Acute Bronchopulmonary Suppuration: Therapy with Endoscopic Application of Oleaginous Penicillin*

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For purpose of discussion the entity of bronchopulmonary suppuration must be better defined anatomically. With the advent of improved knowledge and standardization of the bronchopulmonary segments¹ we may assume that the segment be considered the pathological unit of suppurative disease in the lung. Larger areas of pathology are made up of two or more segments up to the lobar aggregate of the component segments. The peculiar anatomical localization of bronchopulmonary suppuration, since it starts with blockage of a segmental bronchus and involves a definite segment of the lobe, makes this concept fairly acceptable and practical. The radiographic as well as the bronchoscopic manifestations of this entity both permit the possibility of using the segment as the pathological unit of suppurative disease of the lung.

Again, for purpose of better definition and in consonance with the expressions in the literature,²⁻⁷ the various disease states which have been rather loosely described as “unresolved pneumonia,” “middle lobe syndrome,” “drowned lung,” “residual interstitial pneumonia,” “partial atelectasis,” “obstructive pneumonitis,” “fibrous pneumonia,” “parenchymal fibrosis,” “focal parenchymal fibrosis,” “chronic suppurative pneumonitis,” etc., may all be fitted into the segmental pattern. These are, in all probabilities, originally due to disturbances of the normal function of the segments secondary to intrinsic or extrinsic bronchial block; and therefore different pathological manifestations of bronchial block.

The pathological changes following bronchial obstruction have been fairly well studied both clinically and pathologically⁸⁻¹⁰ and the following sequellea of such block well accepted in the literature:

1) Blockage occurs from retained exudates, transudates, or aspirates (liquids or solids). Rapid absorption of the air distal to the block occurs with creation of a vacuum which retains the viscous mass. The absence of the normal air cushion distal to the block impedes the normal expulsive efforts of the lung to free the plug. Retention of the mass in time dulls the receptors which initiate the cough reflex. The cilia in turn become powerless since the mass may be too tenacious for their efforts at removal; and the spiral musculature which molds and pushes the mass cephalad

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All the instruments mentioned in this paper are available from the George P. Filling & Sons Company, 4451 Walnut Street, Philadelphia, Pennsylvania, to whom the author has given the specifications for their manufacture.
soon becomes exhausted for the same reason. Unless the plug is removed and the normal function of the segment re-established, we enter the first phase of bronchopulmonary segmental pathology—atelectasis. This phase may be considered reversible since the pathological changes are absent or mild.

2) Once the normal respiratory function of the segment is altered by block, the retained semi-liquid mass inspissates and coagulates in the bronchus and alveoli to make the segment fairly solid and thus further decrease its ability to regain its function. Pressure from the contiguous healthy segments closes off or impedes the normal lymphatic and capillary circulation and at the same time cuts down or nullifies the venous return with creation of passive congestion and transudation of fluids. Now even the normal defense of phagocytosis and lymphatic absorption of the offending mass is no longer operative. The segment becomes, to all intents and purposes, a dead unit which in time may undergo fibrosis or carnegification never to recover its respiratory function.

3) If there is a predominance of the proper organisms; or if the destructive processes to be described are fulminating, acute abscess may form. In cases where the body survives the toxemia and self-drainage is established a chronic lung abscess results.

4) The pathological process in the segment may alter the mucosa resulting in edema, erosion, ulceration, granulation, and eventually destruction of the muscularis, cartilage, and elastic tissue with resulting ectasia. Modified epithelium relines the damaged bronchus with the establishment of irreversible bronchiectasis.

In view of the pathological sequence of events just described, it would appear that the entities presently recognized by various terms and syndromes could be grouped into three distinct categories which center about the concept of the bronchopulmonary segment as the initial focus and pathological unit of bronchopulmonary disease:

1) Acute suppurative segmental bronchopneumonitis, obstructive in type. (Acute suppurative atelectasis, acute bronchopulmonary suppuration, acute abscess.)

2) Chronic fibrous-segmental bronchopneumonitis, obstructive in type. (Segmental fibrosis, carnegification, chronic atelectasis, chronic interstitial pneumonitis.)

3) Chronic suppurative segmental bronchopneumonitis, obstructive in type. (Chronic abscess, bronchiectasis, chronic suppurative pneumonitis.)

Since this paper is primarily concerned with the therapy of the acute phase of bronchopulmonary suppuration, no attempt will be made to further discuss the chronic phases of this entity except to state that its therapy is in the realm of extirpative surgery.

The Clinical Phase of Acute Suppurative Segmental Bronchopneumonitis

Clinically acute suppurative segmental bronchopulmonary pneumonitis is an acute illness which is characterized by chills, fever of the septic type, cough, expectoration, pleuritic pain, dyspnoea and hemoptysis which may
be either frank or characterized by streaked spittles. Malaise and the usual concomitants of systemic toxemia are also present. Pleuritic pain, dyspnoea, and hemoptysis may not be present. In some patients the constitutional symptoms may be absent and the entity discovered on a routine film following acute episode of lower respiratory infection. The physical signs may be entirely absent unless the segment involved lies superficially, when dullness and deep-seated rales are noted. At times an associated effusion may be present. Leukocytosis is usually found and in patients with a paucity of symptoms the count may even be normal. The sedimentation rate is usually accelerated; yet it too may be normal in patients with few symptoms. When this is the case it is assumed that the block is intermittent and the toxemia present only during the intervals of block. The x-ray picture is characteristic and present in all cases. This shows a constant opacity confined to a bronchopulmonary segment. Gravitational forces do not seem effective in confining the process to the dependent portions of the lungs as it may be commonly seen in the upper lobes. No segment may be specifically spared. Oblique and lateral studies must be made to supplement the routine film for proper evaluation as the segment must be viewed in its proper anatomical and dimensional relationship to the rest of the lung for proper diagnosis and identification.

The bronchoscopic picture is needed to round out the diagnosis. This may show pus oozing from the involved bronchus; though on occasions no pus is seen and seriatim aspiration of each segmental bronchus in the area must be made before pus can be detected. In the cases studied the mucosa was almost always more or less normal except for the visible excessive purulent secretions which were seen on the surface. With the exception of the pus the bronchoscopic picture cannot be considered pathognomonic. On Papanicolaou stain the aspirated secretions show numerous polymorphonuclears in their normal state or exhibiting various stages of degeneration. Normal cellular components such as ciliated cells and macrophages were frequently seen in small numbers. On direct smears the secretions were found relatively free of organisms though some cases presented numerous pneumococci.

The Rationale of Endobronchial Application of Oleaginous Penicillin.

Interest in the present method of treatment evolved with the discovery that antibiotics could be safely introduced into the lungs by aerosol techniques. This new portal of therapy became rather wide-spread since it could be used at home by the patient and was recommended for practically any bronchopulmonary infection for either definitive or palliative therapy. Careful consideration was given this technique for possible use in focal bronchopulmonary suppurations but the conclusion reached that there were several distinct disadvantages to the method for these purposes. First it was felt that diagnostic bronchoscopy was in order to definitely make the diagnosis and rule out other pathology such as a foreign body or neoplasm. Secondly it was felt that since acute bronchopulmonary suppuration presupposed a focus with a plugged bronchus and absent or
deficient respiratory function of the segment, the introduction of an antibiotic nebulum in the respiratory tract permitted very little of it to enter the diseased area.11 Again, on the assumption that absorption occurred from the entire vascular pulmonary bed, very little of the blood-borne antibiotic would concentrate in the diseased segment because of its relative avascularity. It was decided that this was the reason for failure of the parenteral or aerosol administrations of antibiotics in the cases studied.

It was noticed that lipiodol whose viscosity closely approximates that of penicillin in oleaginous medium could be introduced bronchoscopically into selected bronchi and would remain in the normal or even abnormal lung for long periods of time up to six months. The use of oleaginous penicillin in the same manner for focal therapy immediately suggested itself. The next step was to test the tolerance of the bronchi and alveoli to its instillation. This was done in the human subject with very little quantities and the amount gradually increased to three and four cubic centimeters with no untowarded local or systemic results. The control patients were followed with x-ray studies as well as clinical observation. The original studies were conducted on known bronchiectatics and later on cases of bronchopulmonary suppuration. It may be stated parenthetically that this procedure in well-established bronchiectasis has been found useful in thinning the secretions, abating the symptoms, and preparing patients for surgery. Some patients experienced a marked increase in weight and freedom from toxemia but long-range study soon limited its use only to preoperative preparation of the poor-risk patient. An interesting complication was the development of a rather severe penicillin reaction of an urticarial type two weeks following endobronchial instillation.

At body temperature penicillin in oil retains a fair viscosity and appears to remain in situ even after cough with very little loss. To detect the drug in the spittles, the preparation was dyed with Sudan III which gave it an orange color. Very little appeared in the sputum. At times none was noted in spite of the fact that the patient was alerted to watch for the orange discoloration. Bronchoscopically it was noted that if the instillation is made deep into the involved bronchus, the preparation cannot be seen oozing from the area even after the lapse of some time.

**Method of Application of the Penicillin and the Instruments Used:**

To facilitate the introduction of the penicillin a special applicator was designed which fitted a standard luer-lok syringe. The length was 50 cms. The tip was of the velvet eye type (Jackson) to render it atraumatic. The diameter was about 2 mm. The proximal end was fashioned with a bayonet curve so that unimpeded vision could be had to accurately place the tip. For “around the corner” work a second applicator was designed which had the same general characteristics except that it was fitted with a curved spiral tip. Bronchoscopy was under local anesthesia by a method developed by the author.12 It was discovered that a 2 cc. syringe was better than a 5 or 10 cc. since the latter “froze” when used with oleaginous penicillin.
Case 1, Figures 1-5: (Rev. D.) Acute lung abscess with cavitation of two weeks duration. Treated since onset with terramycin. Involvement of the anterior bronchopulmonary segment of the right upper lobe.

Figure 1: Film taken just prior to the endobronchial instillation of a single dose of 600,000 units of oleaginous penicillin. — Figure 2: Two days later, showing the decrease in the size of the abscess cavity and the parenchymal inflammatory mass. — Figure 3: Four days later, showing closure of the cavity and marked decrease in the parenchymal reaction.
During the bronchoscopy the area under suspicion is carefully inspected and at times the bronchus concerned can be readily identified by the pus which oozes from its orifice. However, this is not always the case and each visible segmental bronchus must be aspirated seriatim until pus is obtained. On occasions pus was obtained from several adjacent bronchi in which case instillation was made in each as it was difficult to tell whether pus had been aspirated from a diseased segment into a normal segment or whether two segments were involved. For aspiration a special specimen collector was designed which permitted collection of very small quantities.
Case 2, Figures 1-3: (M.M.) Acute bronchopulmonary suppuration of two weeks duration with no prior therapy. Process confined to the medial bronchopulmonary segment of the right middle lobe.
of pus. Coarse collectors are not recommended as they will not enter deeply into the bronchi and pus will be lost in the collecting system and cannot be easily handled for special studies. Once pus is obtained, the bronchi is identified for the introduction of the penicillin. The amount of penicillin was arbitrarily chosen and usually amounted to 2 or 3 cc. representing 600,000 to 900,000 units. Under direct vision the tip of the applicator is placed into the bronchus and gently introduced until it stops. No pressure must be used as the structures at these levels are delicate and perforation may occur. The patient is asked to take deep breaths and the penicillin slowly introduced. Haste will result in regurgitation of the preparation from the bronchus. Slow introduction permits it to be "breathed" into the segment and aspirated into the diseased area as the segment has partially recovered its respiratory function following the removal of the pus. When the syringe is empty, the full dose has not been introduced since about 1 cc. remains in the applicator proper. The syringe is disconnected, filled with air and the air gradually injected. This process is repeated several times so that the residual penicillin in the applicator is also introduced thus assuring the patient of the full intended dosage.

Material Studied:

The material studied consisted of 10 patients with bronchopulmonary suppuration of the segmental type. One had an associated basal serosanguinous effusion which complicated the primary diagnosis. Another had a typical segmental lesion which differed from the others in that the mucosa was an intense crimson red and very velvety. Routine smear showed that the secretions teemed with tubercle bacilli. The acute phase of this patient as well as the results with endobronchial penicillin paralleled the course of the others and hence was included in the series. It is interesting to note that the lesions occurred in the left lower lobe. It is further interesting to note that suppuration in endobronchial tuberculosis may mask the underlying diseases and shows the importance of routine smear for tubercle bacilli in all patients.

The acute symptomatology of most of the patients began and persisted from one week to four weeks prior to bronchoscopy and penicillin instillation. A definite history of specific antecedent disease was not at all characteristic. All had been treated for such indefinite entities as "colds," "bronchitis," "virus infection," "grippe," etc. All the patients, however, had had the benefit of thorough treatment with penicillin, aureomycin, terramycin, etc. Several had penicillin aerosol. Several of the patients gave a history of repeated attacks of "pneumonia" or "bronchitis." Weight loss was characteristic of the majority during the acute phase of the disease. Constitutional symptoms varied from temperatures of 104 degrees F. with associated chills and signs of sepsis to mild pyrexia with few symptoms except cough and expectoration which appeared to be constantly present in all cases. About 50 per cent of the patients looked and were rather ill. Hemoptysis was present in four and varied from frank bleeding to streaked sputa. Accelerated sedimentation rates were present in almost all cases.
though some were normal. Leukocytosis was seen in seven cases. X-ray film studies showed lesions characteristic of bronchopulmonary suppuration of the segmental type in all cases. These lesions were located anatomically as follows: Right upper lobe 3, right middle lobe 3, right lower lobe 2, left upper lobe 0, left lower lobe 2.

Results:

It was quite striking to see the almost immediate improvement both in the temperatures as well as the cough and expectoration in each of the patients thus treated. At times a rather dramatic result was noted in

Case No. 3, Figures 1-4: (M.K.) Acute bronchopulmonary suppuration confined to the anterior bronchopulmonary segment of the right upper lobe of one week duration. Patient on parenteral penicillin therapy.

FIGURE 1
CASE 3, Figure 1: Film taken at the time parenteral penicillin began, 300,000 units daily.—Figure 2: Film taken after 10 days trial at parenteral penicillin. Note increase in the size of the lesion. Endobronchial penicillin begun on this date—one instillation of 900,000 units.

FIGURE 3
CASE 3, Figure 3: Film taken seven days following the instillation of endobronchial penicillin. Note the marked change in the size of the lesion and reappearance of radiolucency of the area involved.—Figure 4: Film taken three weeks later. There is almost complete resolution of the original lesion.
from one to two days. In most cases the temperature dropped to almost normal on the day following the endobronchial penicillin instillation. Three cases had a slow temperature drop which took a week to become normal. Two of these latter cases required a second aspiration and penicillin instillation. The morbidity as judged by the temperature was never longer than one week in any of the series. X-ray film evidence showed clearing of the lesions in one week in most cases; in a few it took two weeks and in the more severe, three weeks. The reversion of the sedimentation rate to normal grossly paralleled the time required to clear the x-ray picture. The amount of secretions or their type apparently had no bearing on the severity of the lesion. One patient with 15 cc. of puru-sanguinous secretions had a clear x-ray film in one week and the acute symptoms subsided in two days. On the other hand a patient with only 2 cc. took one week before she was temperature free and the x-ray film cleared in three weeks. Follow-up bronchograms were done on six of the series and definite mild segmental bronchiectasis diagnosed in one.

Discussion

The chain of events which follows obstruction of a segmental bronchus is due to disturbance of the normal expulsive and excretory forces of the segment. Pathological increase in the size of the lesion is additive by involvement of contiguous segments by the same secretions of the original focus. The causative factor therefore must be considered one of mechanical block with the cause of the obstruction an exudate, transudate, or aspirate. Extrinsic pressure by glandular enlargements has been fairly well proved in the case of the middle lobe but the same cannot be said of other areas. Bronchostenosis as an etiological factor is acceptable theoretically but the fact remains that in the acute cases it is rarely, if ever, seen bronchoscopically and in pathological specimens may well be due to the end result of the suppurative process.

As can be readily seen the source of the offending semiliquid mass in the segmental bronchus will be rather difficult to determine since any of the following may be operative: Postnasal drip (sinusitis); exudates secondary to any of the lower respiratory infections; foreign bodies that are not removed early; residual clots in the bronchi following pulmonary hemorrhage; inspissated secretions following the use of atropine and heavy sedation; lipid products following the use of nose drops.

A fundamental question to be settled is whether or not we are justified in the large scale use of cough depressants on the theoretical and practical basis that all coughs are to be stopped. Certainly we know that anatomically the tracheobronchial tree is a cul-de-sac with a countergavitational pathway for excretion; we are aware that infections in this area are characterized by a bronchorrhea with secretions of varying viscosities; and again we are familiar with the end results of retention and block in the bronchial tree. And yet, in spite of all this fundamental knowledge, the practice of medicine in the realm of cough control goes counter to the basic principle that these secretions must be removed by the normal
defense mechanisms of excretion inherent in all lungs. We routinely pre-
scribe drugs which definitely depress the cough reflex, suppress the excre-
tory mechanisms at the segmental level, and even inspissate the secretions!
In children especially is the habit of cough elimination dangerous since
the viscosity of the secretions is the same as in the adult and yet the
bronchial lumina are proportionately much smaller.

Early diagnosis of acute suppurative segmental bronchopneumonitis and
its treatment will prevent the chronic sequellae\textsuperscript{3-8} of this entity which is
responsible for so large a proportion of all chronic pulmonary disease.

SUMMARY

1) The clinical entity of acute bronchopulmonary suppuration is better
classified as \textit{acute suppurative segmental bronchopneumonitis, obstructive
in type} since the primary focus is the bronchopulmonary segment which
may be considered the pathological unit. This concept is also in harmony
with the radiological as well as the bronchological aspects of this disease.

2) Antibiotic therapy via parenteral as well as aerosol route has not been
particularly effective in the author’s experience in the treatment of the
acute phase of this disease.

3) A new method of endobronchial instillation of oleaginous penicillin
directly into the segmental bronchus involved is described as are the
instruments required for this procedure.

4) A series of 10 patients with acute suppurative segmental broncho-
pulmonary pneumonitis, obstructive in type, in which this method was
used with rather dramatic results is reported.

5) The method is also recommended for “poor-risk” patients of chronic
suppurative bronchopneumonitis prior to definitive surgery.

6) Early therapy of acute suppurative segmental bronchopneumonitis,
obstructive in type, with endobronchial penicillin is a powerful prophylactic
method for avoiding the chronic sequellae of this entity.

RESUMEN

1) La entidad clínica de la supuración aguda broncopulmonar, se clas-
ifica mejor como bronconeumonitis supurativa segmentaria de forma ob-
structiva, puesto que el foco primario es al segmento broncopulmonar que
puede ser considerado como la unidad patológica. Este concepto está
también en armonía con los aspectos radiológicos, así como el bronco-
lógico de la enfermedad.

2) El tratamiento por los antibióticos por vía parenteral así como por
los aerosoles, ha sido especialmente efectivo según la experiencia del autor
en esta enfermedad aguda.

3) Un método nuevo de instilación de penicilina oleaginosa directamente
dentro del bronquio segmentario comprometido se describe, así como los
instrumentos requeridos para este propósito.

4) Se refieren los casos de diez enfermos con bronconeumonitis aguda
supurativa segmentaria de forma obstructiva, tratados con este método
con resultados espectaculares.

5) El método es también recomendado’ para los enfermos considerados
como “malos riesgos” de bronconeumonitis supurativa aguda, antes de
emprender la cirugía.

6) El tratamiento precoz de la bronconeumonitis aguda supurativa segmentaria de forma obstructiva, por medio de la penicilina endobronquial, es un método profiláctico para evitar las secuelas crónicas de esta enfermedad.

RESUME

1) La suppuration bronchopulmonaire aigue serait mieux désignée comme bronchopneumonie aigue suppurative segmentaire, à type obstructif. Le foyer primitif et anatomiquement défini est en effet le segment bronchopulmonaire. Cette conception est également en accord avec les aspects radiologiques et bronchologiques de l'affection.

2) Selon l'expérience de l'auteur, la thérapeutique antibiotique par voie parentérale ou par aérosols, n'a pas été particulièrement efficace dans le traitement de la phase aigue de cette affection.

3) L'auteur décrit une nouvel le méthode d'instillation endobronchiale de pénicilline hulleuse, ainsi que les instruments utilisés pour cette technique.

4) L'auteur rapporte les observations de 10 malades atteints de bronchopneumonies suppurative segmentaire à type obstructif, chez lesquels ce traitement fut appliqué avec des résultats assez impressionnants.

5) Le procédé est également recommandé chez les malades moins dangereusement atteints, porteur de bronchopneumonie suppurative chronique avant qu'ils ne subissent l'intervention chirurgicale.

6) Le traitement précoce de la bronchopneumonie aigue suppurative segmentaire à type obstructif avec la pénicilline endobronchique est une méthode efficace pour assurer la prophylaxie des séquelles chroniques de cette affection.

REFERENCES