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TREATMENT OF NON-TUBERCULOUS

PULMONARY ABSCESS

BY

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## Introduction

Abscess of the lung, in the ordinarily accepted meaning of the term has reference to the primary localized pyogenic process. Secondarily infected tuberculous cavities, echinococcus cysts and localized lesions due to other specific infections such as streptothrix, fungae, amoebae, etc. are, therefore, by definition excluded.

In a subject as extensive as the treatment of non-tuberculous pulmonary abscess, a complete review of the literature could not be done. It is only my intention to present the measures which are used in the treatment with an opinion as to their efficiency. A brief summary of etiology, bacteriology, pathology, symptoms and diagnosis was inserted so that the discussion of treatment would be more intelligible.

Grateful acknowledgment is made to T. W. Buschmann (8) and J. Maxwell (61) for their historical review.

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### Historical Review:

Hippocrates in the fourth century, B. C., recognized that pneumonic abscesses opened into the bronchus and slowly recovered in that way. He repeatedly opened them through the chest wall and resected the rib to obtain a better field. He advised thoracotomy and pneumotomy as the proper treatment for these cases.

These operations were lost sight of and did not come to light again until 1584 when Schenk recommended them. Oblivion was its fate again until Willis in 1664 drew attention to it. Bligney in 1670 reported a case of phthisis which was cured by accidental puncture of the chest with a sword. Purmann in 1692 advised incision of the chest wall in hemorrhage, empyema, pulmonary cavities and for removal of all kinds of effusions. The next step was taken by Baglivi who in 1696 first established treatment by costal incision.

Berry of Dublin in 1726 suggested the drainage of pulmonary cavities and cites cases of recovery following pulmonary incision. Compardon in 1759 reported a case which he cured by incision of the chest wall. Sharpe in 1769 dwelt on the difficulties of separating

pleuritic adhesions and advised cutting into the cavity with the lance and inserting tubular drainage.

Pontheau and David in 1783 advised incision to pleura and trochar to depth of pus. Gumprecht in 1793 emphasized the importance of determining the presence and seat of pus and the presence or absence of pleural adhesions. These are probably the most important observations made up to this time.

Faye in 1797 operated for abscess of the lung which was adherent and advised puncture, irrigation and tampon; for such cases, Jaymes and Richerand in 1813 advised drainage. H. Collisen, in 1815, advised puncture and exploration of the chest by paracentesis, and if pus were detected, incision of the pleura, then digital palpation for fluctuation in the lung with immediate incision. Zang in 1818 reported fifteen incisions of the chest wall, seven for empyema and eight for abscess. Nasses in 1824 incised a pulmonary cavity. Brickaton in 1830 opened a cavity with a caustic paste and also one with a scalpel. Postmortem after nine months showed the cavity in the latter case to be obliterated.

At this time, Gaire collected only 122 cases from the entire literature. Huntington, at the Massachusetts

General Hospital, reported thirty-two cases in 1836 observed during the previous eighteen years, none of which were operated upon. Most of the operations during this period consisted of trochar puncture, or incision of abscess pointing into chest wall. Inter-costal incision was performed by a number of men.

On account of the uncertain results of treatment and the very high mortality up to this time, search was made for other methods of treatment. In 1860, Green attempted to catheterize the air passages to promote nature's method of drainage. Attempts were made to inject antiseptics into the bronchi. Sterilization of the lung parenchyma was attempted by the injection of carbolic acid tincture of iodine, salicylic acid, etc.

Maragliano, however, reported the cure of a chronic lung abscess of thirty years duration following the intratracheal injection of a solution of silver nitrate. In 1867 Leyden and Jaffe had published their observations on the bacteriology of pulmonary diseases, and it is of interest to note that they were the first to report the presence of spirilla in the foul sputum obtained from cases of bronchiectasis and lung abscess.

The next great advance was made by Gluck and others, and this was that animals could survive resection of the lung and that one lung can function for both as in the case of other paired organs.

Sutton in 1881 reported a cure in a case treated by external operation, and in the same year Fenger reported a cure in a case of his own, although he quotes other unsuccessful cases. In the following years, Bull published a series of papers on thoracic surgery including a detailed study of fourteen cases of lung abscess. In 1887, Runeberg reviewed a series of eleven cases collected from literature, of which two had recovered following operation. In 1893, Huber recorded a successful operation for lung abscess in a child of thirteen and one-half months.

In 1898, J. B. Murphy (69) gave a very comprehensive discussion on surgery of the lung before the American Medical Convention. He discussed the problems to be met in thoracic surgery and concluded that a detailed understanding of the anatomy and physiology must be had before this comparatively new field could be a successful one.

Alfred Kirsten of Berlin, in 1895, introduced direct autoscopy of the larynx and trachea. Three

years later, Gurtar Gillian invented metal tubes and introduced bronchoscopy. J. W. Miller (64) could not find in the literature who was the first to treat bronchoscopically and report cases of the lung; however, M. L. Harris in a personal communication to Miller, informed him that Chevalier Jackson, of Philadelphia, inaugurated this treatment.

It was during the second decade of the twentieth century that the greatest advances were made in the treatment of non-tuberculous abscess. Chevalier Jackson with bronchoscopic drainage, W. D. Tewksbury with artificial pneumothorax, and others with their favorite method have caused a very diversified opinion as to the manner of treatment.

Etiology:

There has been a large amount of literature written on the etiology of lung abscess, but the answer as yet is not definite. The majority of the men seem to believe that there is more than one factor in the causation, and that all cases are not due entirely to aspirated material or entirely to emboli, but that both are important factors.

There has been a large increase in the incidence of lung abscess since the turn of the century, but



whether this is a true increase or an apparent increase is debatable. C. A. Hedblom (43) surveyed the literature and found reports on over 3,000 cases, of which ninety percent had been reported since 1900.

H. Lillenthal (53) recognizes four main avenues by which a lung can be infected: (1) traumatism, (2) blood vessels, (3) lymph channels, (4) air passages.

Traumatic abscesses are due to penetrating wounds of the chest wall which were very common during the World War, or puncturing the esophagus by a piece of ingested material such as a fish bone. Blood borne are embolic infections following surgical incisions through peripheral rigid tissue, such as furuncles. When the infection is lymph borne, the interstitial tissue is infected. The last group is the air-borne. This includes foreign bodies in the bronchial tree and abscesses produced by aspirated infected material. Lillenthal states that this is common after tonsillectomies and other oral operations. However, the abscess is less apt to be multiple in contrast to blood borne.

C. H. Harrell (39) believes that an unresolved pneumonia may break down and form an abscess, but in the experience of W. Whittenmore (98) lobar pneumonia is never the cause of pulmonary abscess.

In certain cases, according to Hedblom (41) the infection is, undoubtedly, embolic and severe symptoms and widespread pulmonary involvement are indicative of such origin. The point is proven by a report on a posttonsillectomy case, in which multiple minute abscesses were found at postmortem, ten days following the operation.

D. T. Smith (86) in 1932 analyzed 1,212 cases of lung abscess from the American literature and his findings were as follows: Twenty-eight percent followed tonsillectomy, fifteen percent after other operative procedures, and one and five tenths after aspiration of a foreign body. Pleumonia was listed as the cause in twenty-three percent, but Smith believes that they were primarily a fuso-spirochaetal infection which progressed to abscess formation. Miscellaneous and unknown cause accounted for twenty and five-tenths percent. In eleven and five-tenths percent, the onset was so insidious that the disease was not suspected until the patient began to cough up foul pus.

In a series of 692 cases of acute abscess or chronic pulmonary suppuration observed at the Mayo Clinic, Hedblom (41) reports that twenty-one percent followed operation. Of the postoperative cases,

thirty-one percent followed tonsillectomy, nine and five-tenths followed extraction of teeth and twenty-six percent, laporatomy. With but few exceptions, these operations were performed under general anesthesia.

C. George, Jr., (33) states that about seventy percent of the cases of lung abscess followed surgical operations and of this group fifty-six percent followed tonsillectomies. P. A. Midelfart and J. W. Gale (62) reviewed thirty-one cases in 1937 and only eight followed operation. Of these, two followed tonsillectomy, one after dental extraction, four from abdominal operations and one from lancing a peritonsillar abscess.

J. Maxwell (61) did not find upper respiratory operations to be a frequent cause of either single or multiple lobe abscess in a review of 315 postmortem cases.

H. Morrison Davies (23) considers that it is more than probable that both aspiration and embolism play an important part in the causation of lung abscess, and that in each case the development of the abscess is dependent upon a combination of both trauma and sepsis. The aspirated matter acts as a trauma by either causing a local inflammatory reaction or occluding a bronchiole and on the other hand the embolus produces interference with the blood supply.

### Bacteriology:

The infecting organism is not constant in lung abscess, but the one that is the most common is the fuso-spirochaestal organism. C. I. Allen and J. F. Blockman (2) found anerobic organisms in eighty percent of the cases and aerobic in twenty percent. J. Maxwell (61) reports a great variety of organisms, and that the infection was always mixed. He found the following bacteria: Staphylococcus aureus, non-hemolytic streptococcus, pneumococcus, Bacillus Pfeiffer, Bacillus Friedlander, Bacillus coli, Bacillus Welchii and streptococcus viridans. H. Lillenthal (53) found a variety of organisms, but he states that they are unimportant in regard to the surgical aspect. He considers any case of lung abscess existing more than one week as a mixed infection.

### Pathology:

C. A. Hedblom (41) has found that the pathologic changes in this type of pulmonary infection vary according to the avenue of infection, the amount, distribution and virulence of the infective organism, the relative resistance of the patient, the length of time the infection has been present and the treatment. If abscesses result, they vary greatly in size and

location. They may be simple, multiple or multi-ocular. They are usually surrounded by a peripheral zone of pneumonia, which may be circumscribed or extensive and in various stages of resolution or liquefaction. In the more chronic stages purulent bronchitis or bronchiectasis usually develops. Long continued infection results in thickening of the walls of the abscess, of the adjacent pleura and fibrosis of the lung.

A. J. S. Pinchin and H. V. Morlock (81) do not believe that a division of the pathological types of lung abscesses into acute or chronic is an adequate one upon which to base treatment and they suggest the following classification:

- I. Pre-abscess stage of pneumonitis.
- II. Pyogenic type
  - A. Simple
    - 1. With localizing reaction
    - 2. Without localizing reaction
  - B. Gangrenous or liquefactive
- III. Putrid or spirochaetal
  - A. Secondary to simple
  - B. With local reaction
  - C. Fulminating gangrenous

#### IV. Multiple

A. Simple pyogenic

B. Gangrenous

#### Symptoms:

According to E. A. Graham (36) abscesses of the lung offer a great variety of symptoms and no definite characteristic signs, but certain symptoms are very common. In most cases there is a septic temperature and night sweats. The sputum in the beginning is very scant, and the cough very severe. The sputum is mucopurulent, and then becomes purulent. Chills are very common and there is a considerable loss of weight and strength, and a decided anemia. Occasionally, a large amount of sputum is brought up at one time and may relieve the patient. Severe hemorrhages occur occasionally, similar to tuberculous hemorrhages. Pulmonary abscess, when ruptured into the pleura will produce empyema. It is not uncommon for the abscesses to rupture into a bronchus.

H. I. Spector (88) has found a pain over the site of the abscess, especially in those which are peripheral to be very common. A rapid pulse and a leucocyte count varying from ten thousand to forty thousand are usually present and a shift to the left of the

neutrophilic leucocytes is especially marked in the acute cases. Recurrent chills are more frequent in multiple abscesses than single. Clubbing of the fingers is usually seen in the chronic cases, and elastic tissue is not always present in the sputum.

It must be borne in mind that this condition occasionally follows operation, according to H. Lillenthal (53) so a history of an oral operation or an incision of abscess or boils during the four weeks previous should cause one to suspect a beginning lung abscess.

Physical:

H. Lillenthal (53) says that the physical signs are misleading or apparently absent until the condition is advanced.

H. I. Spector (88) writes that the physical examination will vary depending upon the size and location of the abscess, and whether or not rupture has occurred. Hilar and centrally placed abscesses present few physical changes; peripheral ones, if large enough, may present scattered fine or medium rales over the abscessed area. After the abscess has ruptured, signs of cavitation may be present; such as bronchial breathing, medium and coarse rales and whispering pectoriloquy. Generally speaking, the symptoms are out of proportion to the

changes observed, and the most common physical observations being dulness on percussion and a diminution of breath sounds.

Diagnosis:

It is the belief of H. Lillenthal (53) that the diagnosis of acute lung abscess or chronic lung abscess can only be solely determined by the x-ray. Three different exposures should be taken; the first one should be with the patient erect and either taken as an anterior-posterior or posterior-anterior, preferably both. Another is a full lateral with the patient still erect and the film against the suspected side. The last should be either an anterior-posterior or posterior-anterior with the patient lying on the well side. Pinchin and Morlock (81) say that the x-ray may be negative and they advise injection of the lung tree with lipiodol as the only means of diagnosis if the x-ray is negative but if lung abscess is still suspected.

Practically all the writers agree that if a case of pulmonary suppuration is suspected, the patient should be subjected to a bronchoscopic examination. However, no atropine should be given prior to bronchoscopy as it may dry up the secretions. At the same time, the site of the suppurative process can be readily



localized by noting the bronchi in which the secretion is present. This is an aid in the treatment.

Age and Sex Distribution:

Cutler and Gross (21) reported in 1936 that the incidence of lung abscess in regard to age is exactly comparable to the incidence of postoperative pulmonary complications as a whole. Their review of ninety cases disclosed the following results:

<u>Age in Years</u>	<u>Cases</u>
10 - 19	5
20 - 29	18
30 - 39	24
40 - 49	28
50 - 59	11
60 -	4

The sex distribution in these ninety cases was sixty-one males and twenty-nine females. They found that this agreed with the general statistics for pulmonary disease. They had no evidence to determine whether this two-to-one ratio is related to the different types of respiration in the two sexes - thoracic in women and diaphragmatic in males - or to other etiological factors.

C. I. Allen and J. F. Blockman (2) in a review of one hundred consecutive cases, found eighty-one males and nineteen females. J. Maxwell (61) reviewed three hundred and fifteen postmortem cases and he segregated

his cases into two groups: (1) single abscess and (2) multiple abscesses. In the single abscess group, there were one hundred and fifty males and forty-nine females. In the multiple lung abscess group, there were eighty-two males and thirty-four females. The age incidence of the first group was widespread with a preponderance in the middle age group. The youngest case died at twenty-two days and the oldest at seventy-eight years. The following is a more detailed study of the age incidence of the single abscess:

<u>Age in Years</u>	<u>Cases</u>
0 - 9	28
10 - 19	18
20 - 29	15
30 - 39	19
40 - 49	43
50 - 59	35
60 - 69	35
70 - 79	6

Maxwell (61) says that the heavier incidence in middle and later life is to some extent related to the incidence of malignant disease involving the respiratory tract. The age incidence of multiple lung abscess which consisted of one hundred and sixteen cases is as follows:

<u>Age in Years</u>	<u>Cases</u>
0 - 9	26
10 - 19	16
20 - 29	14
30 - 39	18
40 - 49	21
50 - 59	14
60 - 69	6
70 - 79	1

Prophylactic Measures:

Many men say that a considerable number of lung abscesses can be prevented if the proper pre-operative measures are taken.

B. Fantus (26) of Chicago advocates a few prophylactic measures prior to operations on the mouth and pharynx. The best possible oral hygiene should be employed. Disease of the teeth and gums should be taken care of in a routine manner and an antiseptic mouth wash should be used routinely. During tonsillectomy, the following precautionary measures will help to prevent lung abscess: Anesthesia below the point of abolishing the cough reflex, keeping the head lower than the body and keeping the pharynx clear of mucus and blood by means of a suction tube and prompt ligation of all vessels. Following operations of any kind, aspiration of vomitus must be prevented by constant attendance of a nurse until the patient can clear his throat voluntarily. Coughing should be

encouraged and not checked by opiates. If respiration is feeble, hyperventilation of the lungs by carbon dioxide and oxygen inhalation is indicated to prevent atelectasis.

C. J. Heuer (46) and C. H. Fitts (28) also admit that aspiration should be prevented insofar as possible and Heuer writes that in all operations, strict asepsis should be observed, a careful handling of tissue and avoidance as much as possible of ligation of large masses of tissue to lower the incidence of lung suppuration. If one is in favor of the embolic theory, frequent turning of the patient, encouragement of cough, and overventilation of lung with carbon dioxide are contraindicated; however, if one favors the aspiration theory, the previously mentioned measures are indicated.

It is agreed by all that if a foreign body is present in the bronchial tree, its immediate removal by bronchoscopy is imperative.

Medical Treatment:

The treatment of lung abscess is very variable. There is not any hard and fast rules one can follow in an attempt to control this suppurative process. In fact, the literature produces many conflicting ideas, but for the most part, it is fairly well established

that for the first six weeks of the disease, it is a medical problem. This period of the acute phase varies according to the man in charge from three weeks to three months. Following this initial acute stage, which can only be determined by x-ray, is the chronic stage. This phase is universally accepted as a problem for the surgeon. However, it has been advised by many men that the best possible treatment can be given only when an internist, a bronchoscopist, a roentgenologist and a surgeon are working in conjunction with each other.

In presenting this discussion on lung abscess, including acute, chronic and multiple, I have divided the treatment into four phases: (1) medical, (2) bronchoscopic, (3) artificial pneumothorax and (4) surgical for the purpose of convenience and possibly a better understanding.

The treatment to be rational must be based on the pathologic anatomy of the suppurative process, which is of several types and presents many variations, according to Hedblom (41). Indications for treatment must also be based, in each individual case, on the clinical course. Expectant treatment is indicated during the incipient stage of the abscess, and also in all cases in which there is progressive improvement and in which

the patients do not become progressively worse during a period of one or two months. Localized uncomplicated abscesses that do not show unmistakable signs of improvement after a limited time should be treated surgically.

The treatment of non-cavernous suppurative pneumonitis should be symptomatic according to B. Fantus (26). Spector's (88) patient is kept at complete bed rest during the acute stage of the disease, and H. H. Cherry (12) has found that relapses are frequent if the rest is of insufficient length of time. C. H. Nammack and A. M. Tiber (73) of Bellevue Hospital only kept the patient in bed if the rectal temperature was above 99.8° F. However, in the acute cases, the temperature will usually show a higher degree of sepsis.

J. A. Moore (66) advocates absolute bed rest and by this he means having the patient at complete rest and free from worry. He believes that it is only under these conditions that a cure in the acute stage can be hoped for; however, it is my belief that this would be difficult to entirely accomplish. It might be possible to allay the apprehensiveness of the individual regarding his pulmonary pathology, but business, family and financial concerns would probably be on the

mind of an individual who could only lie quietly in his bed and think.

In the opinion of J. S. Pritchard (83) rest is the most important factor in the treatment of lung abscess. He placed five patients on the rest regimen and four made complete recoveries in an average of from two and one-half to four months; the fifth showed excellent improvement after two months of rest and then left the institution. Eleven patients with a chronic abscess were given the same treatment and three of the eleven recovered after being placed on this treatment for from four to seven months. In the first case, abscess had existed for two years; in the second, eighteen months had elapsed since the onset of the symptoms; while the third had suffered for six months. The remainder either showed only very slight improvement or none at all.

The matter of diet is another important factor in the general treatment of these patients. C. George, Jr. (33) C. H. Nammask and A. M. Tiber (73) and J. A. Moore (66) advise giving the patients a high caloric diet with frequent feedings. H. D. Jump and F. Bauman (48) do not force fluids or food but only attempt to satisfy the wants of the patient. R. A. Kern (50) advises bitter tonics to stimulate flagging appetites and transfusions, sedatives, iron and liver preparations

for the betterment of the general condition of the patient.

Before rupture of the abscess into a bronchus or pleural cavities, there is often an irritating and non-productive cough and such men as G. O. Cummings, (20) L. Eloesser (25) C. H. Fitts (28) and others advise the judicious use of some cough depressant as one-fourth grain of codeine, or elixir of terpine hydrate. Their argument is that excessive paroxysmal coughing is pernicious, and that it tends to spread the infection. The reasons they present seem very plausible and they recognize the fact that when the cough is productive it should be uninhibited as this is the physiological mechanism of clearing the bronchial tree.

J. A. Moore (66) stimulates the cough rather than suppresses it in the early stages of the disease by the inhalation of carbon dioxide with a resulting expectoration of the secretions. This seems undesirable since the expectorated material is not purulent and the effect of the prolonged coughing would be more detrimental to the patient than beneficial effects of raising a small amount of mucous secretion.

H. P. Nelson (74) of England depresses the cough and he reasons that coughing scatters the pus through-



out the lung and is also a severe drain on a debilitated patient. His first point might have some foundation, but the beneficial effects to be arrived from the removal of the purulent material from the bronchi by coughing which is an attempt to drain the abscess seems to me to be the most important. Another point is that if the purulent material is carried to another portion of the bronchial tree, it is logical to assume that the cough reflex will be initiated at the new site so in a short time the material will eventually be expectorated. However, it is entirely possible that the infective material could be scattered into the alveoli, but C. I. Allen and J. F. Blockman (2) say that the lung is remarkably resistant to infection.

It has already been stated that the fuso-spirochaetal organism is very commonly found in lung abscess lesions. Various men have found an incidence varying from twenty to ninety-one percent; in fact, D. T. Smith (86) found the fuso-spirochaetal organism in forty out of forty-four consecutive cases. Such being the case, measures should be taken to eradicate this particular organism.

J. A. Moore (66) C. H. Fitts (28) and Alexander and Buckingham (1) along with many others advise the

use of an arsenical preparation as neoarsphenamine if the fusiform bacillus and the spirochaete is present. C. J. Heuer (46) injected neoarsphenamine in cases of primary gangrene in which the above mentioned organisms were found. The dosage he gives is nine-tenths of a gram every seventy-two hours for the more fulminating cases. He had eleven cases who recovered out of fifteen.

D. T. Smith (86) used either neoarsphenamine or sulpharsphenamine in fourteen cases. The diagnosis was made between the third day and the eighth week of the disease, and of the fourteen, thirteen were cured. On the other hand, of thirteen patients who received arsenic treatment, six months or more after the onset of their disease, none was cured but several were very much improved.

O. W. Bethea (3) in three cases used three-tenths of a gram of neoarsphenamine every four or five days and at the same time gave an intramuscular injection of sodium bismuth thioglycollate. His three patients made a prompt and complete recovery.

C. I. Allen and J. F. Blockman (2) observed that nothing more than a transient improvement resulted from the neoarsphenamine injections. K. D. Winter (100) used

arsphenamine in a chronic abscess without effect. E. C. Cutler and R. E. Gross (21) had an incidence of eighty percent of the spirochaete and fusiform bacillus. They administered four-tenths of a gram of arsphenamine as often as three times a week and in no case did they find any striking benefit from the use of this arsenical preparation. They commented that it is commonly administered in the hope that it might exert some favorable influence on the course of the disease.

From the above discussion of the use of arsenical preparations in the treatment of lung abscess, it seems safe to say that the use of the previously mentioned drug is indicated in almost every case.

We have seen that a cure can be obtained if the patient's abscess is in the acute stage. It must be remembered that after ten to fourteen days have elapsed from the onset of the disease process, the infection is always mixed. Therefore, it is reasonable to assume that in chronic lung abscesses, the removal of one of the organisms is not going to effect a cure or even benefit the patient to any gross extent. However, we are disposing of one of the most resistant organisms of this mixed infection, so that other measures should be more effective.

The use of autogenous vaccines is a much debated point, but it seems to assume more importance as the years pass. The value of a vaccine is questionable but it is relatively harmless and might possibly be of some benefit.

According to R. J. Kern (50) an autogenous vaccine is worth trying after the acute initial stage with its phenomena of sepsis is past and the lesion is to all intents and purposes a localized one. The cultures are best made from uncontaminated material obtained through a bronchoscopic aspiration rather than sputum, according to G. Tucker (92). Just how much good such a vaccine does in any particular case cannot be said, but Kern believes it is of undoubted value, especially in borderline cases and may be the determining factor in the non-operative cure of a patient.

C. J. Heuer (46) has found that large doses of vaccine, two to three cubic centimeters twice a day, have cured some lesions which were resistant to other forms of treatment. R. Ellis (24) states that vaccines are of the most value when the lesion is slow in resolving, in spite of free drainage. H. D. Jump and F. Bauman (48) have found autogenous vaccines of benefit in some cases. They also agree with Kern in refraining

from its injection during the acute stage or when a high fever and marked signs of toxemia are present. These investigators have found that the pneumococcus, staphylococcus and streptococcus infections respond the best. They begin with small doses and gradually increase with an interval between injections of four or five days.

Myerson (71) and L. Markey (60) believe that vaccines exert a beneficial effect, but as to the degree, neither one is prepared to say and D. T. Smith (86) seems to think it is of value in some cases as a supplementary treatment.

G. O. Cummings (20) used an autogenous vaccine in six patients after they had passed the peak of the sickness and begun to convalesce with no definite results.

K. D. Winter (100) injected two hundred cubic centimeters of absolute alcohol in doses of thirty-five cubic centimeters combined with sixty-five cubic centimeters of five percent dextrose solution intravenously at two day intervals. He obtained very promising results at first, but a cure was not obtained. His explanation of the action of the alcohol is that it is taken up by the reticulo-endothelial system causing an attenuation of the existing organisms and a stimulation of local antibody reaction.

C. H. Nammack and A. M. Tiber (73) of Bellevue Hospital have used guaiacol intravenously. They began its use in 1922 and by 1937 had treated about fifty cases. They have adopted a special regimen for the treatment of either acute or chronic lung abscess which is as follows:

1. Bed rest if the rectal temperature was above 99.8° F.
2. Twenty-four hour collection of sputum.
3. Temperature taken every four hours.
4. X-ray films of chest in posterior-anterior, lateral and oblique positions, which are repeated every three to four weeks.
5. Examination of teeth and careful mouth hygiene and extraction of decayed teeth if necessary.
6. Bronchoscopic examination soon after admission.
7. No tobacco or alcoholic drinks.
8. High caloric diet.
9. Intravenous injection of guaiacol every third or fourth day. All patients were given the solution until the amount of sputum was reduced, its foul odor disappeared and the general condition of the patient improved.
10. On discharge, the patient was sent to a convalescent home and not permitted to work until the roentgenograms revealed complete healing.

In their present analysis of twenty treated cases, they found that the patients felt considerably better in a very short time, owing to the subsidence of fever and cough, to the decrease of the daily sputum output and the loss of the foul odor. Serial roentgenograms showed early regression of the large area of pneumonitis surrounding the abscess cavity and later its actual disappearance. Of this, series of twenty, there were four deaths

with one as a result of a malignant neoplasm of the lung; another from a traumatic subdural hemorrhage and the other two from a recurrence of the abscess.

J. W. Miller (63) reported a case of an extensive lung abscess involving the entire right inferior lobe. The patient was first tried on guaiacol carbonate three times a day, but became progressively worse so that it was necessary to rely on other measures.

According to Cummings (20), the use of non-specific proteins in a disease that frequently runs a protracted course, in which drainage is fundamental and in which material for cultures for autogenous vaccines may easily be obtained, does not seem logical. However, he did use a non-specific substance containing albumin, lipoid and fat. This was given twice to one patient who made an uneventful recovery under basic medical treatment and postural drainage, but he seems to think that there is no reason to believe that this substance played any part in his recovery.

Very little is mentioned concerning the value of x-ray in the treatment of lung abscess. It is the opinion of L. Eloesser (25) that very mild doses of roentgen ray, one-tenth to one-twentieth of an erythema dose, are often helpful, especially in reducing the surrounding

pneumonia. He advises the cautious administration and feels that too little is better than too much. He sites several cases in which roentgen ray was used in the treatment. An operation upon a girl of eighteen seemed dangerous because of repeated attacks of pneumonia and a soft infiltrate surrounding an upper lobe abscess, so mild doses of roentgen ray were administered. The pneumonia rapidly dissolved, leaving the fibrous wall which was opened later. Another young woman with a recurrent abscess was given a large dose approaching a full erythema dose. Immediately the lung softened and broke down and the girl died.

J. W. Miller (64) sites a case in which expectoration did not entirely cease after bronchoscopy so the patient received six irradiations within a period of two months. X-ray disclosed a fibrosis of the involved area and the expectoration gradually ceased.

According to H. Brunn (7) the use of roentgen therapy to cause more rapid liquefaction of the abscess early rupture into a bronchus, clearing up of surrounding pneumonitis and delimitation of the disease is probably advantageous.

There has not been enough work done on the x-ray treatment of lung abscess, so a true valuation of this means of treatment must be deferred.



The next phase is one of the most important adjuncts to the medical treatment. Its value is almost beyond question in the acute phase in which the abscess communicates with the bronchus, according to E. E. Graham (36). There is a difference in the positions that the internists advise, but the result they seek to obtain is the same.

W. Whittenmore (99) has his patients hang their head over the side of the bed so that the abscess drains into the bronchus and then the contents may be coughed up. He has had ten percent recovery with this measure. C. I. Allen and J. F. Blockman (2) treated twelve patients with postural drainage and general supportive measures and eight were cured, one improved, one unimproved and two died. C. J. Heuer (46) believes that this method is simpler and less harmful and he had a fifty-five percent cure in one hundred and twenty-six cases.

C. H. Fitts (28) institutes postural drainage when the radiological appearance shows that the abscess is becoming more circumscribed or at times even before this. However, H. Brunn, (7) J. A. Moore (66) and B. Fantus (26) have found that postural drainage is definitely contraindicated in very sick patients, es-

pecially if they are cyanotic or have a high fever, rapid pulse and low vital capacity. In their opinion, the use of the inverted posture in such cases may result in death.

H. I. Spector (88) institutes postural drainage several times a day with the frequency of treatment and the length of time of treatment depending on the tolerance of the patient. In his series of cases the very acutely ill patients did not always tolerate postural drainage for more than a few minutes at a time.

The technique that S. U. Marietta (59) employs is to place the patient on the healthy side for five to ten minutes. This permits the purulent material to drain down into the large bronchi so that the next step, the inversion of the patient, will be more productive of further drainage. If the abscess is in the upper lobe, he has the patient sit erect for five to ten minutes before taking the position on the healthy side.

E. C. Cutler and R. E. Gross (21) placed their patients so that the abscess cavity is uppermost. The patients hung their head over the side of the bed, maintaining such a position for fifteen to twenty

minutes three times a day. In this way, two hundred to four hundred cubic centimeters of purulent exudate were commonly brought up a day and one patient raised as much as eight hundred cubic centimeters. One fact worthy of note is that the amount of drainage did not prove to have any prognostic significance.

O. W. Bethea's (3) technique is to place the patient in six different positions, in each of which the patient remains about five minutes, takes several deep breaths and voluntarily coughs a few times. The positions are (1) lying upon the back, (2) on the right side, (3) on the abdomen, (4) on the left side, (5) sitting up and (6) the knee-chest position. If the patient is too ill to assume the knee-chest position, the foot of the bed may be elevated. To me, this treatment is very inadequate and it seems inadvisable to have the patient take all of these different positions, if the site of the abscess is known.

H. V. Morlock (68) uses a special postural drainage bed in which the entire bed can be placed on an inclined plane. At first, they are placed in a position of drainage for a few minutes at a time, but the time is increased until they are constantly maintaining this position. It is Morlock's belief that if

the faulty position of drainage is used during sleep, the infected sputum may become aspirated into the alveolae, producing an acute pulmonary abscess. He concludes that the correct position for nocturnal drainage is one in which the right and left main bronchi are on the same horizontal plane, and in which the trachea is lower than the infected area. In other words, the patient should lie on the abdomen with the foot of the bed raised at least twenty degrees. However, it must be remembered that in the inverted position, an abscess in the upper lobe will not drain, so C. H. Fitts (28) advises a posture in which the bronchus leading from the affected area is dependent and that the bifurcation of the trachea is the center to which drainage is directed and not the mouth.

The amount of tilting of a bed, according to H. C. Luettt (55) varies with the condition of the patient. In large or recently ruptured abscesses, angles of eight to eleven are needed. If some of his patients found this elevation uncomfortable, they were put up at eleven degrees for one hour, two or three times daily, and then restored to five degrees for the remainder of the twenty-four hours. Many of Luettt's patients complained when the bed was first tilted of

fullness in the throat, throbbing of vessels of the neck, headaches, transient vertigo and even nausea, but all disappeared within three to four days.

L. Eloesser (25) writes that Major Shields, of Letterman General Hospital, in San Francisco, had a table constructed which was movable in three planes. The patients were strapped to this, then they could be turned into any position and the abscess brought uppermost. The patients coughed and expectorated most abundantly, but they were not benefited, but were rather the worse for their strenuous bouts of coughing.

In the opinion of H. M. Rich (84) postural drainage should not be continued more than two or three weeks unless there is good evidence that the abscess may be completely emptied by this method.

R. J. Sisson (85) does not believe that postural drainage is of much value, but L. B. Mackenzie (58) believes that adequate postural drainage is indicated in the early stages and L. Markey (60) sites a case which is fairly typical. The patient developed an abscess following pneumonia and he was in such a poor condition that it was not advisable to operate. Postural drainage along with other medical measures was begun

and four months later x-ray failed to show any evidence of the lesion.

O. W. Bethea (3) seems to think that steam inhalations containing menthol and benzoin favor drainage. S. U. Marietta (59) advises the judicious administration of expectorant cough mixtures such as potassium iodide or ammonium chloride when the sputum is viscid and difficulty is experienced in getting drainage.

R. A. Young (102) is in agreement with these men and E. C. Cutler and R. E. Gross (21) prescribe four cubic centimeters of calcerose three times per day for its beneficial effects in loosening secretions.

It will only be briefly mentioned here but a bronchoscopic examination of the bronchus which connects with the abscess will often disclose an obstruction. If the obstruction blocking the draining bronchus is removed, postural drainage will be much more efficient.

One can readily see that postural drainage is of inestimable value when the suppurative process connects with a bronchus, but one must not lose sight of the fact that the other medical measures are also necessary and a close observation of the pathological process in the lung and the condition of the patient is imperative to successful treatment.

The value of the results of medical treatment are always open to question. I know that I have found in reading the literature various men's classifications of medical and surgical treatment differ. One man may include bronchoscopy and artificial pneumothorax under medical treatment whereas the next one will say they are surgical measures. Another point which is confusing in the study of the results of treatment is the question of malignancy. Some do not include a case of lung abscess if it develops in a malignant neoplasm; whereas, others will, and the latter's mortality figures will be appreciably higher. All this confusion only leads to a misinterpretation of the value of the treatment used, and it would, undoubtedly, be better to have a standard classification for the primary condition, and the modes of treatment which can be considered medical and those which can be considered surgical.

H. Brunn (7) had two hundred and five cases, and of these one hundred and thirty-three were treated medically. Sixty-three were improved and seventy died. C. George, Jr., (33) found that thirty percent of patients recover under medical management if the abscess ruptures into a bronchus and drains freely.

Twenty-one were cured, five were unchanged and ten died in Luett's series of thirty-six cases. Both O. W. Bethea (3) and S. U. Marietta (59) had cures of fifty percent with medical management. M. Clyne and C. S. Kibler (16) had a mortality of sixty-three percent without operation.

C. H. Fitts (28) with purely medical treatment had amelioration of symptoms and signs in sixty-one percent. E. C. Cutler and R. E. Gross (21) treated forty-three cases medically and twenty were cured, seven improved, one unimproved and ten died. H. I. Spector (88) in nineteen cases with a solitary abscess had a cure in eleven cases, improvement in six and death in two.

It doesn't seem reasonable to believe that there should be such a wide variation so I think it is safe to assume that we are not dealing with the same problem in all the articles.

#### Bronchoscopy:

Bronchoscopy is one of our most valuable aids in diagnosing, in localizing and in treating lung abscess.

H. L. Kearney (49) states that bronchoscopic drainage done under local anesthesia is advisable in (1) acute abscesses which do not drain promptly and



become quickly afebrile with posture, (2) cases in which the location of the abscess is not near the periphery and (3) chronic cases where it may be a curative agent or where it may be used as an accessory to medical or surgical measures.

In the experience of Pinchin and Morlock (82) a diagnostic and therapeutic bronchoscopy can be done before a lung abscess has made communication with a bronchus, first to exclude any removable obstruction and secondly that a drainage tube may be passed along a suspicious bronchus with the hope of making communication with the abscess.

L. H. Clerk (13) agrees with the statement of Pinchin and Morlock, but states the suppurative process must be definitely localized.

If H. J. Moersch (65) finds that an abscess does not drain into a bronchus, but bulges into the bronchus, he does not hesitate to introduce an aspirator directly into the abscess but does not deem it advisable to probe into pulmonary tissue through the bronchial wall in the hope of encountering an abscess.

Bronchoscopy attempts to accomplish a cure in acute cases according to M. C. Myerson (71) through aeration, irrigation with a thinning of secretions

and aspiration. After evacuation has occurred, a collapse and obliteration of the cavity occurs and there is a replacement fibrosis.

In another article by M. C. Myerson (72) he accomplishes aeration by merely straightening out the bronchial tree down to the secondary emptying branch. A majority of cases are anerobic infections so that aeration destroys the anerobes and the odor that goes with them.

Irrigation of the abscess cavity and injection of antiseptics and other materials is a favorite method of cleaning the cavity and the bronchus. W. H. Stewart (89) injects through a bronchoscope, in the more difficult cases, a solution of silver salts such as colline or silver nitrate. Pinchin and Morlock (81) have found the most satisfactory disinfectant to be a ten percent solution of gomenol oil in olive oil or lipiodol with normal saline. R. M. Lukens (57) reports a cure with bronchoscopic aspiration and an instillation of a twenty percent solution of gomenol oil in mineral oil into the bronchus and draining bronchus. We have heard very much about the dangers of a lipiod pneumonia but Lukens reports that there was not any evidence of a broncho-pneumonia following the injection of the oil.

In the cases reported by C. J. Imperatori (47) the amount of sputum was remarkably controlled by bronchial irrigations. Patients who had from three to four cupful of sputum per day could by these irrigations be reduced to less than one cupful.

It is the belief of S. W. Harrington (40) that bronchoscopic lavage is often of great assistance in facilitating drainage, particularly of cavities centrally situated and frequently postural drainage was more efficient following the lavage.

Irrigations with a solution containing five minims of phenol and one dram of Lugol's solution in a pint of normal saline were tried first, but R. M. Lukens, W. F. Moore and E. H. Funk (56) have lately substituted two grains of trinitrophenol for the phenol and in this strength it proved non-toxic and non-irritating. They used twenty percent argyrol once, but the patient complained of not feeling as well and she coughed more, so it was discontinued. However, F. R. Herriman and F. Welker (45) used a twenty-five percent solution of argyrol without any ill effects.

A. J. S. Pinchin and H. V. Morlock (81) say that the drainage tube must be passed up the branch bronchus of drainage and, if possible, into the abscess cavity.

It is J. W. Miller's (64) belief that a bronchoscope cannot be inserted into the abscess cavity to wash out its cavity and apply medication unless an entire lobe is involved in the abscess formation, taking in part of the main bronchus or orifices to the secondary bronchi.

The value of bronchoscopic drainage over postural drainage is one where an obstruction is present and prevents adequate drainage.

P. P. Vinson (94) gets his best results with bronchoscopic drainage in cases in which there is an associated bronchial stricture. He finds that one dilation is usually sufficient to promote better drainage. However, L. H. Clerf (14) and S. U. Marietta (59) have found that a mechanical obstruction may result from inflamed mucosa, inspissated pus and likewise granulation tissue. Clerf (15) temporarily shrinks the inflamed mucosa by instilling ephedrine sulphate in normal saline.

In children, bronchoscopic drainage is carried out without anesthesia, either general or local and without sedatives according to Tucker (93) but in adults Herriman and Welker (45) give a preliminary hypodermic of morphine and atropine one hour before

drainage is to be instituted.

Herriman and Welker (45) have listed the following contraindications to treatment by bronchoscopy:

1. Fulminating suppurative pneumonitis is present.
2. Danger of rupture of an abscess which has already extended to the periphery and is likely to involve the pleura.
3. Cardiovascular disease.
4. Marked hypertension.
5. Recent severe pulmonary hemorrhage.
6. Aneurysm.

P. P. Vinson (95) had three cases in which spontaneous pneumothorax developed following bronchoscopic aspiration of a pulmonary abscess. He has found that a tiny rupture of the lung occurs as the result of the coughing and straining associated with bronchoscopic aspiration. However, these patients made uneventful recoveries.

There is considerable argument against the routine treatment of lung abscess by bronchoscopic aspiration, but W. Myer advises bronchoscopy at the earliest moment possible in every instance of beginning suppuration due to aspiration. They all admit its value in diagnosis, but question its efficiency over that of adequate postural drainage.

T. L. Case (10) says that he is unable to establish complete and adequate drainage of the cavity and that one must bear in mind the possibility of spilling

the fluid contents of the abscess into another part of the lung. His last statement seems to be entirely without foundation and even if it were true, the danger of spreading the infection by postural drainage and coughing seems infinitely greater.

I believe that bronchoscopic aspiration in itself is not sufficient but must be used in conjunction with the other medical measures.

The question as to the length of time bronchoscopic treatment should be continued is very important. It should be remembered that surgical treatment will be necessary if a cure is not brought about by other means, and the longer surgery is postponed, the less chance of a cure.

Clerf (14) says that no rule can be applied as to the number of aspirations or to the duration of treatment. The progress of the disease as recorded by frequent roentgen examinations, bronchoscopic findings, clinical observations and the quantity of pus expectorated must be the determining factors. However if there is not any improvement in the physical signs or symptoms following several bronchoscopic treatments, it does not indicate that bronchoscopy should be discontinued, as the improvement may be delayed for several

days, according to P. P. Vinson (94). W. H. Stewart (89) goes so far as to say that surgery should be resorted to only if the patient does not show any improvement after six months.

This seems an entirely too long a time, and in my opinion such a statement is very misleading. The termination of bronchoscopy should rest upon a lack of improvement in symptoms, signs, and roentgenographic findings.

The results are variable, as I have pointed out, under medical management. C. J. Imperatori (47) had seven cases and of these, two recovered and five died. Of the five, four proved to be tubercular at autopsy.

H. J. Moersch (65) reviewed nineteen cases and cures resulted in sixteen cases; surgical measures were performed on two and one died. M. C. Myerson (71) states that this type of treatment is free from injury to the patient if done by a skilled endoscopist and has no mortality.

A. J. S. Pinchin and H. V. Morlock (82) reported a cure in seventy-seven percent; probable cures in fifteen percent, no improvement in eight percent, and no mortality. Of the eight cases reported by H. L. Kearney (49) six recovered, one improved and one died.

Of the seventy-one treated by S. Yankauer (101) fifteen percent were cured, fifty percent were improved, fifteen were unimproved, ten percent went to operation and ten percent were unaccountable. Eight patients died but only two of the eight died as a result of bronchoscopy.

From these figures one can easily see that my previous statement of variability is not without foundation.

#### Artificial Pneumothorax:

M. Clyde and G. S. Kibler (16) found that pneumothorax treatment of lung abscess was advocated by Carson and Edinburgh in 1819. According to B. Goldberg and M. Biesenthal (34), there appears no mention again in the literature until 1914 when Jacobaeus reported three cases treated by this method. Lehman and Maes at about the same time cite one case. Tewksbury (90) was the first American to report its successful use in 1917.

C. J. Heuer (46) reports that patients are more likely to respond to artificial pneumothorax when (1) abscess is centrally situated, (2) it communicates with a bronchus, (3) treatment is established within three to four months of onset, (4) complete



or almost complete collapse of lung can be obtained and (5) treatment can be continued for three to four months.

There is considerable argument as to whether artificial pneumothorax has any advantages over medical management with postural and bronchoscopic drainage.

H. Lillenthal (54) does not have any objection to treatment by pneumothorax in early lung abscess, and W. B. Faulkner, Jr., (27) finds pneumothorax easy to perform and it does not aggravate the patient's condition.

F. G. Chandler (11) believes that artificial pneumothorax may be worth trying in a diffuse uncircumscribed abscess, and C. O. Giese (31) is in agreement with this. According to C. H. Harrell (39) collapse therapy is the safest, quickest and easiest form of treatment for an acute lung abscess.

Artificial pneumothorax is a dangerous therapeutic procedure, according to T. C. Case (10) and should be avoided in all but unusual cases such as bleeding or central abscess. C. A. Hedblom (43) finds that the only type of acute abscess in which it is reasonably safe to use pneumothorax is that which

is centrally situated and draining adequately.

D. B. Cole (19) is convinced that artificial pneumothorax is (1) one of the best methods of treating an acute abscess of the lung, (2) has few contraindications in acute cases if small quantities of air (fifty to two hundred cubic centimeters and never more) are injected, and (3) is successful in the treatment of peripheral abscess.

This last statement of Coles is not in agreement with any of the other men. Alexander and Buckingham's (1) statement is typical and they say that pneumothorax should not be used for those abscesses that dwell in the peripheral portion of the lung, because here adhesions form very early and prevent an adequate collapse of the lung. Empyema is the most common complication resulting from artificial pneumothorax due to a tearing of the lung at induction. Another disadvantage, according to Alexander and Buckingham (1) who are surgeons, is that any extensive pneumothorax that is unsuccessful may create a condition of great danger if drainage of the abscess should later prove necessary. The reason they give is that expansion of that part of the lung which is to be entered for drainage is limited and it must be firmly adherent to the

thoracic wall in order to prevent an empyema.

Many writers, including E. C. Cutler and R. E. Gross (21) have found that collapse of the lung reduces the size of the aperture leading from the abscess to the bronchus and thereby causes retention of exudate in the abscess, but according to C. J. Heuer (46) the purpose of pneumothorax is collapse of the cavity, so we can see that collapse of the cavity must be obtained without interfering with drainage.

In cases of multiple abscess pneumothorax collapse is ineffective because of the danger of a secondary empyema, and small abscesses do not readily drain into a bronchus.

According to H. M. Davies (23) when adhesions are the stumbling block to the success of artificial pneumothorax, it may be possible to overcome the difficulty, if they are not too universal, either by rupture or by a stretching of the finer bands by a maintenance of a constant high intra-pleural pressure or by dividing them. Davies lists three methods by which division can be accomplished. One is by the electrocautery, which is introduced into the pleural cavity through a cannula and a view of the adhesion and of

the cautery is obtained through a thoracoscope. Another way is to divide the band or bands by a special tenotome, with the field of operation and the whole procedure being made visible by the x-rays. The last method is to obtain a direct view of the adhesion by an opening made through an adjoining intercostal space and to divide it with a knife or cautery. However, all of these methods of Davies seem useless, for even if the results allow an artificial pneumothorax, a cure will not always follow. If this much surgery is to be done and adhesions are present, it seems to me that a one-stage drainage operation would be indicated.

Besides the danger of empyema, there is also the possibility of air embolus with resulting death according to D. B. Cole (19) and W. Whittenmore (99). However, the frequency of air embolus is much less than empyema.

W. D. Tewksbury (91) made the remark in 1918 that most cases of chronic pulmonary abscess will not be materially benefited by the use of pneumothorax because of the firm fibrous wall of the abscess. Piery and L. Barbier (80) cite an illustrative case in which an abscess was present for over five months. An artificial pneumothorax was induced, but was soon followed

by a purulent pleurisy and death.

The technique of artificial pneumothorax is comparatively simple, but the dangers mentioned above must be closely watched for. E.K. Geer (32) finds that the thorough use of novacaine guards against pleural shock. W. B. Faulkner, Jr. (27) places the patient in a horizontal position with the side uppermost into which the air is to be introduced. This is a precautionary measure against the possibility of a cerebral air embolus. An attempt is made to introduce the air into the pleural cavity at a point quite distant from the diseased portion so as to lessen the chances of perforating the abscess and penetrating the pleura.

The amount of air used is governed by the intrapleural pressure, the vital capacity and the subjective reaction to the air. Whenever a negative intrapleural pressure is shown on the manometer, air can be introduced with safety. If the patient experiences extreme pain, restlessness, giddiness, shortness of breath, or any other unusual sensations during the induction, the procedure should be discontinued immediately.

W. D. Tewksbury (92) injects only one hundred and fifty to two hundred cubic centimeters every two to

five days, and in his series of thirty-five cases the average number of treatments was from six to seven.

M. Clyne and C. S. Kibler (16) do not inject over three hundred cubic centimeters at the initial filling and they gradually increase this at short intervals, until full collapse is obtained. To avoid over filling fluoroscopic studies are done. C. A. Hedblom (41) finds that three hundred to five hundred cubic centimeters of filtered air can be safely injected.

W. D. Tewksbury (90) was the first American to report a cure in 1917 by artificial pneumothorax, and he successfully treated two cases. B. Goldberg and M. Biesenthal reviewed the literature in 1919 and found only nineteen patients who had been treated with artificial pneumothorax. Twelve of these had made a complete recovery, and two were reported as dead.

C. I. Allen and J. F. Blockman (2) had twenty-six cases and cures in only eight patients. Four developed empyema, six were unimproved and one died with the rest not accounted for. Five of D. B. Cole's (19) cases were successfully treated with artificial pneumothorax. One patient had a recurrence but was successfully treated with the bronchoscope. Another patient desired

operation and died following this. Two died while receiving pneumothorax - one of air embolus and the other of rupture of the abscess into the pleural cavity.

Fifty-two percent of C. J. Heuer's (46) patients were cured; nine percent were not improved and fourteen percent died. Of the sixteen cases treated by C. H. Harrel (39) nine were cured and one died. Three of the patients were later operated upon with recovery in two. W. D. Tewksbury (92) reviewed thirty-five cases of acute lung abscess in 1925 and twenty-eight recovered, three developed empyema but later recovered, and four died.

R. J. Sisson(85) reports an interesting case in which a tooth was aspirated into the lungs following an extraction. Bronchoscopy was deemed inadvisable because of peculiar location of the foreign body, but artificial pneumothorax resulted in expulsion of the foreign body and ultimate recovery.

E. K. Geer (32) states that artificial pneumothorax has several advantages over surgery. There is not any operative discomfort or shock, or protracted malodorous drainage requiring frequent dressings or any resulting chest deformity. As has been stated

before, the value of artificial pneumothorax is in the treatment of acute lung abscess, which means approximately within the first six weeks after the onset. The role that surgery plays is in the treatment of chronic lung abscess, so I cannot understand how one can say that one method is more advantageous than the other, when each method is used to treat a different phase of the disease.

#### Surgical Treatment:

The surgical measures vary from a simple interruption of the phrenic nerve to the removal of the entire lung. It is almost universally agreed that medical treatment should precede surgical, but the time of operation varies from two weeks after the onset to months. For those in the early stage operation is preferred on those who are becoming progressively worse.

H. Neuhof and A. S. W. Touroff (75 and 76) classify the operative indications as either imperative or elective. The imperative cases are the rapidly fulminating and the perforated cases. The elective indications are (1) septic or severely toxic clinical course which border on the imperative, (2) an absence of any tendency towards spontaneous subsidence, (3)



an apparently stationary lesion (in successive x-rays) coupled with a moderately severe clinical course, (4) an increase in size of lesion accompanied by increasing clinical manifestations, (5) a lesion which is more or less cut-off from the bronchial tree, (6) a potentially dangerous situation of the lesion, as in the cardiac lobe and (7) unusually large lesions and with roentgenographic evidence of pronounced pleural reaction suggesting impending perforation of the abscess.

R. A. Young (102) presents three indications for the use of phrenic avulsion. When an abscess has evacuated spontaneously, but when drainage is slightly incomplete owing to the relation of the abscess cavity to the bronchial open, phrenic avulsion which produces a rise in the diaphragm may be all that is necessary to permit gradual closing of the abscess.

Another indication is when secondary bronchiectasis is developing owing to the cicatrization and the resultant drag on the adjacent bronchi. Here, the ascent of the diaphragm may relieve the drag and prevent dilatation. The last is as a preliminary step to thoracoplasty, if such proves to be necessary.

Phrenicotomy was originally suggested by Stuertz

in 1911 and later by Sauerbruch according to C. P. Coke (18). This measure was originally intended when there was a tuberculous or bronchiectatic cavity in the lower lobe, but its field of applicability has steadily widened. Paralysis of the diaphragm on one side eliminates the pumping motion on that side and causes that one-half of this muscle to assume the position of full expiration. As the muscular atrophy progresses in the paralyzed one-half, it gradually becomes thinned out and stretched. As this occurs, it is forced upward by the negative pressure in the chest, the elasticity of the lung and the intra-abdominal pressure.

J. R. Coffey (17) secures a primary apical collapse with a phrenic neurectomy, removal of the desired amount of the first rib, cutting the long thoracic nerve and the scalenius and medius. Coffey attempted to prove that the long thoracic nerve was a nerve of respiration. Investigators before him thought that it was involved primarily in elevating and externally rotating the arm by means of the serratus anterior muscle. Therefore, the nerve of Bell was cut purposely in four radical breast operations, and he found that movement of the arm was not affec-

ted. He made tracings of several dogs' thoraces where this nerve had been severed on one side. Upon forced respiration the movement of the chest on the affected side was greatly diminished. Coffeey believes that this should be an important adjunct to a phrenic nerve avulsion.

R. B. Bettman (5) cites a case in which the patient was very markedly improved following a lobectomy, but a preliminary phrenicectomy was done so that the lung tissue would be immobilized.

G. O. Cummings (20) states that avulsion of the phrenic nerve is best suited for the treatment of parenchymal abscesses of the lower lobe, but E. C. Cutler and R. E. Gross (21) have found that results disprove this. A. J. S. Pinchin and H. V. Morlock (81) report that drainage is not so free after this operation owing to the kinking of the bronchus.

Phrenicotomy must not be thought of as excluding or replacing the traditional form of treatment according to C. P. Coke (18). It is to be used simply as a supplementary procedure to bed rest and postural drainage, or some of the other more radical measures.

H. Lillienthall (53) does not precede artificial pneumothorax with phrenic avulsion, since the para-

lyzed diaphragm is liable to be merely pushed down to its normal position or even greatly below it by the air pressure.

C. A. Hedblom (43) has found this procedure to have an advantage over pneumothorax in that it does not involve the danger of perforation of the abscess into a free pleural cavity, and it does not interfere with later thoracotomy drainage, if that should seem necessary.

Extrapleural pneumolysis is the operation of stripping the pleura from the fascia of the thoracic wall in order to allow the lung to collapse.

Tuffier, as cited by H. Davies (23) was the first to try extrapleural pneumolysis in 1910, and he endeavored to maintain the separation by air but this failed too often. He tried paraffin and later fat, but the paraffin was a foreign body and liable to produce an extrapleural effusion which distended the cavity and forced its way through the tissues and eventually escaped through the scar. Once the sinus was established, the liquid drained through it and brought with it the paraffin. The fat tended to liquify, so that it was not successful.

Alexander and Buckingham (1) report that Sauerbrach and Mittledorpf are enthusiastic about this

operation and they use paraffin to fill the space. F. P. Miller has devised a useful pneumatic bag as a filling. Roux-Berger reported three successes and two failures and he considers it best for multiple abscesses. Alexander and Buckingham (1) have employed it only once in a non-tuberculous cavitation, and used the pectoral muscles as a filling with complete success in a chronic upper lobe abscess.

F. S. Dooley (22) advocates its use in slowly progressing cases of abscess or pneumonitis and during the acute stage. He offers this method of treatment because he has found that surgical drainage in the acute stages is disastrous.

The location of the abscess with its surrounding pneumonitis is determined by x-ray and the direction of the lobar bronchus draining the involved area is determined by bronchoscopy. A site in a direct line with the bronchus draining the involved area is located at the point where the abscess is nearest the lung surface.

Under local anesthesia, short portions of three or four ribs are excised together with their intercostal bundles, leaving for the floor of the wound the parietal pleura clear of muscle, vessels and

nerves except for the periosteum of the removed ribs which are left in situ.

The parietal pleura is not freed beyond the limits of the wound, since too great collapse may interfere with bronchial drainage. The wound is packed very tightly with continuous five inch gauze and closed without drainage. The area is strapped very tightly with adhesive in order to restore as nearly as possible a solid chest wall for counter-pressure in coughing. The wound is not opened for fourteen to eighteen days unless infection demands. The wound is then opened widely and the packing is removed. It is at once repacked with gauze saturated in some antiseptic solution and left wide open. The packing is changed every two days until rib regeneration has firmly occurred with the ribs in the compressed position. If the collapse obtained by this procedure is insufficient, at a second stage another adjoining area is deprived of its ribs to obtain further collapse and still another stage if deemed advisable. Gauze compression is, however, limited to its original site.

The technique of Dooley is fairly representative of this procedure and it has been presented so that

the problem can be better understood.

Thoracoplasty is a more extensive operation than the preceding, but the same principle holds true and that is collapse of the cavity and drainage into the bronchus. This measure was first suggested by Carl Spengler in the latter part of the last century, but it was not until many years later that the operation became recognized as a practicable method of treating disease of the lung according to Davies (23).

C. A. Hedblom (43) believes that a complete extrapleural thoracoplasty is never indicated in the treatment of a single abscess of limited extent.

T. W. Buschman (9) has found this method relatively more useful in deep seated lesions than open thoracotomy drainage. C. J. Heuer (46) tried thoracoplasty in many cases of chronic multiple abscesses, in which artificial pneumothorax was impossible because of adhesions. He found that many times the purpose for which measure was undertaken was defeated, for drainage from one or several of a group of multiple abscesses may be actually obstructed by collapse.

R. H. Overholt (79) used this surgical measure

in a patient with multiple lung abscess and a fourteen months check-up disclosed an obliteration of the cavity.

In the opinion of Fitts (28) and Cutler and Gross (21) thoracoplasty is to be discouraged and G. O. Cummings (20) does not recognize it as a successful measure in the treatment of lower lobe abscesses.

Thoracoplasty does not appear to be a successful means of treatment except in isolated cases. The deformity of the chest wall is most marked and I believe that a thoracotomy operation would be more preferable in a single abscess, especially if it is near the periphery.

Thoracotomy and pneumonotomy is the most widely used procedure in the treatment of chronic lung abscess. The indications and the time for this surgical approach have already been mentioned.

Anesthesia for all of these surgical measures will be discussed here as they are very similar.

F. G. Flick (30) uses a local anesthetic, alone or in combination with nitrous oxide analgesia. He has occasionally used avertin supplemented with nitrous oxide or local anesthesia, but he considers



avertin objectionable because it diminishes the cough reflex for too long a period of time.

F. G. Chandler (11) believes it is essential to have a highly expert anesthetist, who realizes the problems of chest surgery if a general anesthetic is used.

S. E. Lambert (52) says that chloroform should never be used if ether, nitrous oxide or a local anesthesia are available.

O. H. Wangenstein (96) is strongly in favor of the local administration of novacaine, but if he contemplates using general anesthesia, he encourages the patient to evacuate the cavity insofar as possible.

T. C. Case (10) uses a combination of avertin and ether, and he starts a saline infusion before the operation and continues it throughout.

When the operation is to be in one stage or two stages depends upon one factor and that is whether adhesions are present or not. If adhesions are not present, the operation cannot be continued as there is danger of contaminating the pleura so measures must be taken to produce them.

C. O. Giese (31) has a special technique for the determination of the presence of adhesions.

They use the ordinary artificial pneumothorax outfit and introduce the needle over the suspected site of the abscess, which is determined by physical examination and x-ray. The water manometer is watched for negative pressure and oscillation. If no oscillation is secured at this point, or if oscillation both above and below zero is secured, and they are unable to affect a change in the pressure by the withdrawal or introduction of a small amount of air, they feel that they have established the presence of adhesions. They then make observations lateral to this so that the extent of the adhesions is known. The one drawback that I see to this procedure is the possibility of puncturing the abscess and producing an empyema.

H. Neuhof and A. S. W. Touroff (75) place a medicated packing against the exposed unopened parietal pleura after the excision of several ribs at the proposed site of drainage to produce adhesions.

W. Whittenmore (99) advises suturing of the two layers of pleura or a gauze pack, but he recognizes the danger in suturing of producing a pneumothorax or a pyopneumothorax. There are other preparations used but plain gauze is now considered to be sufficient. A period of four to five days are allowed

to elapse for the production of adhesions and then the second stage of the operation is done.

J. Weinberg (97) and C. A. Hedblom (42) do an exploratory puncture with an aspirating needle in order to accurately locate the abscess prior to the pneumonotomy. According to the latter, there is danger of puncturing a large blood vessel. E. A. Graham (36) and H. Lillenthal (53) never aspirate unless they are prepared to continue with the operation because of the danger of a spread of the infection. Following this, Neuhof and Touroff (75) advise the use of cautery to avoid hemorrhage and embolic phenomena and C. H. Fitts (28) leaves the needle in situ. They cauterize a sinus around the needle and down to the abscess.

O. H. Wangensteen (96) uses a slightly different technique. He places the lower one-half of a small trochar around the aspirating needle and then pushes it into the pulmonary substance to the same depth as the needle. The needle is then withdrawn and the upper one-half of the trochar is attached. The coagulating current is applied and then the lower one-half of the trochar next in size is passed over the trochar. This procedure is repeated until the

largest trochar has been introduced into the abscess cavity, and then a drainage tube is inserted through the trochar. He believes that abscesses are quickly drained in this manner and without the hazard of intratracheal bleeding or secondary hemorrhage. He has even cured multilocular abscesses by this method.

After drainage of the cavity and probing the surrounding tissue with a finger to break down any adjacent abscesses, Flick (30) advises the destruction of the wall of the abscess with the endotherm knife or the electric cautery or the soldering iron.

H. Lillenthal (53) then packs the abscess with gauze saturated with polyvalent antigangrene sera or 1:1000 acriflavine packs, or with iodoform gauze to prevent hemorrhage. He does not advise the use of rubber tubes for drainage because of the possibility of erosion of a vascular wall and hemorrhage.

Midelfart and Gale use a rubber tube, but it is just long enough to reach through the chest wall. C. A. Hedblom and others use soft rubber tubes, but J. B. Flick (30) has discontinued the use of drainage tubes except when he wishes to establish a permanent fistula. If obliteration of the cavity does not keep pace with the healing of the external

wound, Flick (30) excises the scar and repeats this if necessary and if a fistula remains after symptoms of infection have subsided, he closes the tract with a pedicle graft of muscle.

Before continuing with the other types of treatment, it would be well to mention the recent work of H. Neuhof and H. Wessler (77). They consider an acute abscess a surgical lesion and base their views on (1) the pathology of the lesion, (2) the disclosure of overlying adhesions and a localized abscess in the lung at operation and the results of operation. However, they consider all pulmonary abscesses to be peripheral and never central or hilar. This does not agree with any of the other writers who have found lesions in all places in the lung.

Lobectomy is one of the more drastic procedures for the treatment of pulmonary abscess and consists of removal of an entire lobe of the lung. Lobectomy has been reserved for those cases of chronic suppuration in which multiple abscesses are present and do not respond to other measures.

Before E. A. Graham's (35) important work in 1923 with caustic lobectomy, he reviewed the literature and showed that of forty-eight cases of lobectomy for

bronchiectasis there were only eight complete successes, and there was an actual operative mortality of fifty-two percent. He devised an operation in which it was not necessary to remove the adhesions, and this made the likelihood of an infection of the pleura more remote. He exposes the diseased lung which is adherent and burns it with a soldering iron and an anesthetic is only necessary for the first stage. The removal of the tissue is done in several stages. Graham has not encountered any hemorrhages in his successful treatment of three cases, but if hemorrhage occurs in H. F. Graham's (38) cases, he finds that it is easily controlled by packing because of the low pressure in the pulmonary artery. In 1926, E. A. Graham (37) reported thirty-four cases and there were only seven deaths. Seventy-seven percent were known to be completely well.

In 1930, F. G. Chandler (11) stated that successful lobectomy depended to a large extent upon the absence of dense adhesions. This is in direct contradiction to E. A. Graham (35) and there is still the danger of infection as Graham previously stated. Graham has found that the cavity and bronchial fistulas gradually obliterate themselves and that ex-

posure to sunlight removes the anerobic organisms which are present.

R. L. Moore (67) uses Graham's procedure and states that if the bronchi reopens, the chances of ultimate healing are very good unless a residual bronchiectasis remains.

J. V. Bohrer (6) cites a case in which lobectomy was done because of repeated lung hemorrhages and it was done in one stage because of fear of hemorrhage between the first and second operation. The pleura was contaminated but cleared up with zinc peroxide.

N. H. Bethune (4) used cautery pneumectomy and then placed maggots in the wound because of the foul odor to the discharge. The lesion eventually cleared up, but he does not believe the maggots had any beneficial effects.

K. D. Winter (100) cites another case in which all of the other procedures were carried out, but without a favorable response. A cautery pneumectomy was successfully done, and this was ten months after the onset of the disease.

It can be seen that lobectomy is a serious undertaking, but with the advent of cautery pneumec-

tomy, the mortality has been greatly decreased.

R. H. Overholt (78) reported eight cases of pneumonectomy for malignant and suppurative disease of the lung. In one of these, there is a case report on multiple abscesses in both lobes of the left lung with a stenosis of the left bronchus. Overholt considered thoracotomy and cauterization of the lung, but he was fearful of a resulting empyema. So, as the only remaining course, he amputated the lung and ligated the hilus. The pleural cavity was irrigated with Dakin's solution, and the postoperative course was uneventful.

C. I. Allen and J. F. Blockman (2) treated forty-five cases surgically and had cures in twenty-one cases, improvement in three and death ensued in twenty-one cases.

C. J. Heuer (46) has found a mortality from twenty to forty percent.

In an analysis of thirty-seven cases by Neuhof and Touroff (75) in which operation was performed within six weeks in all, twenty-two made an uneventful recovery. Midelfart and Gale (62) operated on twenty-two cases and had a mortality of fifty-two percent.



C. I. Allen and J. F. Blockman (2) collected 2,114 cases from the literature and of these fifty-one percent were treated conservatively with a mortality of thirty-four percent. Forty-nine percent were treated surgically with a mortality of thirty-four percent.

C. A. Hedblom and W. Van Hazel (44) believe that in chronic abscesses the relatively high mortality from hemorrhage, metastatic abscesses and other complications independent of the operative procedure, and the prolonged convalescence, residual damage to the lung and the residual bronchial fistula, which often remain, should be credited to injudicious conservative expectant treatment, postural drainage, bronchoscopical lavage, etc. and not to the belated drainage operation.

Convalescent Treatment:

H. Klapper (51) recommends a period of one to two years in a dry sunny climate, but it is often necessary to watch the patient continuously as he will be financially unable to convalesce in the drier climates. Klapper offers an outline of the daily routine which is used at the Burke Foundation Home. The patient rises at 6:30 A.M., walks or sits outside

until breakfast at 7:30, bed making and light cottage duties, morning papers, restricted smoking, library, games, both indoors and out, light gymnastics for some; milk at 10:00 A.M., prescribed occupation therapy from 10:30 to 11:30, rest or play till dinner at 12:30, rest hour or bed from 1:00 to 2:00 - afternoon free, but with directed mild outdoor games and various walks, recreations and occupations, supper at 5:00; evening dances and other entertainment and finally lights out at 9:00 P.M. Extra milk and olive oil are often prescribed. The diet is moderate in meat but ample and well balanced.

This is an ideal regime, but I fear that very few of the patients would be financially able to take advantage of these convalescent homes. The only alternative, periodic x-ray examinations should be done to determine whether or not the lesions is recurring and hospitalization is necessary.

### Conclusions

Pulmonary suppuration may be either of aspirated or embolic origin with oral operations being the most common cause.

The bacteria present in the lesion are multiple and variable, but the spirochaete and fusiform bacillus are present in from twenty to ninety-one percent of cases.

The type of treatment to be instituted depends upon many factors and no one method can be outlined for all patients. For the acute cases, which are those that have not been present more than six weeks, a strict regimen of medical treatment and postural drainage should be tried.

If there is progressive improvement, medical therapy should be continued and bronchoscopic drainage is a valuable ally in the conservative treatment. I am inclined to believe that if postural drainage were used continuously as Morlock advises, there would be fewer chronic cases.

Artificial pneumothorax should be given serious consideration, only if the suppurative process is near the hilus, and never if it is peripheral.

Phrenic avulsion is only important in the conjunction with other measures. Thoracotomy seems to be more successful than other surgical measures for the treatment of a chronic solitary abscess. The question as to whether a one or two stage operation is indicated depends entirely upon the presence or absence of adhesions.

Cautery pneumonectomy is a better operative procedure than lobectomy, as there is less danger of infection. The operative results have been greatly improved since E. A. Graham recommended cautery pneumonectomy for the treatment of chronic multiple lung abscess.

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