camps, however, the mortality was so high that it approached 90% in the operated cases.

Due to these startling results, Drs. Graham and Bell were appointed to study the situation and to determine if possible the cause for this high mortality.
They worked on the principle that the treatment of acute empyema could not be intelligently accomplished unless the underlying principles of the physiology of respiration was thoroughly understood. As a result of their experimental work and of the clinical observations made in the military hospitals during the epidemic in 1917-18, definite addition was made to the knowledge of the physiology of respiration and certain well established physiological facts and principles were reemphasized. As a result of their work, these authors showed clearly that the mediastinum cannot be considered to be a structure dividing the chest into two cavities entirely independent of each other in their pressure relationships, but that it is an unstable partition and that changes in pressure in one side of the chest are quickly reflected, although to not quite the same degree, in the other side, but that there is an inverse proportion between the pressure and resistance due to the mediastinum approaching its limits of elasticity. However when the limits of elasticity have been reached, the mediastinum does then act as a definite partition, concave upon the side of the greater positive pressure, and does then protect the opposite lung from total collapse. This
is then the explanation of the well known fact that in a normal being it is possible to open one side of the chest widely without immediate fatal results.

There has been an interesting controversy arise over this work, which has unfortunately diverted attention from the fundamentally important contribution which Dr Graham and his colleagues have made. They have established the fact that in a normal individual any open wound in the chest wall is followed by a pneumothorax depending in extent upon the size of the opening, and that a definite embarrassment is caused to the respiratory mechanism by pressure exerted upon both lungs. There is however, a large factor of safety in a healthy man, and such an individual may survive even a large open chest wound. But on the other hand, a patient very ill with a widespread pneumonia may be laboring under respiratory difficulties as heavy as he can bear, and any further burden may be enough to turn the scale against him. The patient's vital capacity is the measure of his respiratory reserve and is the result of many factors including the lung tissue available for aeration, the cardiac strength, the capacity of the muscular respiratory machine, and the connection
of the respiratory center. The patient with pneumonia suffers from an active infection, and a large part of his pulmonary tissue may be consolidated; fluid accumulations in the pleural cavities may be compressing other areas; cardiac action is likely to be compromised by mechanical conditions within the chest and by the severe toxemia. There is usually high fever, the metabolic rate is increased, and there is therefore, an increased demand for oxygen. The respiratory muscles are overworked, and the products of their metabolism through an increased burden upon the respiratory apparatus for their elimination.

In the early stages of a streptococcus broncho-pneumonia and empyema, there are no adhesions binding the layers of the pleura together, and the inflammatory reaction in the tissues of the mediastinum is not sufficient to stiffen it so that it may act as an unyielding partition between the two halves of the thorax. In pneumococcus pneumonia an empyema, these changes occur earlier, the pleurae promptly adhere and bind the lung to the chest wall, thus stabilizing the mediastinum and preventing collapse when the chest is opened.

An opening made into the chest in the early stage
of streptococcus pneumonia and empyema results in the collapse of the lung already compressed by the fluid, and as the mediastinum has not at this time been stabilised, there is a corresponding compression of the lung upon the other side. In the severe toxemia of a streptococcus infection with the widespread pneumonia and greatly diminished respiratory capacity, this may be sufficient to cause death. It may be possible, on the other hand, to tide the patient over this critical period by simpler procedures, and the pneumonia clear up, the vital capacity increase, fever diminish and the general condition improve so that a more radical operation may be born.

From the foregoing remarks, it becomes apparent, therefore, that in acute streptococcus empyema, especially if areas of pneumonia in one or both lungs are present, an operation, as immediate rib resection which produces an open pneumothorax, should not be done, and there remains either one of two procedures. 1, repeated aspiration, or, 2, air tight continuous drainage with negative pressure.

Theoretically, the early establishment of continuous drainage with negative pressure should have the advantages of keeping the pleural cavity relatively free from liquid exudate and organisms, of aiding the
expansion of the lungs as well as of avoiding an open pneumothorax with its attendant dangers. Practically, however, it seems doubtful if the results are appreciably any better than with the method of repeated aspirations. There is also the additional risk, even tho it may be slight, that a delirious or unmanageable patient may by interference with the apparatus or the drainage tube allow air to enter his pleural cavity and may suffer from the effects of an open pneumothorax before it can be corrected. This danger is one of the considerations which detered the empyema commission from adopting as a routine the early establishment of an early continuous drainage with negative pressure. There is also the additional fact shown by the empyema commission that 13% of the cases they observed of streptococcus empyema recovered merely with repeated aspirations, and Dr Stone who was in charge at Fort Riley, Kansas., reported that 11.3% of his cases recovered by aspiration alone and without operation.

However it has been recognized that repeated aspirations are not without danger. It is possible that the point of the needle may penetrate the lung and inoculate virulent organisms directly into the lung substance and cause abscess formation.

If early continuous drainage is to be carried out
the simplest possible procedure should be carried out, as for example, some one of the methods which are based upon the principle of the insertion of a drainage tube thru a canula between the ribs with the later withdrawal of the canula.

If the method of repeated aspirations followed by a deferred operation is to be used, then an important issue to decide is when to operate and what type of operation to perform. However the decision as to when to operate is not difficult, and it is doubtful whether days one way or the other would make much difference. The most convenient criterion to take is the presence of frank pus as determined by aspirations; for it is almost a certainty that by the time the exudate has changed from its initial serofibrinous nature to a distinctly purulent quality, the pneumonic involvement has practically cleared up, the vital capacity is probably increased, the patient's resistance is better, the abscess walled off and the general condition so improved that there is a distinct drop in temperature, and pulse and there is no longer any delirium. The empyema commission found that usually a period of from two to three weeks elapsed from the onset of a streptococcic pneumonia and the appearance of frank pus in the exudate, and an average of four aspirations had
been made. It is to be presumed that while the vital capacity remains low, an operation with the establishment of an open drainage would be dangerous and so it is probable that in the light of the experimental work done on pneumothorax, that a more accurate criterion of a safe time to operate would be furnished by actual determination of the patients vital capacity by the use of a spirameter.

In selecting the type of operation to perform, certain considerations must be thought of. In the first place, it should be emphasized, that since the main purpose of an operation during the acute or sub acute stage of an empyema should be to provide drainage, any measure which does not accomplish adequate drainage falls short of its object. Methods of treatment, therefore which consist merely of the insertion of a tiny catheter to allow the installation of an antiseptic fluid into the pleural cavity at intervals but without affording an opportunity for the free escape of the contained exudate are almost certainly bound to fail in the majority of cases. At the present time, "Dakins solution is the most ideal antiseptic solution for this purpose, but it loses its effectiveness when in contact with the albuminous contents of an exudate,
and drainage away of the old solution with frequent instillations of the fresh solution is very important. If an early operation is to be done therefore, it would seem desirable to choose a method which would permit continuous free drainage under negative pressure, combined preferably with the frequent instillations of Dakins solution.

There have been many methods devised which permit continuous free drainage under negative pressure and the installation, as often as wished of any desired quantity of an antiseptic solution without interference with the air tight connections of the apparatus. Such an operation requires only a small opening, in order to keep the connections air tight. The type of operation, therefore, would seem to be preferable one of simple intercostal opening into which the tube can fit snugly. It should also be remembered that a delirious patient may loosen the connection and cause an open pneumothorax and that there is a tendency for all tubes, however snugly fit, to work loose, and that if rubber dams or any appliances be used about the site of entrance in the chest wall to make it air tight, that secretions will tend to collect beneath the material and excoriate the skin.
If on the other hand, the method of deferred operation is selected, better consideration can be given as to whether simple intercostal drainage or the resection of a rib should be performed. There is no doubt of course that under ordinary circumstances the creation of a large opening, as by rib resection, will afford the better drainage, but yet the conditions present in a case of empyema differ from those of an ordinary abscess of the soft tissues or even of the peritoneal cavity. As has been mentioned before, the danger of establishing an open pneumothorax as the result of the deferred operation is slight because by this time circumscribing adhesions have formed which restrict the abscess from the free pleural cavity; yet the possibility of this danger exists because it is conceivable that the adhesions already formed may break down. Moreover the actual drainage of an empyema cavity is facilitated by suction on the tube, and continuous suction is difficult to accomplish if the opening is too large because of the difficulty of securing air tight connections for the tube in the wound. There is also another factor in this connection, namely, that infection of the exposed ends of the ribs occurs with a resulting osteomyelitis of the rib which often persists for
some time after the empyema, properly speaking, has healed. The possibility of osteomyelitis of the rib can be minimised if sterile bone wax is rubbed into the open cut ends of the ribs before the pleura is opened. Dr Graham recommends the use of this bone wax and says that when it is not used, osteomyelitis is the rule after rib resection for empyema, and that it probably occurs constantly. Another point of importance to be considered is that frequently small chips of bone drop into the pleural cavity either at the time of the operation or later as the result of being separated off from the rib by the inflammation. These sequestra are troublesome, and they are responsible for some of the chronic sinuses in old empyema which would otherwise be well. They are difficult to detect and are therefore difficult to remove.

It was such considerations as those above which led the empyema commission during the war to adopt a simple intercostal operation, and then if in some particular case better drainage seemed advisable a resection was done. However they say that the simple intercostal incision was usually found to afford sufficient drainage.

Despite the ardent debate between those who advocate the routine performance of rib resection as a
primary measure and those who advocate the primary employment of simple thoracotomy, the question is not a vital matter if in either case the operation is performed after the acute pneumonic involvement has subsided. But if an operation is performed early in the disease, it is undoubtedly wiser not to make a rib resection for the many reasons discussed above.

In the successful treatment of any case of empyema there are two main objects to be accomplished. 1. The sterilization of the cavity, and 2. The obliteration of the cavity. If these two objects are not accomplished, permanent healing cannot be accomplished, and drainage which is one of the big factors in the accomplishment of sterilization has already been discussed.

"Before the war almost the only means known of sterilizing an empyema cavity was by drainage, sometimes aided by mechanical removal of the thickened exudate by simple irrigation. Many antiseptic solutions had been tried but had been found to be unsatisfactory or of no marked value. The relatively large number of cases which became chronic and which later had to be subjected to mutilating operations bear evidence to the unsatisfactory results obtained by these earlier methods. Many of these patients became
chronic cases without a doubt due to the fact that neither of the two essential factors in treatment had been accomplished. That is, the cavity had neither become sterilized nor obliterated.

The failure of these cavities to become obliterated is probably due chiefly to an inability on the part of the lung of the affected side to expand sufficiently to fill up its side of the thorax, and the inability to expand is due to two factors, 1. The thick, inelastic coat of exudate which covers the exposed surface of the lung and limits its inflation, and 2. fibrosis of the lung due to inflammation.

Evidence of the failure of the lung to properly expand is found at autopsies in cases of unhealed empyema. It is revealed by finding that the lung on the affected side is smaller than the opposite one, and that the exposed surface of the lung is coated with a dense layer of exudate which is sometimes fibrinous and sometimes organized connective tissue, in association frequently with a lake of pus contained within the thorax.

It becomes obvious then that early removal of this exudate is highly desirable, because, at least in streptococcus cases, this exudate becomes organized very early and it is clear, that, other things being favorable, the longer it is allowed to remain on the
lung the longer it will take to obliterate the cavity. For the cavity is obliterated only when the lung is in contact everywhere with the parietal pleura.

In neutral 0.5% solution of sodium hypochlorite, (Dakins solution), we have an agent which, theoretically at least, should be nearly ideal for accomplishment of the two main objects of the treatment of a case of empyema. For not only will it accomplish sterilization of the cavity but also, by its solvent action on the exudate, will effect decortication and thereby obliterate the cavity. The clinical experience gained by the commission on empyema during the war indicated that in the great majority of cases, if it is properly used, Dakins solution accomplished this purpose.

As a rule, the removal of the restricting exudate from the lung is a gradual process which is apparently effected by its solution. In some cases, however, this membrane is removed in one large mass suddenly or in several smaller pieces.

Dr. Evarts A. Graham cites a case of a man 22 years old who developed an empyema following a pneumonia. Eight months later when seen by Dr. Graham there was a small opening still draining pus and on measuring the size of the cavity found that it had a capacity of 350 cc. The patient also stated that two months
previous when the cavity had been measured it was the same size; and according to the patients account, Dakins solution had been used in various hospitals but never systematically. Under local anesthetic a rib resection was done and immediately after the operation instillations of 200cc of Dakins solution at two hour intervals were begun with provisions for adequate drainage. On the sixth day a large piece of tissue was found plugging the drainage opening. This was removed and two days later the empyemic cavity would hold only 35cc of fluid instead of 350cc and no growth of bacteria was obtained from the secretion. Ten days later he was entirely healed and examination, physically and by xray revealed no cavity remaining. Dr. Graham followed this case and says that there was no recurrence, and also says that although it is unusual, he has observed the same thing several times.

It is quite obvious that any method of treatment which accomplishes the two main objects, that of sterilization and obliteration of the cavity, in the shortest time and in the greatest majority of cases is the method of choice.

Based on the extensive experience afforded by the large number of cases of empyema in the army during
the war, the empyema commission felt that careful avoidance of an open pneumothorax in the acute stage and the intelligent and systematic use of Dakins solution would not only strikingly reduce the high mortality but would also make chronic cases relatively rare, and either of these would more than justify the substitution of these principles for older existing methods.

Stevens has shown that of 56 cases healed under simple drainage without irrigations there were 14 recurrences, or 25%; but of 67 cases healed under the Dakin treatment, with drainage, there were only 8 recurrences or 12%.

However there are certain questions which arise in the discussion of the use of Dakins solution. An important one is the question of the method of handling cases in which there is a fistula communicating with the lung. Often these cases cannot be treated with Dakins solution or by any other method of irrigation because of the discomfort and possible danger to the patient induced by allowing the entrance of the fluid into the lung. The only safe way of handling these cases is to temporarily avoid irrigations but allowing for free drainage and keeping up the nutrition and the body fluids as well as possible. The majority of these small openings close spontaneously and give no serious
trouble. After they have closed, the use of Dakins solution can be commenced.

Although surgical closure of such fistulae can be accomplished, yet it should be remembered that when present they indicate an intra pulmonary suppurative process and are often safety valves for the discharge of pus from an abscess. Premature surgical closure therefore is not only unsuccessful but it may often be disastrous.

During the treatment of an empyema, another question arises, that is, when may an empyema be considered as healed. It has already been stated that a case of empyema cannot be considered as healed until the cavity has been both sterilized and obliterated. It is clear then that we must be sure that sterilization has occurred before allowing the cavity to close, and the only way of determining this is by making cultures of the secretion before allowing the wound to close. It is always dangerous to allow the external opening to close if there are any streptococci still present in the wound, and it is unwise to allow it to close unless there has been at least two or three successive cultures which have shown no growth.

There have been many methods of treating empyema devised, with all kinds of startling claims for there
unbelievable swiftness in the healing of an empyema. These authors may be unaware that the more rapidly the wound becomes closed is not always to be desired and that this haste may have the result of turning the empyema into a chronic condition; for in the ordinary case there is little difficulty in getting the drainage opening to close and it is surprising that a patient may frequently go around in a fair degree of comfort for several months with a lake of pus in his chest which gradually becomes larger; and so just because the external wound is closed and the patient feels quite comfortable is no reason to believe the empyema is healed and the patient will be permanently well. For this reason all cases of empyema which have stopped draining and have closed off should be watched carefully for at least six months and subjected to frequent rigorous examination, both by physical means and by the Xray. If there still remains doubt about the reaccumulation of pus, an aspirating needle can be inserted and so checked.

As has been previously stated, there have been innumerable methods advanced and exploited for the treatment of empyema with extravagant claims as to their success, but these same methods used by other operators do not always produce the same startling
results. Whether it is due to unfounded claims of the author or to improper technique in their use by other surgeons, we will not discuss neither would it be possible to discuss all the methods of treatment that have been advanced. However some of the more commonly known methods will be mentioned and the technique of their application explained.

**ASPIRATION.**

The simplest method of aspiration is merely by the use of a large syringe and needle, however this necessitates the removal of the syringe from the needle to empty and reconnection, and so is a rather messy procedure if there is considerable pus in the cavity. Another method which is quite simple and in my estimation the most practical is as follows. A needle can be fitted with about twelve inches of rubber tubing attached to a large syringe and with a glass T tube in the middle of the rubber tube with a short two inch piece of rubber tubing attached. After introduction of the needle with the outlet clipped, the syringe aspirates the fluid and then by clipping the tube close to the needle and opening the outlet the fluid can be expressed and the process repeated without detaching the syringe. The needle should be inserted in an intercostal space, preferably the
eighth in the posterior axillary line and the fluid slowly with drawn.

CLOSED DRAINAGE.

This method of drainage has been advocated since 1876 when Hewitt described it as "continuous aspiration". Bulau in 1891 advocated its use and Bryant in 1905 advanced his method; but in spite of these advocates, rib resection became the routine operation until the war when the different type of empyema revived the principle of the closed drainage and Mozingo in 1918 popularized catheter drainage for all forms of acute empyema. Innumerable devises have been employed in the drainage of empyema, all of them embodying one or more of three main principles, siphonage, suction and valvular action.

KENYON'S METHOD. The method of introduction of the tube varies with the different surgeons. Some push a canula and trocar thru the chest wall into the cavity and pass the tube thru the canula, others make a small incision and push a hemostate thru the intercostal tissues to make an opening for the tube. The former method is perhaps cleaner and more exact. The seventh or eighth interspace is selected in the posterior axillary line and the tissue thoroughly anesthetized. A small incision about one half inch long is made thru
the skin and an aspiration needle introduced to check for presence of pus. The trocar canula is then pushed into the cavity, the trocar is withdrawn and the rubber tube quickly passed into the cavity so that about three inches project into the chest. The tube is then clamped off and the patient returned to bed, and then drainage is begun. The wound is then touched with mercurochrome and dressed and the tube anchored by a safety pin and adhesive. When the patient has been returned to bed the drainage tube is attached to a connection of sterile rubber tubing in which is placed a glass T tube at a convenient situation for the purpose of delivering Dakins solution. The drainage ends in a gallon sized bottle fastened to the frame of the bed and filled one fourth with a weak antiseptic solution such as carbolic acid 1:40 or boric acid. A full coil of the tubing should lie in the bottom of the bottle and clips should be placed between T tube and on the tube leading to the Dakins solution. Usually drainage only is practiced during the first 24 hours, after which Dakins solution is introduced every two hours day and night. About 50cc are used each time for children and 100cc for adults. The drainage tube is clipped 15 min. to obtain full action of the hypochlorite solution, after which it is released and
drainage proceeds. The occurrence of coughing or the tasting of chlorine is a sign that a fistula exists and that irrigation should be abandoned. The surgeon himself should begin the irrigation slowly and note the effect before turning it over to the nurse.

This method has become quite popular and is used and recommended by many of our leading surgeons over the country. However there have been many modifications of this method but all have the same basic principle.

MOZINGO METHOD. A small canula is used and the tube should be 5mm in diameter and have a number of fenestrations 3mm in diameter and 1cm apart. It is inserted for a distance of 5 or 8 inches within the chest. No drainage is attempted but the pus is removed with an aspirator or a syringe. Every 3 to 5 hours by day and once or twice at night, from 50 to 200 cc of Dakins solution, depending on the size of the cavity, are injected by means of a bulb syringe, removed and repeated until the return is clear. After sterilization, which takes from 4 to 10 days (according to Mozingo), a 2% solution of formalin in glycerine, prepared 24 hours previously, should be injected once daily in amounts varying from 5 to 15 cc, depending upon the reaction, and after irrigation, when the secretion obtained becomes a clear, sterile serosanguinous fluid,
about 5cc of the formalin glycerine solution should be injected, the tube removed and the sinus closed with adhesive plaster. As can be seen this method requires the constant care of a skilled person and cannot be left up to the care of a nurse. Also this method does not provide for free drainage.

PERTHES METHOD. In this method the drainage tube is connected with some kind of a suction pump which is kept running constantly. If an electric pump cannot be obtained then a water pump can be used. However the negative pressure must be regulated so that it will not exceed 30mm of Hg. This can be done by attaching a mercury manometer to the apparatus. The difficulties of this method can be readily seen. It would be difficult to maintain a constant negative pressure and keep the attachment air tight at the drainage opening in the chest. Also this would require the constant attention of an attendant to see that the apparatus was functioning properly.

ROBINSONS METHOD. Robinson advocated the use of a silver tube which is screwed into a hole in the rib and so keep an opening which will allow adequate drainage and also be air tight for any type of apparatus one cares to attach. However this operation requires a rather difficult technique infitting the silver tube and then there is also the danger of developing
osteomyelitis of the rib.

There are many other methods of accomplishing closed drainage, some quite complicated and some quite simple, and it would be difficult to say which are the most satisfactory, but it would be natural to assume that those which are simple in design would give more satisfactory results in the large majority of cases when used by surgeons on a large scale.

**RIB RESSECTION.** The technique of rib resection is quite simple. The incision is made down to the rib and the periosteum loosened from the rib. About one to one and a half inches of the rib is removed. The pleura is then exposed and after anesthetizing with novocaine a pair of hemostats is pushed thru and gently spread, and with almost the same motion a large drain is inserted or even two or three drains. The skin is then flapped back and sutured about the drainage tube. in this manner a large opening is made which will supply adequate drainage. Also any of the irrigating methods can be used after rib resection, but it is more difficult to keep the opening airtight so that suction could be maintained.

Another method as employed by Dr. Hoeder is that of rib resection and and of leaving the wound open; then after aspiration of the pus and the removal of the
clots of fibrin the cavity is packed with Bismuth subiodide gauze and the cavity repacked every day. In this method the discharge soon stops and the cavity is early sterilized. It is then a proposition of allowing the cavity to obliterate itself. If too much gauze is packed into the cavity it may not close readily enough and so one must be careful to pack in the right amount of gauze each time. This method also requires the attention of a skilled person each time it is packed. When this method is to be employed it is necessary to be sure that adhesions have properly formed and the pneumonia entirely cleared, or the possibility of an open pneumothorax would be great. Also one must be careful in the removal of the deposits of fibrin so as not to break up all of the adhesions and so in this manner produce an open pneumothorax. Also the advantages of the manual removal of the fibrin deposits over the action of Dakins solution on the deposits is a question which will arouse a controversy with those who are strong believers in the use of Dakins solution and its advantages in producing sterility and obliteration of the cavity.

And in spite of any controversy which may arise over the various methods used in the treatment of
Empyema, the best method can be said to be the one with which the individual operator can achieve the best results. That is, accomplish sterilization and obliteration of the cavity in the shortest amount of time and with the least amount of resulting chronicity.

SUMMARY & CONCLUSIONS.

Empyema in previous years has been one of the most serious problems in surgery, as judged not only by the mortality figures alone but also by the large number of chronic cases which necessitated such disfiguring operations.

The opportunities for the study of a large number of cases under favorable conditions in the military hospitals during the world war, have resulted in the modification of treatment which gives promise of not only greatly reducing the mortality but also the disability from this condition.

The essential points in these new principles of treatment are: 1. Careful avoidance of open pneumothorax in the acute pneumonic stage, 2. The prevention of a chronic empyema by the rapid sterilization and obliteration of the cavity, and 3. Careful attention to the general condition of the patient.

The experimental work done on pneumothorax by the empyema commission, discussed previously, shows that
previous conceptions of the mechanics of pneumothorax are wrong. These conceptions have been based on the false idea that the mediastinum constitutes a more or less rigid partition between the two pleural cavities in the normal individual, and they have led to the belief that when an open pneumothorax is established, the lung on the same side is collapsed and respiration is maintained by the other lung.

On the contrary it has been shown by experiments on the human body that the mediastinum offers only a slight resistance when the pressure in one pleural cavity changes from a negative to a positive pressure.

In the normal individual there is at all times practically an equilibrium of pressure throughout the whole thorax, so that when an open pneumothorax on one side is created, both lungs are compressed and respiration is probably maintained by both lungs.

It is obvious though that factors which tend to immobilize the mediastinum, such as adhesions and thickening from long standing inflammation, change these relationships and makes it a more rigid partition.

Also the maximum opening into a pleural cavity compatible with life depends upon a definite relationship which exists between the amount of air entering the lungs and the amount which enters the pleural
opening, and the length of time that life will be main-
tained in the normal individual with a maximum opening
or one which causes a pressure sufficient to embarrse the
lungs to the extent of their ability, will then be
determined by the strength of the respiratory muscles.

The bearing of these results and deductions upon
the treatment of acute empyema is obvious. Whenever the
amount of air taken into the lungs is limited by the
presence of an active pneumonia, with plugging of both
air channels and alveolae, whenever there is an exces-
sive demand for air, whenever there is sufficient weak-
ening of the respiratory muscles to impair compensation,
or in short, whenever the vital capacity is reduced, the
size of a pleural opening compatible with life becomes
smaller, and if any or all of the above factors are
present in sufficient intensity, even a very small open-
ing into the pleural cavity will produce death from
asphixia. Since all of these factors are likely to be
present to a high degree during the early stage of an
empyema of the streptococcus type, early operation
with the establishment of an open pneumothorax carries
with it a high degree of danger.

The main objects in the treatment of empyema are,
sterilization and obliteration of the cavity, and un-
less both of these objects are accomplished, permanent
healing does not occur, and as long as these objects are satisfactorily obtained, the method of treatment is of less consequence as long as the attending risks of the method are not too great.

Also that Dakins solution when properly used is able to accomplish both of these objects simultaneously. As a decorticating agent it has proved so satisfactory that the necessity for mutilating operations for the closure of a chronic empyema will almost never occur especially when the cases have been properly treated from the beginning.
CASE REPORTS

CASE 1. Patrick Cosgriff, age 28 years.

On Feb. 5, 1932 the patient had a chill and fever, and a pain in the left chest. He became progressively worse and was admitted to the University Hospital on Feb. 9, and a diagnosis of Lobar pneumonia was made and a complicating pleural effusion.

Feb. 11. X-ray confirmed the diagnosis as Lobar pneumonia of the lower left lobe. Fever continued high.

Feb. 17. Temperature remained high and patient looked toxic. In the morning his temperature would go as low as 101.5 and in the afternoon as high as 104 degrees.

At this time empyema was thought of and an x-ray was made. The X-ray report confirmed the diagnosis of empyema.

Feb. 20. Thoracic paracentesis was done and it revealed a very purulent but still thin liquid, verifying the diagnosis of empyema.

Feb. 25. Was transferred to surgery; but as yet the fluid in the chest was not very thick. All this time the temperature remained about the same.

Mar. 2. At this time, about two weeks after the development of the empyema, the contents of the cavity was quite thick and so patient was taken to the operating room.

Operating surgeon, Dr. John H. Nilssen.

Under local anesthetic a needle was inserted into
the seventh intercostal space in the posterior axillary line, and a few cc. of a very thick purulent material was aspirated. An incision approximately six cm long was made in the above space down to the intercostal muscles. By the use of a hemostate an opening was made into the pleural cavity and 900 to 1000 cc. of very thick purulent material containing a cheesy like exudate, was expelled. The patient had a paroxysm of coughing at this time and became very dyspneic. Three penrose drains were inserted and the wound closed by retention sutures which had been placed before the thoracic cavity had been opened.

After the operation the temperature dropped from a high of 103 average to a high of 101.5 on the following day an four days later to 100.5 degrees.

Mar. 6. The re was still considerable discharge but the patient was feeling fine.

Mar. 14. For the past six days the temperature has been normal. Only one drain was remaining and the patient was feeling very well.

Mar. 20. Last drain removed. Very little discharge.

Mar. 23. Patient discharged. Wound still open but practically no discharge. Was told to report at weekly intervals for check up.

As seen in this case simple intercostal drainage was used with very satisfactory results. Three weeks
after operation the discharge had stopped and the patient able to go home. The three drains gave a very adequate drainage and as drainage is the big factor in sterilization of the cavity, the cavity became rapidly sterile. Also it is to be noted that operation was deferred for about two weeks at which time the fluid became quite thick, and with consequent formations of adhesions.

Case 2. Mrs. Mildred Clayton. age 28 years.

On Feb. 4, the patient had a chill and a fever of 104 degrees. Her temp. remained high and she developed a pain in her left chest. Empyema was suspected and she was admitted to the University Hospital on Feb. 19, 1932.

Feb. 12. Her temperature had remained high ranging from 101 to 103.6 degrees. X-ray confirmed empyema.

Feb. 22. The chest was aspirated and a thick green pus was obtained.

Feb. 26. 500 cc. of thick green pus was aspirated and 500 cc. of air injected.

Feb. 27. It was decided to operate and so patient was taken to the operating room.

Operating surgeon, Dr. Clyde Hoeder. Under local anesthetic, about four inches of the eighth thoracic rib on the left side was removed and the empyema opened. About 200 cc. of thick pus and a large amount of fibrinous exudate was removed. There was also a small
hole in the diaphragm which was sutured. The cavity was then packed with Bismuth Sub-iodide gauze and the wound was left open and dressed.

Feb. 28. The cavity was repacked with the Bismuth Sub-iodide gauze but only one half of the original amount could be replaced. The patient also complained of abdominal pain.

Mar. 4. The temperature had returned to normal and the patient was feeling fine. The cavity having been repacked each day. At this time the cavity was much smaller.

Mar. 12. The temperature has remained normal and the patient was feeling fine. The cavity has not drained since the operation, and is still smaller.

Mar 22. The patient was dismissed, the cavity has nearly closed, and there is no drainage. The patient is to be taken care of by the Dr. in her town.

In this case a deferred operation was done with preliminary aspirations and then a rib resection was done. This case was also a good example of the thick fibrinous deposits which result from a streptococcus type which this was. Also after the operation there was no discharge, and in 22 days following the operation the patient was able to go home.

CASE 3. Walter Schon age 4½ years. In December 20,
1931. the patient developed lobar pneumonia of the lower left lobe.

Dec. 28 A thin yellowish fluid was aspirated from the left pleural cavity.

Jan. 1. 1932. 250 cc of a muddy colored fluid was aspirated from between the ribs in the sixth interspace.

Jan. 2. 75 cc of the same kind of fluid was aspirated.

Jan 6. Thoracotomy was performed and an opening was made in the sixth interspace by incision and then jabbing thru with a pair of hemostates. Considerable blood and pus came out under considerable pressure.

The patient's condition was bad and so a catheter was inserted and the wound dressed and the patient returned to bed.

Jan. 9. The drainage was not proceeding properly and so another opening was made in the fourth interspace and the cavity was irrigated with air tight drainage and Dakins solution.

However the condition was only temporarily improved and on Feb. 14 the temperature went up again from a former average of 100.5 to 102 on Feb. 15 and the following day to 103.5 degrees. He continued to run a septic temperature and although the drainage continued it evidently was not adequate.

Mar. 9. Was taken to the operating room.

Operating surgeon Dr. John R. Nilssen.
An intercostal opening was then made in the tenth interspace and three Penrose drains were inserted after the escape of considerable pus. The wound was then dressed and the patient returned to bed.

Mar. 14. The temperature has remained on an average of 101 to 102 degrees but the patient has a positive throat culture and a discharging ear which may be the cause as the new opening in the chest is draining fine. The patient was allowed up but had an attack of vomiting and his temperature went up to 104, and it was necessary to give him O₂ and O₂.

Mar. 31. Drainage has stopped and the chest has closed off and X-ray shows the empyema to have healed but the patient has still a septic temperature. Aspinal puncture was done and the fluid was under pressure and the cell count was 3,000 cells, and a diagnosis of a brain abscess was made.

The interesting point in this case is that the first surgeon who operated contended that the site of the opening had nothing to do with the drainage and so made his openings quite high. The results were obvious. The wound kept draining and did not clear up. However when the opening was made lower down by an
operator who says that drainage should be at the lowest point of the cavity, the empyema drained properly and in 22 days the cavity was obliterated and the empyema healed.

Case 4. Wesley Freger age 7 years.

The patient had a broncho-pneumonia which ended by lysis, the temperature however remaining between 100 and 102 degrees.

Mar. 27. Physical findings suggested fluid in the chest and an X-ray was ordered.

Mar. 30. X-ray showed a resolving pneumonia, a partial collapse of the left lung with a small amount of fluid in the left pleural space.

April 2. The chest was aspirated and 160 cc of fairly thick greenish pus was removed. A smear proved it to be Pneumococcus.

April 4. Dr. Koeder performed the same type of operation as he did in the case previously cited, the cavity being packed with Bismuth Sub-Iodide gauze.

April 8. Temperature had returned to normal and the patient was feeling fine. There was no discharge.
CASE 5. Howard Anderson, age 19 years.

In 1929 the patient had an attack of pneumonia and following an empyema. The patient was aspirated on two different occasions and then a drain was inserted in the fifth interspace. In a few days this stopped draining and the wound closed over. He felt well for a couple of months and then he started running a fever again. He was taken to a hospital and a tube was again inserted. This wound never closed off and the wound continued to drain until June 1930. At this time Dr. John K. Nillsen took him to the Immanuel Hospital and did a Schedes Thoracoplasty in which the ribs were resected from the second to the ninth. It was found that the parietal pleura was one half an inch thick and it was necessary to remove it. The patient then rapidly improved and is now doing common labor every day and is feeling fine.

I cite this case because it is a good example of what will happen to a case of acute empyema if it is not properly handled. In this case the drainage tube was placed in the fifth interspace. This did not allow adequate drainage and consequently the cavity did not obliterate itself. The pleura then finally became so thick that it was impossible for the lung to expand and so obliterate itself and a chronic empyema resulted.
with the necessity of then performing a mutilating operation. It is highly probable that had drainage been properly instituted in the beginning the patient would not have become chronic and the mutilating operation necessary.

CASE 5. George Schultz age 42 years

This case is quite similar to the previous one.

In Aug. 1931 the patient developed an empyema following a pneumonia. The chest was drained and in this case the opening was also made in about the fifth interspace. The wound closed and the patient felt all right until in Oct. when the wound opened up again and began to drain. He was again taken to the Hospital and the chest opened and tubes inserted. The wound closed up again and the patient was again up and around. From this time on the wound would close up for a couple of months and then open. This continued and on Jan 30, 1932 Dr. Nillsen took him to the St. Joseph Hospital and found it necessary to do a Schede operation, removing the ribs from the second to the ninth. The parietal pleura was found to be about one fourth of an inch thick and so was necessary to remove it. The patient gotalong fine and is now up and about and is completely healed,
This case also goes to show that had drainage been adequate in the first place the chronic empyema would not have formed making the mutilating operation necessary.

These two cases just go to prove that drainage must be thorough and that drainage must be in a low point to be adequate. Also that when drainage is not adequate a chronic empyema is likely to form and the acute case has not been properly handled, that is, the essential points in treating an acute empyema have not been carried out. i.e. the cavity sterilized and obliterated, and as proper drainage is the main factor in sterilization, and obliteration of the cavity is dependent upon sterilization, then as long there is not adequate drainage, the empyema cannot heal.
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