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Treatment of acute empyema

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THE TREATMENT OF ACUTE EMPYEMA

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THE TREATMENT OF ACUTE EMPYEMA

An empyema is the presence of pus in any cavity. In its more restricted sense the word refers to the presence of pus in the pleural cavity. Empyema is one of the oldest diagnosticable diseases and was recognized by Hippocrates. Nevertheless the treatment is still a problem and many different views are expressed. Practically all of the pertinent advances in the treatment of empyema have been made since 1918, hence I will confine this paper to a review of the literature since that time. I will not include tuberculous empyema as this is a problem of itself. The etiology, symptomatology, and diagnosis are not within the scope of this paper, it being taken for granted, in considering the treatment, that the pathological condition is known. The pathology shall be discussed only in so far as it affects the form of treatment to be instituted. The problem of chronic empyema will not be discussed.

The old idea that empyema of the chest is an abscess, which, according to general surgical principles must be opened as soon and as widely as possible, is now discarded. This practice received its first shock during the epidemics of influenza of 1888 and 1890. Notwithstanding the many fatal accidents occurring at this time the majority of surgeons continued to believe in early open drainage, ascribing the fatalities to underlying pathological conditions. In 1918 and 1919, during the widespread epidemic of influenza, abundant material was available for the investigation of the different forms of treatment. The experience during this epidemic left no doubt that a sudden wide opening of the chest is fatal to patients suffering from influenza. Further knowledge was added by the surgical treatment of pulmonary tuberculosis. It was shown that the opening of tuberculous empyemas is not tolerated. In thoracic surgery, as in other fields of surgery there has been a general change of thought from a pathologico-anatomical trend to a functional trend.

In order to appreciate the mechanical factor involved in the treatment of empyema we must consider not only the physiology of respiration, but also the pathological physiology resulting from the the entrance of a foreign substance into the pleural cavity. The lungs are hermetically enclosed in the thoracic cavity. Between their two lobes lies the mediastinal space with its organs. A pleural space proper does not exist. There is only a capillary fissure in which the surfaces touching eachother, the parietal and visceral pleura, glide past each other without losing contact. On their contiguous surfaces the traction of the lung and the tension of the thoracic wall balance eachother. The lungs tend to contract due to their elastic tissue. This force is counteracted by the expansion of the thoracic wall and the diaphragm. The permanent traction exercised by the lung on all structures touching its surface is the much discussed "negative pressure," which is really a condition which has nothing to do with pressure. Since the mediastinum is normally nothing but a thin pliable fold of the pleura, the thoracic cavity is a physical unit, and the fluctuations of pressure are always balanced. Differences of pressure only occur if two chambers form due to the induration of the membrane. Inspiration is active, being accomplished by elevation of the ribs and depression of the diaphragm, with resulting enlargement of the thoracic cage and expansion of the lungs. Expiration is passive, resulting from the contractile power of the lungs and the pull of gravity on the thoracic wall. At the end of expiration the negative pressure in the pleural cavity is -6 mm. Hg., at the end of inspiration it is about -30 mm. Hg.

According to Sauerbruch[1] there is not a decrease in the negative pressure, if, for some reason the volume of one lung decreases slightly. The loss of pulmonary expansion is compensated by the displacement of the medium position of the thorax and diaphragm toward the normal side. As long as this is possible the negatibe pressure remains unchanged, or even increases. The intrathoracic structures and any foreign

medium, aeriform or liquid, present within the thoracic cavity are under the influence of this tension. An empyema, for instance, can only unfold its own hydrostatic pressure when the last remnant of pulmonary tension has disappeared. This occurs only when there is a large quantity of pus present and calls for removal of some of the pus.

Besides this elasticity which enables the lungs to expand and collapse mechanically, the lungs, similar to the muscles, possess their own tonus, owing to which they expand and contract actively, opening their interstices for a greater influx of air. This explains, for instance, why in asthma the function of the pectoral dilators in inspiration is futile: the tonus of the bronchial musculature does not relax in incipient inspiration.

Therefore the early changes of intrathoracic pressure in empyema do not depend upon the size of exudate, but upon the conduct of the respiratory forces, residing in the thoracic wall, diaphragm, and lungs. Only when these fail can the exudate develop its own hydrostatic pressure. In a variable length of time, depending upon the type of empyema, the amount of pus becomes so large that these forces fail. Consequently pus should be drawn off before this stage is reached. There are three methods of withdrawing pus from the pleural cavity, by aspiration, by closed drainage, and by open drainage. Each method has its place, depending upon the pathological condition which is present.

In order to seize each case of empyema as a clinical picture it is necessary to appreciate the nature of the underlying disease, the time of appearance of pus in the chest, the general toxicity of the exudate, the age, constitution and present general condition of the patient, and the disturbance of the intrathoracic equilibrium. The local limitation of the empyema is very important for the treatment.

We distinguish total and partial empyema. Partial empyema may be apical, mediastinal, interlobular, or basal.

The stage of the empyema is the most important factor in determining the treatment. The course of an empyema may be divided roughly into a formative stage and a purulent stage. During the formative stage the fluid is thin and there are no adhesions, then, as the purulent stage develops the pus becomes thick and there are dense pleural adhesions.

In pneumococcus empyema the formative stage is very short and thick pus is usually obtained on the first aspiration. In the streptococcus cases, however, the fluid is usually thin and sero-fibrinous when first aspirated. The fluid accumulates early in the disease and does not become purulent for two or three weeks. These cases are usually still suffering from a very active respiratory disease, and the empyema is of secondary importance as far as the immediate treatment is concerned. The fluid is not walled off but occupies the general pleural cavity. The mechanical effect is apt to be serious due to compression of the lungs, pressure on the heart, and kinking of the great vessels due to displacement of the mediastinum. A thoracotomy with the institution of open drainage is contraindicated at this stage. It would result in an immediate influx of air into the pleural cavity, with resulting collapse of the lung and respiratory embarrassment. "Mediastinal flapping", which in itself may produce death, may result. This is a condition due to an open wound on one side of the chest, in which the mediastinum is displaced to and fro with each respiration. Shock, septicemia, an overwhelming toxemia, or, if the patient lives, a fixation of the lungs in collapse may result from open thoracotomy at this stage. The Empyema Commission[2] decided that immediate rib resection or thoracotomy with drainage is dangerous and meddlesome surgery. The patient should be tided over this critical period either by aspiration repeated as often as necessary to remove the fluid, or by closed drainage with negative pressure.

Aspiration is the method of choice for anyone but the specially trained surgeon. Closed drainage with a negative pressure causes more shock, there is danger of mixed infection, and a greater chance of causing a septicemia or increasing the toxemia. Then too, the wound may break down around the tube before pleural adhesions have formed, resulting in an inrush of air and an acute pneumothorax.

As soon as thick pus is obtained, the problem of treatment is entirely diffent. Now the empyema has became walled off by firm adhesions and the lung and mediastinum are fixed. It is now an abscess with no danger of collapse of the lung. Adequate drainage is now the fundamental factor and should be instituted at once if the condition of the patient will permit operation. The pleural adhesions become firmer, and the pleura thickens, and if operation is delayed too long expansion of the lung will be very difficult due to thickness of the pleura and the density of the adhesions.

The local treatment of the formative stage and that of the purulent stage differ greatly. For the sake of clearness the treatment of the two stages will be considered separately.

In the treatment of the formative stage of empyema there are two factors of major importance. The first of these is the infection, which demands free drainage for the relief of symptoms due to pressure and absorption. The second is the elasticity of the lung tissue, which contracts causing the lung to collapse as soon as the pleural cavity is in open communication with fluid or gas under atmospheric pressure. With the rigid chest wall this leaves a large cavity which must be obliterated before a cure can be brought about, and in some cases results directly in death. The first condition ordinarily demands wide incision; the second requires the pleural cavity to be kept closed in order to prevent pulmonary collapse. The problem, then, is to give absolutely free drainage, at the same time maintaining a

a closed system so that the intrapleural pressure can be kept below the atmospheric pressure which is present within the bronchi and and the alveoli. There are two methods of treating empyema in this stage, each of which have their advantages. These are first, frequent aspirations, and second, closed drainage with a negative pressure.

Frequent aspiration is the more conservative of the two methods. There is no danger of an acute pneumothorax resulting from this procedure. It is a simple procedure, is relatively non-shocking, and in case the patient is very septic it may be done without moving the patient from the bed. The site for the introduction of the needle, which should be toward the dependent portion of the cavity, is sterilized with tincture of iodine and alcohol. Aseptic technique is necessary throughout the procedure. A bleb at the desired point is raised by injecting 1% novocaine through a fine needle, and then the deeper tissues are thoroughly infiltrated. Less shock will result if the pleura is also anaesthetized. A large needle is not introduced through the anaesthetized tissues into the pleural cavity. To the end of the needle is attached a tube running to a closed pus bottle, from which issues another tube which is connected with a suction apparatus. Thus air is prevented from entering the pleural cavity and the aspiration requires less time if suction is used. As soon as the patient manifests symptoms of dyspnea and a rapid pulse, aspiration should be discontinued. Lockwood[3] advocates the introduction of alcohol or 1% mercurochrome 220 soluble through the needle just before it is withdrawn. The needle is then withdrawn slowly and the antiseptic escapes into the tract and prevents infection which is troublesome, particularly if operative intervention through the same site is necessary later.

While frequent aspiration is the least dangerous of the two treatments it does not allow perfect drainage. The object of the aspiration treatment is not to cure the condition, but to relieve the

patient until adhesions form, at which time open drainage can be instituted. Needless to say, this results in delay as far as curative treatment is concerned.

The method of closed drainage during the formative stage is more shocking than aspiration, and there is a danger of an acute pneumothorax. It too must generally be followed by open drainage, for as the pus becomes thick the small tube is obstructed. However the cavity will be smaller and much easier to close when open operation is performed. This method of treatment seeks to institute healing from the start before the empyema has become purulent by means of adequate drainage. There is perfect drainage of every square millimeter of the surface of any cavity as long as this cavity is covered with a relatively clean solution, at a pressure not greater and preferably slightly less than atmospheric pressure. Both negative pressure and perfect drainage can be maintained by keeping the cavity filled with a clean, non-irritating fluid, supplied and removed through a tube or tubes which do not become obstructed, and with the provision that the fluid shall never be run in under positive pressure. The latter provision is readily met by permitting the fluid to flow in from an outside reservoir by suction whenever the intra-pleural pressure drops sufficiently low during the normal respiratory expansion of the chest, a condition similar to the normal inspiration of air. The amount of negative pressure within the pleural cavity is determined by the level of the reservoir below the chest, added to the amount of suction maintained within the irrigation system. Obstruction to the drainage tube has been the principal cause of trouble with the various types of drainage or irrigation systems, regardless of whether one or two tubes were used. This, together with the running in of fluid under pressure, has invariably caused an influx of air into the pleural cavity, a leakage of pus around the tube, and not infrequently has led to severe dissecting infections in the chest wall. By the employment of a back and forth, or tidal, flow through a single tube, carried

on by the normal respiratory movements, the system is made to work automatically. This applies not only to the irrigations, but to freeing the lumen of the tube whenever the outlet becomes obstructed by flakes of fibrin. The flakes are not forced into the tube tightly by passive expiration and when the flow of fluid is next reversed by the inspiratory effort, the flakes are washed off the opening. Even where the pus is quite thick it will usually be broken up and gradually evacuated by this slight but frequently repeated force.

Three types of tidal irrigation have been used.[4] The simplest depends for suction on gravity, which is obtained by placing the rubber bag used as a reservoir below the level of the empyema cavity when the patient is in Fowler's position.

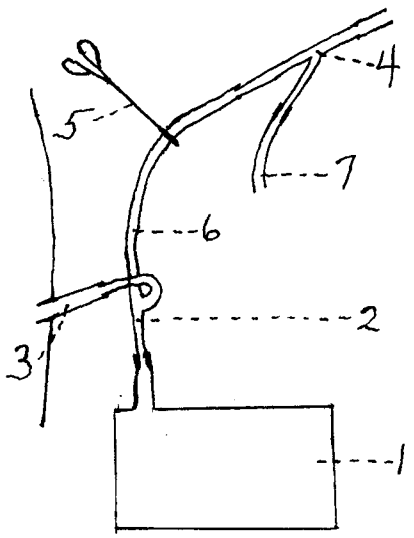
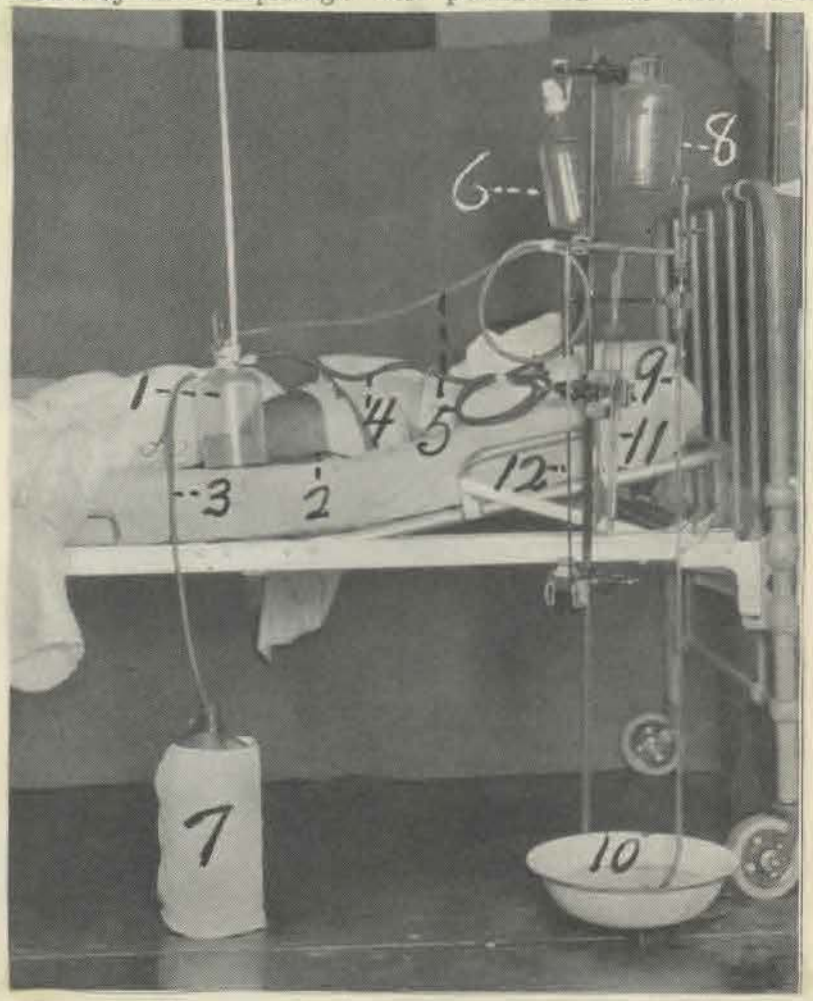


Fig. 1. This shows the first and simplest apparatus used. A rubber bag or reservoir, 1, is strapped to the abdomen and is connected with a T-tube, 2. The upright part of the T-tube has been bent so as to connect with the rubber thoracotomy tube, 3, at the point where it enters the chest, and still allow the cross part to be strapped tightly to the side. The upper end of the cross part is bent to point away

from the chest at the place where tube 6 is connected. The other end of tube 6 is connected with a Y-tube, 4, one branch of which is connected with an infusion bottle suspended above the bed and filled with sterile normal salt solution; the other is connected with a drainage bottle on the floor by tube 7. Suitable clamps, one of which is free of air, can be emptied into the drainage bottle, then partially refilled from the infusion flask. With each inspiration fluid is sucked into the chest from the rubber bag, and with each expiration pus is forced out of the chest. The fluid in the reservoir, 1, is replaced every hour or as often as is necessary to keep it relatively clean. Moderate suction is obtained at all times by the dependent position of the bag; in the later stages, periods of greater suction can be obtained by removing all clamps between the chest and the drainage bottle, the amount depending on the height of the column of water. This apparatus is not suitable for use on patients who have a bronchial fistula.

Fig. 2. This shows apparatus No. 2, in which a glass reservoir, 1, replaces the rubber bag, and to which is added a suction unit which is composed of parts 8, 9, 10, 11, and 12. All connections are made directly with the tidal irrigation reservoir. Tube 2, which enters the empyema cavity at its most dependent part, is connected with an opening in the flask near its bottom. The flask, 1, is emptied from the bottom by syphon action, the waste passing in to the drainage bottle 7, through tube 3 when this is unclamped. The flask,1, is then partially refilled from the infusion bottle,6, when tube 4 is unclamped. The tube 5 connects the flask,1, with the suction unit, and through this any air which enters through a leak about tube 2 or through a bronchial fistula is eliminated. The suction unit is attached to an upright stand which can be moved about as desired. Suction is obtained with the well known Connell apparatus, in which the water is allowed to drop slowly through the tube 9 from the flask 8, thus eliminating a certain amount of air beneath each drop of water,

which, as it passes downward, forms a diaphragm across the tube. The tube, 9, must project beneath the water in basin, 10; otherwise the rapid up and down excursions of the drops of water with each respiration cycle will destroy the diaphragm and permit air to enter through tube 9



To the Connel apparatus is added a water manometer, 12, to indicate the amount of suction present at any time, and a cylinder, 11, to regulate the maximum suction which can be obtained. This latter device consists of a cylinder almost filled with water and with two tubes through the cork. One tube connects the upper air space with the general suction system; the other, open to the outside air, projects below the level of the fluid and permits air bubbles to enter whenever the pressure within the system is sufficiently below atmospheric pressure to cause the fluid within the tube to be displaced downward to its lower end.

This apparatus allows the use of continuous irrigation and continuous suction in any desired amount. The irrigation reservoir also does not have to be below the level of the empyema cavity since any height can be counterbalanced by a corresponding increase in the amount of suction. Placing it at a slightly higher level permits the free exit of air from the empyema cavity, and the suction applied prevents the escape of fluid along any narrow avenue containing air under atmospheric pressure. This arrangement permits the use of this apparatus not only for cases complicated by bronchial fistula, but also where there is a large thoracotomy wound, providing that this is covered by thin rubber dam, fitting snugly around the tube and sucked against the surrounding skin, which is coated with vaseline.

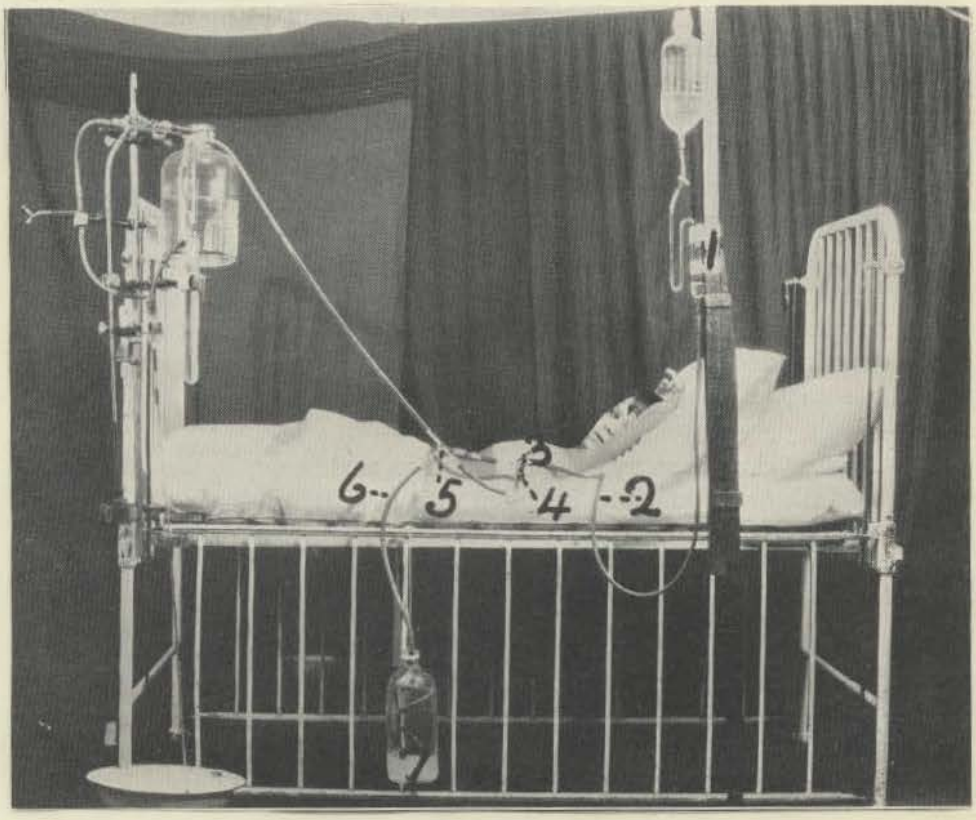


Fig. 3. Apparatus No. 3. This is probably the most satisfactory apparatus and is used at the present time by Hart.[4] A current of fluid passes slowly along a tube,2, connecting a Murphy drip,1, with the suction unit described in Fig. 2. At the point of the thoracotomy a T-tube,3, is inserted for connecting up the tube,4, entering the chest, as in Fig. 1. At the edge of the bed another T-tube,5, is

inserted with a tube,6, running down beneath the furface of the fluid in a drainage bottle,7, on the floor. T-tube 5 must be so placed that the fluid runs up the last part of the tube from the chest to a point where it runs over into the drainage bottle on the floor. The connection with the suction unit is at the uppermost end of the T-tube so that the pus does not go over into the suction apparatus. As a result of the tidal flow through the tube entering the chest, with expiration there is an overflow of a small amount of fluid into the drainage bottle; with inspiration there is a recession from this point.

The operation for the establishment of closed drainage is done under local anaesthesia and is only slightly more than in aspiration. A catheter is inserted through a trochar, which is then withdrawn. The continual presence of the catheter is the cause of a certain amount of irritation and discomfort to the patient. One of the great advantages of closed drainage is that it need not always be followed by a larger open thoracotomy. This is a disadvantage in one sense, however, for the surgeons who use this method are prone to depend upon it for a complete cure, and keep using it long after pleural adhesions have formed and open drainage is indicated.

The flattening of the chest, elevation of the diaphragm, and expansion of the lung hastened by the negative pressure within the cavity are beneficial since they favor the rapid closure of the cavity with the minimal fibrous tissue formation. In the presence of only slight fibrosis, without any system of exercises the chest resumes its normal contour within four weeks after healing occurs.[4] This result compares very favorably with that seen in patients with extensive fibrous tissue formation due to prolonged drainage, in whom deformity persists and at times progresses despite every exercise to favor lung and chest expansion.

Freed[5] states that " The open method of drainage, with its numerous modifications is gradually becoming more in disuse for some

form of occlusion treatment. I believe that the time will come when rib resection as a routine in acute empyema will be considered malpractice"

In the treatment of the purulent stage there is but one factor of major importance, that is the presence of pus in the pleural cavity, which indicates immediate and adequate drainage. The second factor in the treatment of the formative stage, that is, the danger of acute pneumothorax, need not be considered in the treatment of the purulent stage, for there are firm adhesions present which prevent collapse of the lung. In cases in which the empyema is in the purulent stage when diagnosed, open drainage need only be preceeded by a diagnostic aspiration of the pus. In most cases open operation has been preceeded by several aspirations or by closed drainage. If the drainage tubes are repeatedly becoming occluded by fibrin during closed drainage, open drainage should be resorted to without undue delay.

There are two methods of instituting open drainage. The aim of each is to form a large opening in the thoracic wall. In the first method a portion of one rib is resected, and in the second no ribs are resected, but the incision is longer. This method is designated by Lilienthal[6] as a major intercostal thoracotomy.

Local anaesthesia is generally sufficient for a rib resection, but it must be very thorough. Usually the eighth rib in the posterior axillary line marks the incision of choice unless the XRay shows a full cavity in which case the ninth rib may be resected. A wheal about four inches in length should be raised by successive injections of novocaine and with a three inch needle the subcutaneous tissues should be well saturated for a distance of several inches. The incision is then made down to the muscles and these should be well infiltrated before cutting. When the rib is reached the needle whould be introduced above, below, and behind the bone at either end of the incision,

care being taken not to introduce the novocaine solution into the vessels. An incision is then made on the bone above and below to separate the intercostal muscles and a periosteal elevator is gently introduced, separating the periosteum and intercostal tissues from the posterior aspect of the rib. This is easier in children, but is not difficult in adults if the muscle attachments are nicked with a knife. One must keep close to the bone however, or troublesome venous bleeding may occur. It must be done slowly to avoid nicking the pleura. The rib is then cut and a portion of one or two inches is removed.

In nervous people and in children some difficulty may be encountered with local anaesthesia and gas or ethylene may have to be administered during the process of separating and cutting the rib. A minimal amount suffices to produce an anoci-association and to alleviate the nervous strain if the operation has been rendered relatively painless by the use of novocaine.

After the opening is prepared the pleura should be infiltrated with novocaine solution and a pair of pointed hemostats inserted through the pleura into the cavity and gently spread. Three or four large drainage tubes are inserted and the muscles are pulled together around them with one or two catgut sutures. Safety pins should be placed through the tubes to prevent them from falling into the pleural cavity.

The procedure of major intercostal thoracotomy is essentially the same except that the incision is longer and a rib is not resected. The incision should be four or five inches long usually in the eighth interspace posterior to the posterior axillary line. Many say that an intercostal incision will not provide adequate drainage. If the incision is long enough however, it will provide a sufficiently large opening. Through this incision the cavity can be explored with the hand. At least four large tubes are left in, extending

about two centimeteres inside the pleural cavity. Iodoform gauze is packed about them subcutaneously and no sutures are used.

Rib resection is slightly more deforming and there is a possibility of an osteomyelitis of the rib ends causing a chronic discharge of pus into the cavity. If the periosteum is not removed, occasionally bone forms about the tube and compresses it.

After allowing free drainage for a few days, the Carrel-Dakin treatment is begun. All details must be carefully carried out or the results will not be satisfactory. In cases complicated by a broncho-pleural fistula, the Carrel-Dakin treatment cannot be employed until the fistula has closed, because Dakin's solution is irritating to the bronchial mucous membrane and produces a severe cough and choking. Such fistula generally close spontaneously in a short time. The anterior one or two tubes are removed and five or six Carrel tubes are inserted in their place, leaving the large posterior tubes in place for drainage. All the tubes are removed daily and sterile ones are inserted. This prevents the possibility of a tube becoming rotten, breaking, and lodging in the cavity. Fresh Dakin's solution is allowed to flow in through the Carrel tubes every two to four hours. Under this treatment the purulent nature of the discharge should disappear in three to five days. Bacterial counts and cultures should be done bi-weekly until practically sterile, and then daily. After several consecutive days show the discharge to be sterile, the Dakin treatment should be continued for a week. The solution is now discontinued and a sterile dressing is applied. The wound should then close in a short time.

Most authorities agree that Dakin's solution is the most satisfactory solution for the irrigation of purulent empyema cavities. Sauerbruch advocates the use of hydrochloric acid-pepsine. In 1921 Major[7] advised the use of gentian violet. This is attended by considerable danger however, for in 1925 Kolmer[8] showed that drugs in-

jected intrapleurally are at least from ten to twenty times more toxic per gram of body weight than when they are administered intraveinously. Dakin's solution is not toxic, it has a strong antiseptic action, and its chief merit lies in the fact that it dissolves the fibrin which tends to obstruct the drainage tube.

Pulmonary exercises and calisthenics should be used to aid in expanding the lungs. Various pulmonary exercises are advocated, such as closing the nose and mouth and straining slightly, or having the patient blow water from one bottle to another through a system of tubes. Children may be encouraged to blow up toy baloons. Churchill[9] in 1926 advocated the use of carbon dioxide inhalations as a method of increasing the rate and depth of respiration. The object of all such methods, of course, is to increase the pressure within the lungs and thus promote complete expansion of the lung and closure of the cavity.

The general care of the patient should not be neglected, for nutrition plays a very important part. Bell[10] of the Empyema Commission states that these patients show a negative nitrogen balance on 1500 calories intake per day. This negative balance results in emaciation and even of many fatalities in chronic cases. Therefore a mixed diet, high in carbohydrates, of 3,300 to 3,500 calories per day should be given. Light lunches between meals are beneficial. The high caloric diet causes a gain in weight and an increase in the resistance of the patient to the infection.

Acute empyema cannot be treated in a routine manner. The various factors in each case must be carefully analyzed and the treatment must be varied to fit the case. Far too many cases of acute empyema become chronic, for if properly treated in the acute stage practically all of the cases will be cured before becoming chronic. Complications must be carefully watched for and treated. As the cavities are often multilocular the treatment outlined for the purulent stage will not cure all of the cases. If the patient is not improving and the

temperature is still elevated a week or ten days after open drainage, a secondary operation is indicated. Several operations are necessary in some cases. Secondary operations are indicated in the following conditions:

1. The drainage opening is not at the dependent portion of the cavity. A new opening should be made at the inferior border of the cavity. The upper opening can then be used for Carrel tubes and the lower for drainage;

2. Contracted drainage opening. It should be enlarged by lengthening the incision or resecting a portion of one or more ribs;

3. Osteomyelitic ribs. Remove sequestra and the necrotic ends of the ribs;

4. Retained foreign bodies, such as drainage tubes, gauze sponges, rubber dams, etc. XRay may show the foreign body, which should be removed without delay;

5. Side pockets and lateral branch sinuses. Occasionally adhesions form irregularly around the periphery so that pockets are formed which drain through a small opening into the main cavity. Later the pockets contract forming tortuous lateral sinuses. Occasionally, at the beginning of the purulent stage, adhesions form two separate cavities. At times the smaller cavity ruptures into the larger, but usually it is necessary to enlarge the opening into the main cavity, break down adhesions, or make a separate opening into the smaller cavity and treat it separately.

If empyema is diagnosed early, and proper treatment is immediately instituted very few cases will become chronic.

The principles in the treatment of acute thoracic empyema are:

1. Early diagnosis.

2. Aspiration to determine the organism and the character of the fluid.

3. Either frequent aspiration or closed drainage with negative

pressure during the formative stage.

4. Either rib resection or major intercostal thoracotomy as soon as the fluid becomes frankly purulent.

5. Sterilization by the Carrel-Dakin method.

6. Pulmonary exercises and calisthenics.

7. Maintainence of nutrition and general medical care.

8. Recognition and correction of mechanical complications which interfere with adequate drainage.

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