

CONTINUOUS NEGATIVE PRESSURE IN THE TREATMENT OF TUBERCULOUS
EMPYEMA AND TENSION CAVITIES

BY

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A THESIS SUBMITTED FOR THE DEGREE OF
DOCTOR OF MEDICINE

UNIVERSITY OF WISCONSIN

1940

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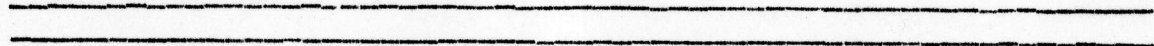
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INTRODUCTION

The unsettled problem of the treatment of tuberculous empyema is apparent to some degree from the incidence of mortality and the complications occurring in that condition. Its resistance to therapy and its uncertain prognosis invites further investigation.

Ordinary methods of treatment produce results which are especially disappointing while we are mindful of the response in the pyogenic empyemata. However, the comparison is unfair: pyogenic empyema is a disease entity, while tuberculous empyema occurs in most instances as a complication of the underlying pulmonary disease. In the former condition, all efforts may be concentrated toward the infected pleural cavity. Tuberculous empyema presents primarily the problem of control of the tuberculous processes found in the lung itself. Existing in several forms, the tuberculous empyemata have different objectives in regard to therapy. Nevertheless, the underlying diseased lung remains of fundamental importance.

"During the past few years the use of continuous negative pressure has played a progressively greater role in the treatment of thoracic diseases"¹. Actually, the measure is not new. "Iselin credits Petain as having been the first, in 1869, to practice continuous intercostal drainage by the closed method."²

During recent years several different workers have directed their studies toward the evaluation of continuous negative pressure as a

1. Curreri, A.J.: Unpublished paper. 1940.

2. Wangensteen, O.H.: Jour. Thoracic Surg., 4:399-413, 1935.

method of therapy with increasing success. The results in pyogenic infections have proven to be quite uniformly good. Those in tuberculous empyema have been varied.

Recently certain tuberculous pulmonary cavities have been observed to be unresponsive to ordinary therapeutic measures, including the more radical methods of collapse. Investigation of these has led to postulation of the reason for their persistence by Corylles.³ Various explanatory terms have been applied to these lesions, most commonly tension, or check-valve, cavities. Meanwhile use of negative pressure therapy has been gaining impetus. It has been felt that such a measure would have application in selected cases of the group, and it has been tried with varying results.

In attempt to evaluate the therapeutic usefulness and indications of continuous negative pressures, the current literature has been searched and summarized and a limited number of cases from the thoracic service of the State of Wisconsin General Hospital have been analyzed.

3. Corylles, Pol N.: Amer. Rev. Tuberc., 33:639, May 1936.

LITERATURE

A. Tuberculous Empyema.

There are two main types of tuberculous empyema: Pure, where only the tubercle bacillus can be recovered from the pus; and mixed, with pyogenic organisms also present. Increased use of induced pneumothorax¹ has multiplied the incidence of tuberculous empyema of both types. Spontaneous tuberculous pleural effusions are infrequent in comparison to the above group. They are "much more often associated with hematogenous infection from an extrapulmonary focus (bone, kidneys, glands, etc.), or from direct extension of the cold abscess pus in tuberculous caries of the vertebral bodies."²

Very little is known, however, of the mechanism of production of the exudates in tuberculous empyema, and the factors which influence their course. Coryllos contends that in pulmonary tuberculosis the production of a purulent exudate in the pleural cavity, or the change of an existing clear exudate to a purulent one, is always due to the development of pleuropulmonary fistula.³ "In proportion to the size of the fistula exists the possibility of closure, the likelihood of changed intrapleural pressure of significant degree and the threat of pyogenic superinfection."⁴

Woodruff states that the problem of all empyemas is a dual one composed of, first, the infection itself, and second, the abnormal pleural

1. Alexander, John: The Collapse Therapy of Pulmonary Tuberculosis, C. E. Thomas, 1937.
2. Ornstein, G.G. and Ulmar, I.: Quart. Bull., Sea View Hosp., 4:269-285, April 1939.
3. Coryllos, Pol N.: J. Thoracic Surg., 7:48-73, Oct. 1937.
4. Alexander, John: Op. cit.

5 space. As we shall presently see, this statement is entirely too simple.

For successful treatment of tuberculous empyema one should know whether the infection is pure or mixed, and whether there is unilateral or bilateral pulmonary tuberculosis. 6 The presence of a broncho-pleural fistula also serves as a factor in influencing treatment. 7 To determine the nature of the condition, pus should always be aspirated and cultured for pyogenic organisms, whether or not the empyema is assumed to be tuberculous. Repeated cultures with no growth are strong evidence of pure tuberculous empyema, even with thick pus, high intermittent fever, and other signs suggesting pyogenic infection. A rare exception is pure pneumococcic or other pyogenic type which has undergone auto-sterilization. These patients are usually not toxic. If pulmonary tuberculosis cannot be demonstrated and if only pyogenic organisms are found, 8 still there is a possibility of mixed tuberculous empyema.

In classifying the tuberculous empyemata, Alexander adopts the group classification of Hedblom:

- Group I No active pulmonary tuberculosis, pure tuberculous infection
- Group II No active pulmonary tuberculosis, mixed infection
- Group III Active pulmonary tuberculosis, pure tuberculous infection
- Group IV Active pulmonary tuberculosis, mixed infection.

5. Woodruff, Warriner: J. Thoracic Surg., 7:420-432, Apr.1938.

6. Alexander, John: Op. cit.

7. Ornstein, G.G. and Ulmar, D.: Op. cit.

8. Alexander, John: Op. cit.

Alexander states that most patients with pure tuberculous empyema are not very ill, except during several weeks immediately following the onset and during recrudescences of the infection. Delay of a week makes very little difference in the effect of therapy. Yet some patients are overwhelmed by the severity of the infection of the pleura, and die after a few months of toxicity and progressive debility. If the pressure of the pus in the pleural space is not great and pleural infection is mild, without symptoms of toxicity, tuberculous lesions in the underlying collapsed lung may benefit from the empyema.⁹

To be successful, management must be highly individualized in these cases. In all, the best means of treating the underlying tuberculosis must be followed, during active therapy and for many months afterward. The delay of surgical treatment must be considered in the light of its probable effects.

In Group I, the purpose of treatment is first to stop pus formation, then to cause expansion of the lung with consequent obliteration of the pleural cavity by adhesions. Alexander states that this can often be accomplished by repeated aspirations of the pus, with or without lavage and instillation of antiseptic solutions. He believes that tube drainage rarely affects active tuberculous lesions in the wall of a pure tuberculous empyema favorably, and sooner or later results in introduction of harmful pyogenic organisms. The danger of secondary infection through aspiration tract or a bronchopleural fistula in such a case is real and serious.¹⁰

9. Alexander, John: Ibid
10. Alexander, John: Ibid.

Oleothorax is recommended by some when pus keeps forming and there are mild toxic symptoms. Pus formation may be checked by this method, but desired gradual expansion of the lung is prevented and there is some danger of rupture of pus into a bronchus due to contraction of the walls on the very slowly absorbable oil. Thoracoplasty gives rise to small risk in this group, has a better prognosis than oleothorax, and usually stops pus formation by approximation of the walls.¹¹

"In pure tuberculous empyema with negative sputum, conservative treatment (aspiration, alone or with air replacement, or irrigations with saline or antiseptics) results in seven to ten per cent mortality, cures around seventy per cent, provided the amount of therapy is adequate." However the condition should be managed according to the clinical condition of the patient, the presence or absence of bronchopleural fistula and its patency, as calculated by gas analysis of the pleural air.¹²

Group II (mixed infection in the presence of no active pulmonary tuberculosis) should be treated with the purpose of evacuation of the pus, sterilization of the walls and obliteration of the cavity. Occasionally these things are accomplished by repeated aspirations with partial air replacement. Most often there is failure to sterilize the walls, even though there be temporary improvement of symptoms. This is especially true when the pyogenic organisms are staphylococcic or streptococcic. If fever remains and cultures of the pus are still positive for pyogens,

11. Alexander, John: Ibid.

12. Coryllos, Pol N.: Op. cit.

aspiration should not be continued for more than a few days in cases with symptoms of severe infection, or more than a few weeks with symptoms of mild infection. Airtight or open tube drainage should be instituted. This frequently results in progressive improvement of symptoms and likewise the general condition of the patient.

If after prolonged trial of drainage and antiseptic irrigations it is apparent that the cavity is no longer decreasing, thoracoplasty is the only chance for complete closure and elimination of pleural infection, which may incidentally result in amyloidosis.

Group III (cases with active pulmonary tuberculosis and pure tuberculous empyema superimposed) should be treated with two objectives. These are, first, stopping pus formation in the pleural cavity; and second, maintenance of collapse of the actively tuberculous lung. The simplest measure is repeated aspiration of the pus and replacement with air. Adhesions preventing collapse of cavities should be removed by closed intrapleural pneumonolysis if possible, despite the empyema, provided it is not in an acute or subacute stage. Aspiration removes much fibrin-containing fluid and debris which ordinarily deposits on the pleura, organizes, and shrinks, giving rise to obliterative pleuritis with gradual expansion of the lung. Here oleothorax has its greatest usefulness, preventing expansion, and possibly combatting pleural infection. The measure should not be used routinely, but rather reserved for cases where the above complications demand it. If pleuritis and expansion persist, despite

13. Alexander, John: Op. cit.

14. Alexander, John: Ibid.

these measures, phrenic paralysis and thoracoplasty are the measures of choice, if there are no specific contraindications. ¹⁵

Bronchopleural fistula in this group should be treated by aspiration, keeping the pleural space practically free from pus, and the intrapleural pressure at practically zero. Extensive thoracoplasty ¹⁶ frequently closes such a fistula.

¹⁷
Hedblom objects to indefinitely aspirating pure tuberculous empyema and air replacement because of the danger of secondary pyogenic infection and amyloidosis. Active pulmonary tuberculosis and virulent secondary pyogenic infection are major causes of the mortality in tuberculosis empyema, and even more so when combined.

¹⁸
Corylles states that in cases of this group the consensus of opinion favors immediate thoracoplastic collapse, with the double aim of collapsing the diseased lung and obliterating the pleural cavity. Pre-operative drainage is the only point for discussion, and is favored by him for twenty-four hours, he adds.

In Group IV (mixed empyema with active pulmonary tuberculosis) objectives of treatment should be threefold: Evacuation of the pus, sterilization of the empyema cavity, and (usually) maintenance of collapse of the diseased lung. As in group II, repeated aspirations seldom kill all of the pyogenic organisms. Closed or open drainage should be instituted early if a brief trial of aspirations fails to more than give

15. Alexander, John: Ibid

16. Alexander, John: Ibid

17. Hedblom, C.A.: J. Thoracic Surg., 2:115, 1932.

18. Corylles, Pol N.: Op. Cit.

temporary relief, without permanently eradicating the pyogenic infection. Phrenic paralysis may be used early to relax the diseased lung and reduce the size of the empyema cavity. If pyogenic infection can be abolished without tube drainage, the lung should be kept collapsed by thoracoplasty, if not contraindicated, in cases of failure of pneumothorax.

B. Bronchopleural Fistula as a Complication of Tuberculous Empyema.

Bronchopleural fistula may result from rupture of a cortical pulmonary tubercle or cavity into the pleural cavity. It sometimes is caused by breaking of pleural fluid or the oil of an oleothorax into the lung. This more readily occurs with too high intrapleural pressure, pyogenic infection of the pleura, or a diseased lung. "Spontaneous pneumothorax" and mixed tuberculous pyopneumothorax usually follows. The empyema may remain purely tuberculous for varying periods or permanently, probably due to resultant collapse sufficient to close and seal the open bronchus. For this reason it is unwise to aspirate without air replacement and cause expansion of the lung during the first weeks or months of a pure tuberculous empyema, the pus of which is not being discharged through a bronchus.

Until the empyema has been surgically drained, the amount of sputum arising from the empyema and that from the tuberculous lung cannot be determined. Where there is evidence of bronchopleural fistula, there is danger of aspiration of pleural contents with obvious complications.

19. Alexander, John: Op. cit.

20. Alexander, John: Ibid

21. Alexander, John: Ibid

22. Ornstein, G.G. and Ulmar, D.: Op. cit.

C. Results with Ordinary Measures of Therapy.

The largest series of cases obtainable for quotation in the matter of results of treatment of tuberculous empyema is Woodruff's two hundred ²³ ten cases. In this series, 28 per cent of cases of straight tuberculous infection are dead, 42 per cent are well and working. Of the cases with mixed infection, 60 per cent are dead and 17 per cent are well and working, all types of treatment having been employed.

²⁴ Corylles presented a more detailed study of eighty-five cases, seventy-five of which had mixed infection. In this series the most frequent etiology was spontaneous pneumothorax and bronchial fistula developing in the course of artificial pneumothorax, thoracic fistula, or accidental infection of an existing pure tuberculous empyema.

MORTALITY OF EMPYEMAS ACCORDING TO TREATMENT

<u>Treatment</u>	<u>No.</u>	<u>Cures</u>	<u>Per Cent</u>	<u>Deaths</u>	<u>Per Cent</u>
Thoracentesis and drain	25	4	16%	21	84%
Gregoire-Flap	2	1	50%	1	50%
Aspiration (all recent)	7	4	57%	3	43%
Thoracoplasty	44	32	72%	12	28%
Schede	7	4	57%	3	43%
Total	85	45	53%	40	47%

Thirty-eight of the patients had negative sputum, and of these nine (23.0 per cent) died. Of the remaining forty-seven with positive sputum, thirty-four (72 per cent) died.

23. Woodruff, Warriner: Op. cit.

24. Corylles, Pol N.: Quart. Bull., Sea View Hosp. 1:456, July 1936.

"Considering the severity of the prognosis of mixed infection empyema, the most conservative treatment seems to be early drainage followed by thoracoplasty. Undue delay with drainage and irrigations has given 84 per cent mortality. On the contrary, temporary irrigations with azochloramide preparatory to thoracoplasty or Schede operation have yielded excellent results."²⁵

"In routine expectant treatment, as a rule, the longer one waits the worse the condition of the patient grows. Early operation has increased cures to fifty per cent instead of twenty per cent, and has decreased mortality to twenty-five per cent instead of eighty per cent."²⁶

"With conservative treatment (aspiration, alone or with air replacement, or irrigation with saline or antiseptics), mortality is around forty per cent in pure tuberculous empyema in the presence of a positive sputum, eighty per cent for tuberculous empyema with pyogenic superinfection, and in pure tuberculous empyema with negative sputum, when adequately treated, seven to ten per cent, with cures around seventy per cent."²⁷

"In all cases of tuberculous empyema, pure or infected, best results have been obtained with radical collapse methods (thoracoplasty and Schede operations). Statistics of Hedblom, Jones and Alexander, the Committee of Tuberculous Empyema of the American Sanatorium Association, Beery, etc. showed that with thoracoplasty mortality fell to twenty-five to thirty per cent, whereas cures rose to seventy to seventy-five per cent."²⁸

- 25. Coryllos, Pol N.: Ibid
- 26. Coryllos, Pol N.: Op. cit
- 27. Coryllos, Pol. N.: Ibid
- 28. Coryllos, Pol N.: Ibid

D. Negative Pressures in Treatment of Pyogenic Empyema.

Wangensteen has stated that the treatment of pyogenic empyema
"is essentially a problem in bacteriology and physics."²⁹ More directly
stated, the problem of all empyemas consists of the infection itself,
and the abnormal pleural space.³⁰

In the treatment of pyogenic empyema continuous negative pressure
has been shown to offer several advantages. Frequently with this method
of closed drainage the empyema may be closed with rapidity. If the lung
is not effectually restrained by exudate over its visceral surface, or
its inflation is not limited by edema or exudate within the lung, expan-
sion will occur immediately. Most often, however, there is a restrain-
ing exudate over the visceral pleura. Nevertheless, closed drainage
with continuous negative pressure will bring the majority of acute
empyemas to complete healing more quickly than open drainage. By this
method there is provided an adjunct in the re-expansion of the lung in
large empyema cavities not afforded by any other mode of treatment. The
chest is preserved intact, which is mandatory in the presence of a thin
exudate, a displaceable mediastinum, or a non-adherent lung, in order to
avoid serious changes in intrapleural pressure.³¹

The mechanical features of closed tube drainage of pyogenic
empyema with the use of continuous negative pressure are important. It
has been shown that as fluid is removed from the cavity in the chest, the

29. Wangensteen, O.H.: Op. cit

30. Woodruff, Warriner: Op. cit.

31. Wangensteen, O.H.: Op. cit.

lung expansion is in concentric circles, the mid-region of the cavity on the chest wall being last obliterated. This is in contradistinction to open drainage at the most dependant point. Also it must be remembered that the diaphragm rises on the chest wall to a remarkable extent. In cases of massive empyema, the tube is inserted at the level of the fifth or sixth rib in the mid-axillary line. The tube is not disturbed for seven to fourteen days, and lavage is not indicated unless drainage is unsatisfactory.

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In a series of sixteen cases, Trethwie,³³ following the technical details just given, essentially produced brilliant results. He found that with small negative pressures of 15 to 20 oms. of water, drainage was satisfactory for one or two days, then rapidly decreased. It was found necessary to increase, by 2.5 om. of mercury, the pressure daily until 22.5 om. of mercury negative pressure, on the average, was reached. He found that such a procedure caused no significant change of pressure in the opposite pleural space. All of the cases in this series were operated within two days of the diagnosis, and the average hospital stay was only thirty-eight days. Promptly, the dyspnea, cyanosis and discomfort of the patients diminished. The average negative pressure drainage was twenty-one days in duration, the final pressure varying from 4 to 37.5 oms. of mercury.

The series just mentioned, and other results approaching their brilliance, demand trial of the continuous negative pressure method of treatment in tuberculous empyema. It would not be reasonable to expect

32. Trethwie, E.R.: Birt. Jour. Surg., XXVII, 105:58-77, July 1939.

33. Trethwie, E. R.: Ibid.

an exact correlation, in as much as the underlying tuberculous process remains the first factor, and the infection is classically chronic. Up to the present time a complete and satisfactory evaluation of continuous negative pressures in tuberculous empyema has not been made. With no intention of offering a conclusive series, a few cases will be presented to at least show justification for its further trial.

E. Tension Cavities.

A new concept of the mechanics and biology of tuberculous pulmonary cavities was demonstrated by the work of Coryllos in 1932 by radiologic means, pathological specimens, gas analysis of alveolar air and direct pressure readings of the cavities. This work has been widely accepted, and refuted by no one in print.

In review, cavities are formed by the evacuation of caseated material, leaving a hole which communicates with the exterior by one or several bronchial outlets. Ordinarily the cavity does not collapse due to its internal pressure being equal to atmospheric pressure while outside the lung the pressure is subatmospheric and equal to the negative intrapleural pressure.

Pulmonary tuberculosis begins in the bronchi which present marked lesions, allergic, proliferative and ulcerative, early in the course of the disease. These lesions often produce narrowing of the bronchial lumina. It is expected that these bronchial changes must necessarily influence the further evolution of the cavities.

34. Coryllos, Pol N.: Am. Rev. Tuberc. 33;639, May 1936.

"Bronchial outlets of a cavity may remain open; they may close, or they may become narrowed. In the last case a one-way valve mechanism may develop, allowing ingress of air during inspiratory expansion of the bronchi, while with expiratory collapse of the bronchus obstruction becomes complete and egress of air is prevented."³⁵

36

Salkin and his associates, studying blocked pulmonary cavities, found that they might be due to intracavitating (filling with fibro-gelatinous debris), extrabronchial (dense fibrosis and cicatrization incorporating the cavity and bronchial wall), and intrabronchial (obstructing plugs and tuberculous bronchitis) causes.

When the opening of a cavity remains patent, free circulation of air tends to insure free growth of the bacilli, which will be present in the sputum while their products are freely absorbed by the pulmonary lymphatics. With the occurrence of a blocked bronchus leading to a tuberculous cavity, the bacilli in the sputum will decrease, and absorption of the gaseous content of the cavity will promptly follow, resulting in shrinkage and disappearance of that cavity. If the bronchus becomes again patent, the cavity will obviously reappear. If, however, a check-valve mechanism is formed, the effect will be an obstructive emphysema, as produced by foreign bodies, tumors, or even in a functional narrowing of the bronchi as in bronchial asthma. In this case, "ordinary collapse³⁷ measures are of no avail."

35. Coryllos, Pol N.: Ibid.

36. Salkin, David, Cadden, A.V. and McIndoe, R.B.: Am. Rev. Tuberc., 34:634, Nov. 1936.

37. Eloesser, Leo: J. Thoracic Surg. 1:22, Oct. 1937.

"Novy and Soule, and more recently Loebel, Shorr and Richardson, have shown that the human tubercle bacillus is a strict aerobe; suppression of oxygen for a few days only causes its respiratory metabolism to fall to zero, and strongly injures or even kills the germ. These experimental conditions of anerobiosis are produced in a tuberculous cavity following occlusion of its bronchial outlets. In fact, oxygen is actively absorbed both by the circulating blood and the tissues and cells present in the cavities. Arrest of growth prevents formation of toxic products. This explains the rapid improvement of the patient following closure of the bronchi of the cavities." ³⁸

"Another biological effect is development of fibrous tissue. Tissue anoxemia when sufficiently pronounced and prolonged leads to fibrosis. Fibrosis does not develop in healthy parenchyma in which the nutrient circulation remains unchanged, and is not affected by collapse of the lung; on the contrary, in the diseased parenchyma where lesions of the arterioles of both circulatory systems, and especially of the bronchial one, are caused by the disease, ischaemia becomes marked and permanent, and leads to fibrosis or to necrosis according to degree."

"Thus there is a complete cycle of events leading to the arrest of the disease: Closure of bronchial outlets, disappearance of cavities, negative sputum, arrest of development of toxic products with clinical improvement of the patient and fibrosis of the lung. None of the parts of this cycle can be destroyed without destroying the succession of events."

Salkin and his associates, from their series of case studies, disagree with the belief that blocking of a draining bronchus causes healing of the cavity. Several of their cases indicated that air and fluid might pass in either direction through a cavity wall.

The needling of cavities has been used as a means of study by Coryllos. This procedure is limited to cases in which the pleural space is obliterated. In diagnosis it has been used by Eloesser, for with "no expectoration, or sputum negative for the tubercle bacillus, and the aspirated fluid positive, the cavity may be regarded as blocked."⁴⁰

In Eloesser's series of tension cavities treated by aspiration or continuous negative pressure drainage,⁴¹ the results were universally discouraging. His conclusion from the series was that other methods of attack seem necessary. "Partial or total lobectomy may become the solution to the therapy of blocked tuberculous cavities. To the present it has not been felt justifiable due to the risk."⁴² "With lobectomy the results have thus far been disastrous because of the resulting bronchial fistulas."⁴³ Interest has again been aroused in aspiration of pulmonary cavities by the report of Monaldi in Italy, who has used intermittent suction on catheters inserted through a troca-cannula procedure. He found uniform success in closing cavities, converting the sputum and aspirate from positive to an absence of bacilli, and in completing the course without fistulae. American use of this report and method

- 39. Salkin, David., Cadden, A.V. and McIndoe, R.B.: Op.Cit.
- 40. Eloesser, Leo: Op. Cit.
- 41. Eloesser, Leo: Op. Cit.
- 42. Eloesser, Leo: Op. cit.
- 43. Gurrerri, A. J.: Op. Cit.

is only now occurring, with Kupcha and Delley in California making preliminary reports which confirm Monalid.

The attempts included in this report have been independent and have not previously been reported.

of complete thoracoplasty on the left and bi-directional aspirations on the left in the chest, with a removal of 75 to 80 cc. of purulent fluid. The patient returned in November, 1938, with a persistence of the pleural cavity. The fluid on removal was shown to contain tubercle bacilli, and no organisms were demonstrable by gram stain. Upon thoracotomy was performed, a narrow zone of pneumothorax persisted, no continuous negative pressure in the chest was obtained at 15 cc. of water, gradually increasing to 20 cc. of water. The tube was gradually withdrawn and the cavity decreased rather markedly in size and depth. On the eighteenth day of February, 1939, pleura was left to have been completely and negative pressure was discontinued. The cavity partly collapsed after transfer of the patient to the chest, but expansion was again attempted, successful, and the space finally reduced to a volume of 20 cc. with the tube removed.

Mr. Richard S. was 35 years, was admitted to the State of Wisconsin General Hospital on April 14, 1939, with a left-sided progressive pleural and an old thoracotomy, a broncho-pleuro-pneumonic fistula, and a partial thoracoplasty. The case was treated with liberal drainage, but no progressive expansion was obtained from culture. On April 29th, continuous negative pressure was applied to the upper cavity, by May 1 the lung was in the same position as before this treatment was begun, and the space had disappeared and symptoms were much improved. Three

CASES FROM THE THORACIC SERVICE OF
THE STATE OF WISCONSIN GENERAL HOSPITAL

Mr. Gust, a 35 year old white male, developed a left-sided tuberculous empyema which was diagnosed in May 1937. Treatment consisted of complete thoracoplasty on the left and bi-monthly aspirations on return to the sanatorium, with a return of 75 to 80 cc. of purulent fluid. The patient returned in November, 1938, with a persistence of the empyema cavity. The fluid on smear was shown to contain tubercle bacilli, but no organisms were demonstrable by gram stain. Open thoracotomy was performed. A narrow zone of pneumothorax persisted, so continuous negative pressure by tube drainage was started at 15 cm. of water, gradually increasing to 40 cm. of water. The tube was gradually shortened and the cavity decreased rather markedly in size and depth. On the eighteenth day of February, 1939, closure was felt to have been complete and negative pressure was discontinued. The cavity partly reopened after transfer of the patient to the sanatorium, but aspiration was again attempted, succeeded, and the space finally reduced to a volume of 20 cc. with the tube removed.

Mr. Richard S. age 35 years, was admitted to the State of Wisconsin General Hospital on April 19, 1939, with a left-sided pyopneumothorax and an old thoracotomy, a broncho-pleuro-cutaneous fistula, and a partial thoracoplasty. The pus on smear contained tubercle bacilli, but no pyogenic organisms were obtained from culture. On April 29th, continuous negative pressure was applied to the empyema cavity. By May 1 the lung was in the same position as before this treatment was begun, but the sputum had disappeared and symptoms were much improved. Three

stages of thoracoplasty were performed by the end of July, 1939, with the intention of closing the fistula, continuous negative pressure affording the patient considerable relief of symptoms between operations. Staphylococci appeared in cultures of the pus following the third stage. Persistence in the use of negative pressure drainage resulted in closure of the bronchopleural fistula on September 15, 1939. On the 10th of November, 1939, the remaining ribs on the left were removed with the intention of closing the empyema cavity.

Mr. Harry K. age 34 years, had four stages of thoracoplasty and permanent phrenicotomy performed on the left between April and August, 1938, for pulmonary tuberculosis with tuberculous empyema. The empyema cavity persisted, and studies indicated the existence of an intermittent bronchopleural fistula. Aspiration yielded only slight and temporary clinical improvement. On the twenty-fourth of August, 1939, a Schede operation was performed with no marked clinical improvement. Continuous negative pressure drainage was applied with considerable improvement and diminution of the size of the empyema cavity. Further surgery was deemed advisable and a Schede revision operation, removing all but rib number twelve on the left was performed. The cavity was further reduced by aspiration to a thin sinus which remained patent at the time of discharge.

Mr. John H. age 25 years, had an apical cavity 3 by 6 cm., with infiltration below, persisting without much change after thoracoplasty. Aspiration and gentian violet instillation into the cavity apparently indicated a 'blocked' cavity. After a single further aspiration the cavity was temporarily closed, then opened to about fifty per cent later. The patient was then discharged to the sanatorium, where the cavity clos-

ed slowly.

Mr. Gerald C. age 27 years, had a large cavity extending to the apex of the right lung, from the level of the sixth rib posteriorly. Clinical studies showed the cavity to have a thick wall and stenotic bronchial communication. Aspiration gave no persistent decrease in size or air pressure of the cavity. Apicolysis and three stages of thoracoplasty were performed on the right, with disappearance of the cavity to roentgenologic examination. The patient was returned to the sanatorium.

Miss Virginia S. age 20 years, was admitted to the State of Wisconsin General Hospital with a huge apical cavity (7 by 10 cm.) The basal lung was fibrotic and bronchiectatic as the result of atelectasis. The contralateral lung was partly collapsed by an intra pleural pneumothorax. Studies determined the large cavity to be a "check-valve" type. Cavernostomy with a trocar and cannula, followed by negative pressure, aspiration of minus 5 cm. of water, produced a closure of the cavity within a week. The tube was left in place after the pressure was discontinued, and the cavity reopened to about thirty per cent of its previous size. Attempts at further collapse were abandoned because of other factors.

SUMMARY AND CONCLUSIONS

Tuberculous empyema, especially when there is a mixed pyogenic infection, is known to be a serious and often fatal condition. Treatment of this condition has not been satisfactory, partly because of the poor condition of the patients with the disease. Temporizing has only served to make the problem more serious, as in most cases any attempt to prepare the patient for surgery has resulted in his becoming an increasingly poorer risk.

Continuous negative pressures applied to tube drainage of pyogenic empyema in certain hands has resulted in brilliant clinical improvement and prompt cure of the disease. This naturally suggested application of the method in treatment of the tuberculous empyemata, especially in cases with a thick, resistant pleural surface on the wall and lung.

The method was submitted to clinical trial in a limited number of cases on the thoracic service at the State of Wisconsin General Hospital, resulting in considerable clinical improvement. In conjunction with collapse surgery, it was found to be successful in aiding a closure of the empyema cavities.

Because of the resistance of blocked cavities to collapse measures from without, the continuous negative pressure drainage method of treatment was thought to have application in selected cases, i.e. those in which the pleural space was obliterated and the cavity location was superficial. Results in these cases have been, in the limited series at the State of Wisconsin General Hospital, less gratifying, yet sufficiently successful to warrant further trial. Negative pressure drainage seems to work best as an auxiliary to other surgical collapse measures.

BIBLIOGRAPHY

1. Alexander, John: The Collapse Therapy of Pulmonary Tuberculosis. Charles C. Thomas, 1937.
2. Coryllos, Pol N.: A New Conception of Tuberculous Empyemata Based on their Pathologic Physiology. J. Thoracic Surg., 7:48-73, October 1937.
3. Coryllos, Pol N.: The Mechanics and Biology of Tuberculous Cavities. Amer. Rev. Tuberc., 33:639, May 1936.
4. Coryllos, Pol N.: The Surgery of Pulmonary Tuberculosis, Part IV, Quart. Bull., Sea View Hosp., 1:456, July 1936.
5. Curreri, A. J.: Unpublished Paper, 1940.
6. Eloesser, Leo: Blocked Cavities in Pulmonary Tuberculosis. J. Thoracic Surg., 7:1-22, October 1937.
7. Hedblom, C.A.: The Surgical Treatment of Tuberculous Empyema. J. Thoracic Surg., 2:115, 1932.
8. Ornstein, G.G. and Ulmar, D.: Tuberculous Empyema: Classification, Pathogenesis and Treatment. Quart. Bull., Sea View Hosp., 4:269-285, April 1939.
9. Trethwie, E. R.: The Treatment of Empyema Thoracic by High Negative Pressure Drainage. Brit. Med. Jour. XXVII, No. 105: 58-77, July 1939.
10. Salkin, David, Cadden, A.V. and McIndoe, R.B.: The Blocked Pulmonary Cavity. Amer. Rev. Tuberc., 34:634, Nov. 1936.
11. Wangensteen, O.H.: Observations on the Treatment of Empyema with Special Reference to Drainage and Expansion of the Lung. J. Thoracic Surg., 4:399-413, 1935.
12. Woodruff, Warriner: Tuberculous Empyema. J. Thoracic Surg., 7:420-432, April 1938.

APPROVED BY

W. S. Oatway Jr.

DATE

May 27, 1940