5-1-1933

Surgical treatment of acute empyema: a review

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THE
SURGICAL TREATMENT
of
ACUTE EMPIREMA: A REVIEW

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Senior Thesis
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Omaha, Nebraska.
1933
INTRODUCTION

Since the earliest times few diseases have been more perplexing to the medical profession, with regards to treatment, than empyema. Even in this era of medical and surgical achievement there is a vast diversity of methods advocated for the treatment of this affection, but still the occurrence of chronic empyema and high mortality loom up in the foreground to cast a shadow of uncertainty upon the success of any one method.

However, if we forget, for the present, the imperfections of our present day methods of treatment and consider the great dread which the development of empyema was observed prior to the World War, it puts us in a better position to appreciate the advances made since the War in the treatment of this disease.
HISTORY

When or where empyema was first recognized is not known, but if we allow ourselves to revel in the ancient history of medicine, we may assume that empyema, or at least empyema necessitatis, must have been recognized by the Egyptians as early as 1550 B.C., as indicated in the Papyrus Ebers(1), "If thou findest, in some part of the surface of a patient's body, a tumor due to a collection of pus, and dost observe that at one well-defined spot it rises up into a noticeable prominence, of rounded form, thou shalt say to thyself: this is a collection of pus, which is forming among the tissues; I will treat the disease with the knife". Even antedating the Papyrus Ebers by almost a thousand years (2500 B.C.) are certain pictures engraved on the door posts of a tomb in the burial grounds near Memphis, depicting surgical operations(2). These pictures have no direct bearing upon operations for empyema, but are significant by the fact that almost a thousand years of operative surgery antedated the Papyrus Ebers and we may well suppose, that, by the year 1500 B.C., the ancient Egyptians were performing quite extensive operations with a great deal of dexterity.

Following 1500 B.C., the Egyptians became quite proficient in the use of the knife, performing such operations as, inserting teeth, plugging cavities, removing cataracts successfully, lithotomies by both the supra-pubic and perineal routes and made examinations of the bodies of the dead in order to ascertain their maladies(3).

The Papyrus Ebers was the work of several authors, one of which was an oculist of Bablos, Phoenicia(4). This would lead us to believe that perhaps those ancient peoples of Phoenicia, Babylon, Assyria and Persia were familiar with the medicine of the Egyptians, but in reviewing the available literature at hand of these ancient peoples, we
find that their medicine was so corrupted with spirit worship and hampered by religious superstitions that it never attained the high level of proficiency during this early period as that along the Nile. Nevertheless, we note that Assyrians as early as 2000 B.C. had some knowledge of tuberculosis as shown by Lenormont's translation, "Chaldean Magic" (5), "The poisonous consumption, which in the mouth malignantly ascends".

If these early practitioners observed empyema in these cases, we have no record.

With the destruction of the ancient Egyptian isolation by Psammetichus about 625 B.C., we note a marked decline in Egyptian medicine and at the same time a rise, equally as marked, in Greek medicine, and by the fifth century B.C., medicine among the Greeks had attained some prominence.

The earliest record we have of an operation for empyema is that of Hippocrates (460-370 B.C.). His teachings as to etiology, symptomatology, prognosis and treatment contain much that are fundamental to our present day conception. He attributed the cause to a termination of a pneumonia, to defluxions of the head and to the consequences of a ruptured vessel. His observations on the symptoms and physical signs upon which he based his diagnosis were remarkable. He noted that the chief complaints of empyema patients were pain in the chest, fever, cough, distress when attempting to lie on the sound side and edema of the feet and eyes (7)(8). After an illness of fifteen days, the patient was examined for fluid in the chest by shaking him by the shoulders and noting the presence and site of the fluid by the splash. He based his diagnosis upon the secussion splash and the presence of a certain râle (9).

If no splash could be elicited, the side in which the pain and swelling was the most marked was considered the one affected. For such accumulations of pus in the chest he directed to "Cut down on the third rib from
the last and then make a perforation with a trocar, so as to give vent to small portions of fluid. The opening is then to be filled with lent and the remainder evacuated in twelve days" (10)(11). The cautery was in use at that time but was not used in every case as shown by one of Hippocrates' aphorisms (12): "What drugs fail to cure, that the iron (or knife) cures; what the iron cures not, that the fire cures; but what the fire fails to cure, this must be called incurable". The post-operative treatment of his empyema patients is interesting. On the tenth or twelfth day the lent was removed and warm wine and oil was injected and when the discharge became clear and glairy, he introduced into the opening a hollow metal tube (13). As to prognosis, he observed "When empyema is treated either by the cautery or incision, if pure and white pus flowed from the wound, the patient recovers, but if mixed with blood, slimy and fetid, they die" (14). He also observed that patients affected with empyema after pleurisy recovered if they got clear of it in forty days after the time it ruptured; but if not it passed into phthisis (15).

Euryphon of Cnidos (15)(17) (about 400 B.C.), a contemporary of Hippocrates, treated empyema with the actual cautery.

Aristotle (18) (384-322 B.C.), who taught anatomy by dissection, wrote of the treatment of empyema.

Following the period of Hippocrates to the first century A.D., we are entirely in the dark as to what extent empyema cases were observed and treated, but it certainly seems obvious that such brilliant scholars as Theophrastus (370-286 B.C.), Herophilis (about 300 B.C.), and with the migration of Greek medicine to Rome following the destruction of Corinth (146 B.C.), Asclepiades of Bithynia (128-56 B.C.) should have overlooked the symptoms and treatment of empyema.

Aulus Cornelius Celsus (19) (between 25 or 30 and 45 or 50 A.D.) wrote on the symptomatology and prognosis of empyema much as did Hippocrates. He recommended the cautery be applied in the following manner: "One eschar
is to be burnt with a red-hot iron under the chin, another on the throat, two upon each breast and two under the scapulae. They are to be kept "opened until the cough is removed". As regards this treatment, he observed "Tis common for fistulae to extend beneath the ribs. When this case occurs, the ribs in that part must be cut through on both sides and taken out least anything corrupt be left within" and "Fistulae of the chest are very difficult of treatment, so that sometimes physicians, sometimes the patient, giving up hope, leaves the case to nature herself".

Pliny the Elder (Born 23 A.D., died at Stabiae, in an eruption of Mount Vesuvius Aug. 22nd 79 A.D.) related a story of a soldier having empyema who was pronounced incurable by physicians, exposed himself in battle, in order that he might be killed and thus relieved of his suffering, was wounded in the thorax and the pus escaped and he recovered.

Aretaeus of Cappadocia (about 30-90 A.D.) wrote a clinical description of pleurisy and empyema and suggested treatment with the red-hot cautery iron. He employed the birthwort soaked in oil as a cautery in certain cases.

Galen (131-201 A.D.) observed that a way must be provided for pus to escape from the thorax, to avoid the ravages, especially of phthisis, of which it might be the cause. He resected carious ribs, injected warm wine into the cavity and instructed the patient to cough while leaning toward the affected side, and if the pus and injected fluid did not thus escape, it was removed by aspiration.

Leonidas of Alexandria (about 200 A.D.) referred to by Paulus Aegineta, resorted to incision, as well as, to burning through the chest wall with the red-hot cautery.

Caesius Aurelianus (about 400 A.D.) was familiar with auscultation of the chest and wrote on abscesses and empyema.

Aetius of Amida (502-575 A.D.) made very brilliant observations upon the pathology of empyema and stated that certain cases were
found without fever. He employed the cautery in treating this affection.

Paulus Aegineta(31)(625-690 A.D.), last of the great surgeons of the Byzantine period, wrote an excellent description of empyema and used the root of the long birthwort soaked in oil to burn multiple openings in the pleural cavity. He condemned the use of the knife and spoke lightly of employing the iron cautery as done by Leonidas(32).

Following the Byzantine period, Greek medicine gradually shifted to the Arabians(33)(34). Arabian medicine made very little real progress because of religious scruples which forbade dissection and post mortem examination, yet it propagated many of the ancient Greek writings by translating them into Arabic. While the cautery was used practically exclusively among the Arabians, yet the teachings of Mahomet(35) "Recommended that it be used sparingly and with great 'caution'." Surgery, which was intrusted to the "Wondering Specialists"(36), suffered most and was practically a lost art for some two hundred years.

Rhazes(37)(860-932) mentions clinical observations of empyema and advised that the chest be opened by a small orifice, that matter may be slowly evacuated.

Haly ben Abbas(38)( died 994), a Persian mage, recognized empyema and recommended such an operation as that described by Celsus and Paulus Aegineta. He, also, advised the root of the long birthwort smeared in oil as a cautery in preference to the red-hot iron.

Albucasis(39)(935-1013) wrote an extensive treatise on surgery as a means of treating diseases. He recommended incision, or cautery operations for draining empyema.

Avicenna(40)(980-1037) and Avanzoar(40)(1113-1162) also approved of paracentesis and the cautery in the treatment of empyema.

In 1139 A.D., Pope Innocent II(41) retarded the progress of surgery by describing its practice as degrading and forbidding the clergy
to indulge in it.

During this period there was a Hindu physician, Susruta (42) (about 1000) who was a very ardent student of surgery. His works covered many operations and he described over a thousand surgical instruments, but we do not find a description of the operation for empyema among his works.

The surgical methods of Albuçásis became the standard guide for surgeons until the time of the very able Italian surgeon, Saliseto (43) (1210-1277), who revolutionized the practice by substituting the knife for the actual cautery. If he used the knife to perform empyema operations is not known, however, his pupil, Lanfranchi of Milan (44) (?-1315) operated for empyema as noted in his "Chirurgia Magna" completed in 1296 A.D.

Guy de Chauliac (45) (1300-1370) defined empyema which very closely agrees with our present conception. He also mentioned that his contemporaries were performing operations for this condition.

In 1562, Vesalius (46) (1514-1564) performed an empyema operation successfully on Don Carlos of Aragon, son of Philip II of Spain, as well as, two other successful operations for this condition performed later.

The use of the actual cautery was also practiced by Jacques Callot (47) (1592-1635) in the treatment of chronic diseases of the chest including empyema.

Smetius (48) (Heinrich Smet, 1537-1614) described a case of empyema following a dagger wound of the thorax. He opened the thorax between the tenth and eleventh ribs and foul pus escaped. The cavity was then irrigated with honey and water.

Amatus Lusitanus (50) (1511-1568) wrote extensively on the treatment of empyema and discussed the relative advantages of incision and the cautery. He made the incision just above the septum transversum, so that drainage would be more complete.

Ambroise Pare (51) (1510-1590) wrote a masterful description of
empyema and described the operation, using the actual cautery. He was aware of the dangers of evacuating large quantities of pus too suddenly and so he advised the pus be evacuated a little at a time. After the pus was all evacuated, he cleansed the chest cavity from the purulent matter by a detergent injection of six ounces of barley water and two ounces of honey of Roses.

Marcellus Donatus(52)(about 1540) noted a spontaneous cure in a case of empyema necessitatis. He advised a surgical incision between the ninth and tenth ribs posteriorly.

Leonus Lunensis(53)(Dominicus, about 1500) wrote on the medical treatment of empyema, but advised the knife or cautery in cases that did not yield to such treatment.

Petrus Castellus(54)(Died 1655) wrote at great length on diseases of the chest and empyema but did not contribute anything new on the subject.

Fabricius ab Aquapendente(55)(1537-1619) recommended a silver drainage tube to be worn for life. He also thought that rib resection was too difficult, dangerous and cruel.

Zacutus Lusitanus(56)(1575-1642) published records of three cases. In the first, pus drained by urine; in the second, there was much purulent sputum; and in the third, after much fear, deliberation and hesitating, an incision was made in the thoracic wall and the patient recovered.

Operative treatment of empyema was discussed at some length by Paolo Zacchias(57)(1584-1659), R. Camerarius(57)(1665-1721), Scultetus (Johann Schultes(57) 1595-1645) and Thomas Fienus(57)(about 1675). Scultetus' work is the earliest accessible reference in French and Fienus' work on paracentesis for empyema is the earliest available article in German.
The available literature from the eighteenth century is essentially a repetition of the foregoing: that is, citation and discussion of authorities and a few isolated case reports.

Ingram (58) (about 1751) included in his book on surgery a chapter on empyema of various kinds, and this is the earliest accessible reference in English on this subject.

Dupuytren (59) (1777-1835) reported fifty cases with only four cures. He was an ardent advocate of thoracotomy, but when he, himself, developed a fatal empyema he refused operation, saying that, "I preferred to die by the hand of God than by the hand of a surgeon".

Up to this time, most of the cases dealt with were empyema necessitatis, but with the development of the art of percussion of the thorax by Leopold Auenbrugger (60) (1722-1809) in 1761, a great impetus was added to the improvement of the early diagnosis of empyema. Stoll (60), Cornisont(60), and Laennec(60) were the first to emphasize its value in the early diagnosis of empyema.

In 1810, Aupepin (61) described a "new" technic for performing a thoracotomy by making the incision in the skin and intercostal tissues at different levels, thus giving a valve like action to prevent a pneumothorax following the withdrawal of the aspiration tube.

Paracentesis became a common method of handling empyema cases during the first half of the nineteenth century as shown by articles and case reports contributed to the literature (62).

Hamilton Roe (63), in 1844, advocated aspiration not later than three weeks from the onset. He emphasized the importance of early therapeutic aspirations as a means of preventing chronic empyema.

In 1862, Henry I. Bowditch (64) was one of the first to employ paracentesis in pleural effusions of all kinds and it was largely owing to
his enthusiastic advocacy of the method that it became popular in America.

Smith(65) in his "System of Surgery," published in 1855, gives a concise method of treating empyema by means of paracentesis. If the presence of pus was certain and the condition of short duration, he employed the trocar and canula, but if the location of the pus was doubtful and the disease of a long duration, he practiced cutting down to the pleura so as to avoid the danger of the thickened pleura pushing ahead of the trocar. He included a table of statistics of operation, by the aspiration method, for empyema as follows:

<table>
<thead>
<tr>
<th></th>
<th>cured</th>
<th>died</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 cases in United States</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>(2 cases reported improved)</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>72 cases reported by Velpeau</td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>70 &quot; &quot; &quot; Roe</td>
<td></td>
<td>49</td>
</tr>
<tr>
<td>16 &quot; &quot; &quot; Davis</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>182</td>
<td>119</td>
<td>61</td>
</tr>
</tbody>
</table>

This table shows a mortality rate varying from 22.7 per cent to 43 per cent, with a total average mortality of 35.51 per cent.

In 1860, Walter(66) took another step forward and for the first time resected a sound rib in order to establish free drainage. This procedure was taken up by many others and in 1876 Weissenborn(67) reported a series of five cases treated in this manner successfully.

Protan(68) is to be regarded as the pioneer in the use of the siphon drainage in treating empyema. His siphon, the one comprising but a single tube, was first made known to the medical profession in 1869. The tube was inserted into the pleural cavity by means of the trocar and canula. The outer end of the tube was fitted with a Y connection, one branch of which was connected to a vessel of antiseptic solution above the patient and the other branch connected to a receptacle below the bed. The vessel below the bed contained a disinfectant solution. With this arrangement, the empyema cavity was alternately, irrigated and drained.
In 1872, Playfair (69) (1836-1903) of England introduced a method which he termed "Subaqueous drainage". A tube armed with a glass index was passed into the chest cavity, by means of the trocar and cork, and sealed to the chest wall. The other end of the tube was allowed to remain in a bottle partly filled with water so that the end of the tube was beneath the surface of the fluid. This method was known for some time as the Playfair-Bulau method, although Playfair doubtless antedated Bulau by some years.

Bryant (70) (1828-1914), in 1875, advocated aspiration as a diagnostic measure. He practiced free drainage, making the incision between the eighth and ninth ribs in the posterior axillary line and large enough to admit at least one finger. He then inserted soft India rubber drainage tubes and daily washed out the cavity with a solution of iodine. He observed that sudden death occurred in some cases following rapid evacuation of the pus, but felt it was a coincidence rather than a result of the operation.

In 1876, Creswell Hewett (71) described a plan of "Continuous aspiration". A catheter was inserted into the empyema cavity by means of the trocar and cork, with the outer end connected to a bottle containing a solution of sodium and potassium permanganate. By gently raising and lowering the bottle the cavity was alternately drained and filled with antiseptic solution. By this method the intrathoracic pressure was altered very little and hence less tendency to hemorrhage and transudation.

Rosser (72) (1817-1888), in 1878, revived the idea of Walter and advised the resection of a rib to afford better drainage, if there was any difficulty in cleansing the chest of pus through the aspirating trocar.

Estlander (73) (1831-1881) a year later, described a very radical operation for the treatment of pyothorax. He advised resection of portions of the second to the seventh ribs with periosteum, in order to give more adequate drainage and to facilitate in obliterating the cavity.
by allowing the chest wall to fall into apposition with the collapsed lung.

In 1881 a series of 141 cases of empyema was reported by Homen\(^{74}\), showing a mortality rate of 33.33 per cent which was practically the same as that reported by Smith in 1855.

Parker\(^{75}\)(1800-1884), in 1882, suggested the production of a pneumothorax as a treatment of acute empyema, but this method failed to give the expected results and was abandoned for the time.

One year later, Ranschoff\(^{76}\)(1853-1921) devised an operation in which a number of ribs were resected and a series of incisions made in a criss-cross manner in the thickened visceral pleura to facilitate in expanding the lung to obliterate the empyema cavity.

Thiersch\(^{77}\), in 1885, advocated closed drainage, using a trocar to introduce a catheter into the chest cavity. Small quantities of pus were evacuated at a time until the cavity was empty. The tube was then connected to a bottle and constant drainage instituted until a cure was effected.

In 1889, Agnew\(^{78}\)(1818-1892) advocated the treatment of empyema by aspiration exclusively. The apparatus was so arranged that the fluid drained into a vessel partly filled with water to exclude the possibility of entrance of air into the chest, to which he attached the utmost importance. He was absolutely opposed to free open drainage. He also noted that the mortality of a series of 28 cases reported during the Civil War was approximately 32 per cent, which was only slightly lower than that reported by Smith in 1855 and Homen in 1881.

Schade\(^{79}\)(1844-1902), in 1890, described an operation in which the entire rib, from the costal cartilage in front to the tubercle behind, and from the second to the seventh inclusive, were resected in an effort to produce a collapse of the chest wall.
Bulau(80)(1835-1900), at the medical congress of Vienna in 1890, advocated air tight drainage of acute empyema through the use of a large trocar and canula inserted into the cavity and through which a catheter was introduced. The canula was withdrawn, leaving the catheter in place and held snugly by the soft tissues. The outer end of the catheter was connected to a bottle of antiseptic solution and the pus siphoned into this solution. This method was almost identical to that described by Hewett in 1876, except Bulau used lime water to irrigate the cavity.

Forlanini of Pavia(81)(1847-1913), the same year, advocated preliminary thoracentesis with the introduction of air into the pleural cavity simultaneously with the evacuation of pus. This preliminary procedure was followed by a siphon drainage method similar to that described by Bulau.

Delorme(82), in 1892, enunciated a new principle in the treatment of empyema cavities, namely, that of reexpansion of the lungs by appropriate exercises following the drainage of the cavity and decortication of the involved lung. This operation was first performed successfully by Fowler(83)(1848-1906) in 1893.

Dennis(84), in his System of Surgery published in 1895, advocated aspiration for diagnostic purposes but insisted on free open drainage by a thoracotomy at a place corresponding to the ninth rib a little external to the angle of the scapula. In frank purulent cases he advised irrigation of the cavity with a solution of mercury bichloride of a 1:10,000 strength. Irrigation was discontinued if on the first irrigation there was evidence of a bronchial fistula.

Weeks(85) recommended in certain cases, especially in children, the use of sterilized gauze placed in the cavity to absorb the purulent exudate.
In 1898, Perther\(^{(86)}\)(1863-1927) introduced a form of direct aspiration using a Bunsen hydraulic pump to create a negative pressure within the cavity. The negative pressure was regulated by a manometer attached to the apparatus. This method, as well as, that of Bulau continued to claim recognition during the first part of the present century.

In 1906, Bryant\(^{(87)}\) introduced a method of treatment which could be applied to ambulatory patients suffering with empyema. His method was essentially the same as that of Perthes, except a large deflated rubber bulb was used to replace the hydraulic pump. The connecting tube was fitted with a valve so that the bulb could be detached and emptied without admitting air into the cavity.

Von Eberts\(^{(88)}\), in 1911, advocated the early diagnosis and treatment of cases of empyema in order to avoid the complications of chronic suppuration and deformity. He stressed the importance of treating empyema from the physiological as well as the pathological standpoint. The spirit prior to this time seemed to be in favor of compelling the chest wall to conform to the lung rather than the lung to the chest wall. Von Eberts maintained that the physiological treatment of these cases was to make the lung conform to the chest wall and this same idea was probably what Delorme had in mind when he advocated decortication and re-expansion of the lungs by appropriate exercise.

The same year, Souligoux\(^{(89)}\) advised early open drainage in all cases of acute empyema. He contended that the primary aim in treating these cases was to evacuate the purulent exudate and open drainage would insure better evacuation. He noted a marked difference in mortality between the streptococcus and pneumococcus empyemata. In the cases he observed, the mortality of the streptococcus empyema was never less than 25 per cent.
The resection of a rib in preference to simple thoracotomy continued to gain recognition and in 1912 Kuttner (90) advocated rib resection in every case, except in those cases in which an emergency procedure was paramount.

The idea of Von Eberts was taken up by Lilienthal and Ware (91) in 1914 and a special study was made of empyema at Mt. Sinai Hospital (92) with an idea of developing a line of treatment in line with the therapy of infectious processes in general. They worked on the assumption that the treatment of empyema was a physiological and pathological consideration, and not merely a matter of mechanical drainage. They succeeded in reducing the total mortality to 28 percent, varying from 50 per cent in children to 18 per cent in adults. The work of these two men was a decided step forward in the treatment of empyema and the results that they obtained demonstrated clearly that the approach to the empyema problem was not purely a mechanical one. Their success in handling these cases led others to adopt new avenues of approach and the two years prior to our entrance into the World War showed the routine gradually giving way to the rationalization of treatment of empyema, and surgeons everywhere were striving energetically to reduce the appalling mortality of this disease.

MODERN METHODS

Modern methods in the treatment of empyema may be said to begin with the hitherto unprecedented epidemic of 1917-1918. The appalling high mortality reported at the various army camps led the Surgeon General to appoint an Emphyema Commission (93) to investigate the situation and make recommendations thereon.

At the beginning of this investigation nearly all cases of
empyema, in the various camps, were treated by the then conventional method of operation and open drainage as soon as a diagnosis was made of infected fluid in either one or both of the pleural cavities. The average mortality of 30.2 percent was reported in the cases diagnosed as empyema. In some of the camps the mortality approached 90 per cent. The Commission found that the causative organism was predominantly the streptococcus with a few cases showing some type of the pneumococcus. They also found that the pleural effusion in cases of the streptococcal infections took place during the acute stage of the disease, while that in the pneumococcal type occurred during the period of resolution. It was, therefore, evident that the high mortality was due, in part, to the added embarrassment of the operation on an already overtaxed system. Having ascertained these facts, the Empyema Commission immediately decided that empyema was no longer a surgical emergency and recommended that these cases be treated first by simple aspiration and later the operation for open drainage be performed. The gratifying results of this alternation in the treatment was manifested by a drop in mortality from 40 per cent to 4.3 per cent at Camp Lee(93). The Commission thereupon laid down three basic principles to be observed in the treatment of empyema: (1) careful avoidance of an open pneumothorax in the acute stage, (2) the prevention of a chronic empyema by rapid sterilization and obliteration of the infected cavity, and (3) careful attention given to the nutrition of the patient(94)(95). For the sterilization of the empyema cavity a large number of antiseptics were tried but the Dakin's solution seemed to give the best results(96).

McKenna(97), in 1918, applied the principles laid down by the Empyema Commission and treated 19 cases by repeated aspiration with a large needle and syringe without a single death.

The same year, Mozingo(98) again popularized the closed
method of drainage. The chief features of this method are: (1) a single minor operation done early without danger of shock or collapse of the lung, (2) intermittent removal of secretion and antiseptic treatment given through a small rubber tube with a bulb urethral syringe, (3) rapid partial sterilization of the cavity with Dakin's solution followed by complete sterilization with a 2 per cent solution of formaldehyde in glycerine, (4) maintenance of negative pressure in the empyema cavity, tending to early obliteration of the cavity, (5) one dressing, which will last several days, and no skin irritation, and (6) emphasis on simple physical principles rather than on major operative surgery. He first made a positive diagnosis and then introduced a catheter into the empyema cavity at its most dependent portion. The trocar and cannula were used in introducing the catheter. After the catheter was introduced and the cannula withdrawn a dressing was arranged to hold it in place. A half ounce bulb urethral syringe was used to aspirate the pus and to inject the Dakin's solution. The injections were repeated every two hours during the day and every three hours at night, being careful with each injection not to allow air to enter the cavity. After one to seven days of such treatment, the Dakin's solution was stopped and a 2 per cent solution of formaldehyde in glycerine was injected once daily and allowed to remain from 12 to 24 hours. The formaldehyde solution is much stronger than the Dakin's solution and if used in the acute stage often gives rise to distressing symptoms which are minimized by preceding it with Dakin's solution. In a series of 32 cases treated by this method there was not a single death. This method has many advantages over previous methods in that it does not require the patient to be bed-fast and may be used in the home and country practice. It economizes in time, labor and dressing material and avoids the dangers of surgical shock and collapse of the lung, as well as preventing the absorption of large amounts of toxin and keeps the lung in an expanded condition.
In 1920, Griffin used the method advocated by Thierson and succeeded in reducing his mortality rate from 66.56 per cent in one series to less than 10 per cent in another series.

Kanavel again called attention to the fact that all cases of empyema could not be treated by a set order of procedure and urged that each case be treated as an individual clinical problem rather than by some prevailing method.

McGregor devised an operation to provide an outlet for pus in empyema cases without the use of the drainage tube. A rectangular shaped flap composed of the whole thickness of the chest wall down to the level of the ribs was made. Part of a rib was resected opposite the center of the flap, to give adequate drainage and so that pus could escape under the flap during expiration. The movement of inspiration sucked the flap shut. This method seems to be more radical than necessary and besides no attempt is made to sterilize the cavity.

Eggers emphasized the fact that too many of the empyema studies are based upon treatment and mortality which are incomplete. He maintained that empyema should be studied with regard to the antecedent disease, type of organism concerned and its virulence, the prevailing climatic conditions, whether cases are sporadic or those of an epidemic, treatment and mortality. He advocated aspiration as a symptomatic relief until the pneumonia subsided, then adequate drainage by open operation. He was not favorably impressed with the closed method of drainage because of the possibility of the tubes becoming blocked and fail to dispose of the large fibrin clots. He reserved the closed method for those septic cases in which, early in the pneumonia, the presence of fluid itself is considered a menace to the patient and in cases of double empyema.

Ashurst advocated the necessity of rib resection in every case of empyema in order to establish adequate drainage. He felt
that irrigations were quite unnecessary.

In 1923, Penn\(^{(104)}\) brought out a new method of treatment for acute empyema. He resected a tib for adequate drainage and discarded the use of Dakin's solution because of the dangers of a bronchial fistula, and instead employed normal horse serum as an irrigating fluid, if he irrigated the cavity at all.

Soresi\(^{(105)}\), in 1925, devised an apparatus to be used in the closed method. This consisted of a simple drainage tube fitted with a valve that permitted pus to escape but closed when air was about to enter. The objection to this method and apparatus is the ease that it may become clogged when used in cases where there is thick purulent exudate.

Parton\(^{(106)}\), one year later, described a rather simple apparatus for a closed drainage set-up by means of which he could obtain continual suction over a long period of time, but seemed to have no advantage over the other apparatus used in the closed method.

In 1926, Lilienthal\(^{(107)}\) described a treatment for all general empyemata. The first surgical procedure to be employed is that of aspiration, preferably by the air replacement method. If seropus is present and some relief obtained, the procedure should be repeated as often as there are signs of tension within the chest, with or without mediastinal displacement. The acute symptoms having subsided the next step is to do a minor thoracotomy with air-tight drainage. The opening in the pleura should be small so as to fit snugly about a 14 or 16 French catheter. The pus is allowed to escape slowly. By suitable connections and valves, Dakin's solution may be introduced into the cavity through the same tube. As soon as the patient has recovered from the effects of the operation, lung expansion exercises, such as blow bottles, inflation of balloons and etc., are encouraged. If the infecting organism is the streptococcus, the drainage must be kept up until several cultures taken from within the
drainage tube are negative. If closed drainage is deemed inadequate for a given case then open drainage should be employed. This necessitates an incision long enough to permit of adequate drainage by means of at least two soft Penrose drains; the drainage being absorbed by dry gauze. The cavity is irrigated with Dakin's solution through one of the drainage tubes and is kept up until no more organisms can be demonstrated by smear or culture. The tubes are then withdrawn and the wound soon closes.

Alexander (108) obtained splendid results by the closed method of drainage. He placed the Penrose drains obliquely in the chest wall so that more soft tissue would come in contact with the tubes and insure against air entering the cavity around the drainage tubes.

Danna (109) used the method of aspiration with air replacement. A Luer syringe and needle was used and after the aspiration of a syringe full of pus an equal volume of air was replaced. This process was continued until no more pus is obtained.

Roeder (110) advocates the use of the gauze pack in cases that requires open operation. The advantages claimed for this method are: (1) the pack holds the lung steady following the operation, which gives the patient considerable comfort, (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 nearly always present, (4) it eliminates external purulent drainage almost completely after 48 hours, and (5) it brings about an obliteration of the cavity at least as rapidly as any other method. In this method about 4 inches of rib is resected and the parietal pleura sutured to the skin to facilitate in packing. The cavity is then packed with bismuth subiodide gauze. This is changed daily or every second day for 6 or 7 days, after which additional packs are rarely necessary. The disadvantages to this method are: (1) the discomfort the
patient experiences with each packing especially the first after operation, and (2) it requires someone experienced to do the packing.

Singleton (111) employed the closed method of drainage in a series of 81 cases, varying in age from 5 to 40 years, with a mortality of 6.3 per cent. Twenty seven cases of this series between the age of five and twenty years were treated without a single death.

Lookwood (112) recommends the conservative form of treatment. The routine procedure which he carries out is aspiration to relieve the intrathoracic pressure and afford symptomatic relief. When the patient ceases to show improvement then the closed drainage with the Carrel-Dakin treatment is instituted. Forced blowing exercises are started as soon as the patient recovers from the shock of the operation. If simple thoracotomy does not give adequate drainage then a rib is resected.

In the period 1917 to 1931, the mortality in his cases was 12 per cent, but this includes a number of cases of streptococcal empyema complicating pneumonia. Since 1923 (to 1931) he has not had a single death from uncomplicated acute empyema and only 2 per cent developed into a chronic state.

Davis (113) also advocates preliminary aspiration to be followed by the closed method of drainage. The open operation being performed only when the lung and mediastinum are immobilized.

Stenbuck and Whitaker (114) use the gauze packing and obtained splendid results. They use the iodoform gauze instead of the bismuth subiodide gauze used by Roeder.

Cannors (115) also uses the iodoform gauze packing and has obtained very excellent results.

Freedlander (116) advocates adequate drainage by means of rib resection, with temporary closed drainage at the beginning and later open drainage.

Muller (117) maintains that the closed method of drainage is the
proper procedure and will effect a cure in nearly every case.

Harrington(118) states that he obtains the best results using the closed method of drainage. In his series of 71 cases of acute empyema treated by the closed method 65 per cent recovered without open operation, and 35 per cent open drainage was required for obliteration of small residual cavities. The mortality for this series of cases was 5.6 per cent.

Bettman(119), Howard(120) and Altman(121), working independently, obtained very satisfactory results with the closed method, either by repeated aspirations or the introduction of a drainage tube by means of the trocar.

Boland(122) maintains that the first and most important consideration in any method is to save the patient's life. The next consideration should be to save the patient's life as comfortable as possible. He recommends the open operation as a method of choice for fulfilling these objectives.

Heuer(123) contends there is no question of the greatly reduced mortality by the adoption of a given method -- aspiration, closed or open drainage; the problem is to prevent an occasional and rare death, due to a pneumothorax in the presence of an unsuspected pneumonia and a mobile mediastinum, which is almost sure to occur if routine rib resection and open drainage is practiced in every case.

Roberts(124) uses the air replacement method and reported a series of 30 cases in which this method was used with only two death and both of these occurred in children.

It is evident from this review that the problem of the treatment is still an open question and there is not sufficient agreement among authorities to justify the adoption of any one method.
SUMMARY and CONCLUSION

1. There has been considerable disagreement as to how empyema should be treated since the time it was recognized as a clinical problem.

2. The method of treatment of empyema is still a debatable question.

3. Empyema is not a surgical emergency as it is well shown by the investigations of the Emphyema Commission.

4. All cases of empyema can not be treated in the same manner; the individual as well as the empyema must be treated.

5. Conservative treatment during the acute stage, using repeated aspirations to give symptomatic relief.

6. Free drainage after the acute stage has subsided, using blowing exercises to expand the lung and obliterate the cavity.
CASE REPORTS

CASE NO. I. Donald Silik, age 15 months, was admitted to the University Hospital November 30, 1931. On admission the child appeared malnourished and very sick, having a temperature of 103°F. The Pediatrics Department made a diagnosis of resolving pneumonia complicated by an empyema of the left side of the chest. The child was placed on a high caloric diet in an effort to build up the body resistance. Dec. 3, 1931. A roentgenogram of the chest revealed fluid in the left pleural cavity and the heart markedly displaced to the right. A thoracentesis was performed removing about 30 cc of purulent material from which the pneumococcus was isolated. The patient was much relieved and the 24 hours following the thoracentesis the temperature dropped from 102°F to 99°F. Dec. 5, 1931. Another thoracentesis was performed, removing 20 cc of thick purulent material. The child continued to improve and on Dec. 7, 1931, the Pediatrics Department advised operation, which was performed Dec. 8, 1931. An open operation was done, removing about 5 cm of the 8th rib on the left side. About 300 cc of thick purulent exudate drained from the left pleural cavity. Rubber drain tubes were inserted and gauze packs applied to the wound. Following the operation the child's condition improved greatly until the 26th of December at which time there was an elevation of temperature and drainage became more profuse. Jan. 2, 1932. A roentgenogram revealed a pus pocket which was subsequently drained and the temperature immediately dropped to normal. The child made an uneventful recovery.

CASE NO. II. Patrick Cosgriff, age 28, was admitted to the University Hospital February 9, 1932, with a diagnosis of lobar pneumonia with pleural effusion. A roentgenogram of the chest revealed consolidation of the lower left lobe and a small amount of fluid in the left pleural
cavity. Feb. 17, 1932. Physical signs indicated an increase in the pleural effusion on the left side and a diagnosis of an empyema was made.

Feb. 20, 1932. A thoracentesis was performed obtaining about 50 cc of thin sero-purulent fluid. The pneumonia having subsided, the patient was transferred from medicine to surgery. Feb. 25, 1932. A thoracentesis revealed a thin purulent fluid in the cavity and so operation was postponed until March 2, 1932, at which time thick purulent fluid was obtained and the attending surgeon thought it advisable to operate. Under local anesthesia an intercostal incision about 6 inches long was made between the 7th and 8th ribs and about 1000 cc of very thick purulent exudate escaped. Three Penrose drains were inserted and the wound closed by retention sutures. The 24 hours following the operation patient's temperature dropped to 101.5°F and his respirations were greatly improved.

March 8, 1932. Temperature normal and drainage very small. Two of the Penrose drains were removed. March 20, 1932. The remaining drain was removed and the patient was discharged from the hospital three days later.

CASE NO. III. Darlene Garrison, age 4, was sent to the University Hospital from out state with a diagnosis of empyema of the left chest. Upon admission April 12, 1932 the patient had a temperature of 103°F. A thoracentesis was performed removing 200 cc of thick purulent pus from the left pleural cavity. Two days later a second thoracentesis was done obtaining 250 cc. On April 18, 1932, the attending surgeon performed an open operation, removing a portion of the 7th and 8th ribs on the left side. About 300 cc of pus escaped and the cavity was packed with bismuth subiodide gauze. April 18, 1932. The pack was removed and only a small amount of purulent exudate was present. Cavity repacked. April 20, 1932. Cavity about one fourth original size. Cavity repacked. On April 24, 1932 the cavity was greatly reduced and packing was discontinued and the child made an uneventful recovery.
CASE NO.IV. Wesley Freyer, age 7, was admitted to the University Hospital March 27, 1932, with a history of having had a pneumonia which ended by lysis. The physical findings suggested fluid in the left pleural cavity. A roentgenogram showed a partial collapse of the left lung with a small amount of fluid in the left pleural cavity, and a diagnosis of a resolving pneumonia and empyema of the left chest was made. March 30, 1932. A thoracentesis revealed a small quantity of sero-purulent fluid. The thoracentesis was repeated on April 2, 1932, at which time the exudate was thick. On April 4, 1932, the same type of operation was performed as that on case no. III. Four days following the operation the temperature became normal and there was no discharge. The patient made a speedy recovery.

CASE NO.V. Mildred Clayton, age 28 was admitted to the University Hospital February 19, 1932, with a tentative diagnosis of empyema of the left chest. A roentgenogram was taken of the chest which revealed fluid in the left pleural cavity and the heart displaced to the right. A thoracentesis was done on Feb. 22, 1932 and thick green pus obtained. It was thought not advisable to operate at that time so the patient was treated by repeated aspirations. On Feb. 26, 1932, 500 cc of thick green pus was removed and 500 cc of air injected. This gave the patient considerable relief, but due to the fibrinous character of the exudate it was deemed advisable to do an open operation. Under a local anesthetic, 4 inches of the 8th rib on the left side was resected. After the cavity was evacuated of pus it was packed with bismuth subiodide gauze. The cavity was repacked daily until March 8, 1932, at which time the temperature was normal and the exudate ceased. Packing was discontinued and the patient was dismissed on March 22, 1932 in good condition.
CASE No.VI. Walter Schon, age 4½ years, was admitted to the University Hospital, Dec. 20, 1931, with a diagnosis of lobar pneumonia of the lower left lobe. Six days later the patient developed signs of a pleural effusion and on Dec. 28, 1931 a thoracentesis revealed a thin yellowish fluid in the left pleural cavity. The aspiration was repeated Jan. 1, 1932 and 250 cc of a dark bloody fluid was obtained. The aspiration only gave transient relief. The thoracentesis was repeated two days later obtaining 75 cc of a dark fluid. Following this the patient became very toxic and it was deemed advisable to do a thoracotomy and drainage. The thoracotomy was made in the 6th interspace posteriorly. The fluid in the pleural cavity seemed to be under considerable tension and when released the respiration improved. A catheter drain was inserted and the wound closed. The drainage was profuse for four days but on Jan. 9, 1932 the exudate became so thick that it clogged the tube and so a second incision was made in the 4th interspace posteriorly and Dakin's solution used to irrigate the cavity. This gave temporary relief but still the temperature remained high often reaching 103°F. This condition persisted until March 9, 1932 at which time the patient became very toxic and further interference was thought necessary. This time the incision was made in the tenth interspace posterior axillary line and three Penrose drains were inserted. The patient's condition improved for three days, then he developed an upper respiratory infection of a very virulent nature. The empyema condition became of minor importance as the drainage became less and less and had completely stopped by March 28, 1932. On March 31, 1932, a roentgenogram showed the empyema cavity completely obliterated.
2. Garrison, F.H., History of Medicine, 3rd ed. p 48, W.B. Sanders Company 1924.
7. Ibid.
10. Ibid.

21. Ibid.


30. Ibid.


35. Ibid., Vol. I, p 83.

36. Garrison, P.H., History of Medicine, 3rd ed. p 125, W.B. Sanders and Company. 1924.


38. Ibid.


40. Ibid.


44. Garrison, F.H., History of Medicine, 3rd ed. p 144, W.B. Sanders and Company. 1924.


47. Garrison, F.H., History of Medicine, 3rd ed. p 214, W.B. Sanders and Company. 1924.


50. Ibid.

51. Johnson, Th., The Works of Ambroise Pare, pp 298-299, Cotes and Young, London. 1634.


53. Ibid.

54. Ibid.

55. Ibid.

56. Ibid.

57. Ibid.

58. Ibid.


61. Ibid, p 618.


64. Ibid.


67. Ibid.


69. Ibid.


77. Ibid.


81. Ibid.

85. Ibid.
87. Ibid, pp 298-301.
94. Ibid.
