The Physiological Significance of Bronchiectasis*

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Bronchiectasis is a disease characterized by pathological enlargement of one or more bronchi or bronchioles. The dilatation per se, however, is not the most important pathological factor. The dilatation is only the demonstrable effect of a pathological process which damages the tissues of the lungs and bronchi sufficiently to interfere with their function.

**Pathology**

Examination of bronchiectatic bronchi reveals the loss of normal columnar ciliated epithelium. This is replaced in some instances by purely cicatricial tissue, and in others by a stratified squamous cell epithelium. The basement membrane of the mucosa is likewise destroyed or damaged, and elastic tissue fibers disappear. The submucosa, normally a loose fatty connective tissue, becomes densely fibrotic and rigid. In the immediately adjoining lung parenchyma there appears to be laid down additional fibrosis which adds to the thickness and rigidity of the bronchial wall.

Associated with bronchiectasis one finds varying degrees of pulmonary atelectasis, pneumonitis and sclerosis. In advanced cases the affected lobe or lobule may be small, firm and contracted. There is no absolute knowledge as to whether the bronchiectasis is advanced because it exists in such a lobe, or whether the advanced bronchiectasis causes the lobe to assume these characteristics. If impairment of function is considered, it appears probable that each factor plays upon the other, producing a progressive and vicious cycle of events.

**Physiology**

To visualize the importance of the cleansing mechanism of the lungs and bronchi, observe a wire screen through which an exhaust fan has been blowing for a few days or weeks. Or consider a filter removed from an air conditioning unit after a season's use. It is the same air passing through each that must be inhaled, and it is apparent that without an effective means of self cleans-

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ing, the bronchi would become completely clogged within the first few months of life.

The major air passages from the trachea to the bronchioles are normally supplied with a columnar ciliated epithelium, and mucous and serous glands. Foreign particulate matter is enveloped in mucus and steadily swept towards the larynx by the cilia. A portion of the dust, dirt and pathogenic organisms is disposed of in this manner.

Peristaltic waves have been observed in the bronchi and are thought by some to play a part in the evacuation of secretions containing foreign or noxious matter.

Phagocytic leukocytes have been shown to ingest particles which reach the alveoli, and, with an ameboid type of movement, to pass through the alveolar walls to enter the lymphatic streams. Through one system of lymphatic channels the undesired particles are carried to and deposited in the lymphatic glands located at the various bifurcations of the bronchial tree. Through the other, they are carried towards the periphery of the lung to be deposited beneath the pleura.

Perhaps the most important of all the protective mechanisms is the cough reflex, stimulated by the presence of a foreign substance in contact with the sensitive bronchial mucous membrane, or by the exclusion of air from a bronchus, as by the insertion of a bougie or the presence of a foreign body, a tumor or plug of mucus. The cough itself is picturesquely described by Chevalier Jackson as consisting of "the tussive squeeze and the bechic blast," which implies the necessity of air passing beyond the material to be evacuated (into alveolar air spaces) in order to provide the motivating force for its movement towards the mouth.

Consideration of the anatomical pathology found in bronchiectasis indicates at once the functional impairment to be overcome. The ciliated epithelium is destroyed and is not replaced. The rigidity of the walls of bronchiectatic bronchi precludes any possibility of bronchial peristalsis taking place. The atelectasis, pneumonitis or sclerosis of the surrounding lung parenchyma prevents the admission of air which would play an important role in the expulsion of mucus, pus or foreign material from the damaged bronchi through the medium of coughing. These bronchi, then, are inert receptacles which will retain and which will not expell infection and its byproducts without help. They are truly the "cesspools of the lungs."

It is to be expected that bronchiectasis should be a progressive disease. In an involved lobe the retention of infection produces further destruction of and damage to the tissues of the bronchi and lung parenchyma. With increasing fibrosis and rigidity of
the bronchial walls and lung parenchyma, drainage by means of coughing is still further impaired. Unless measures are taken to prevent it, the constant presence of infected secretions overflowing into adjoining bronchi, or being coughed into distant bronchi, constitutes a menace to previously healthy and normal bronchi.

**Etiology**

Several theories have been put forth regarding the mechanism which produces ectasia of the bronchi. Barring congenital anomalies, all of them contain two factors in common with one another: infection plus interference with the normal mechanism of bronchial cleansing.

The “mechanical pressure of stagnant secretions” of Laennec implies bronchial obstruction, whether it be due to a foreign body, neoplasm, luetic or tuberculous stricture, or sticky mucoid secretions. Broncholiths, collections of detritus and the closure of bronchi due to pressure are also agents which contribute to the development of bronchiectasis in the presence of infection.

The theory of “nutritional changes in the bronchial wall” proposed by Andral suggests a malfunction of the cilia and impairment of resistance of the tissues to infection. More recent observations on the value of Vitamin A in the healing of bronchial ulcers lends some support to the idea that susceptible bronchi are unhealthy or lack normal metabolism.

Stokes writes of the paralysis of the circular muscle fibers of the bronchi with subsequent loss of ciliary action and atrophy of the musculature as an etiological factor.

Pulmonary fibrosis or “cirrhosis pulmonum” was a principal factor in the production of bronchiectasis according to Corrigan, although it was his belief that the enlargement of the bronchi occurred as a result of direct pulsion or traction upon the bronchi. It is equally logical to assume that the fibrotic lung interferes with the cough mechanism sufficiently to interfere with bronchial drainage. Indeed, we have repeatedly seen bronchiectasis develop in the region of a thickened and immobile pleura following chronic empyema.

We have been still further impressed with the importance of impairment of bronchial cleansing in the production of bronchiectasis in a group of over two hundred patients (to be reported in detail in another communication) who had suffered exposures to mustard gas in the last war of exposures of sufficient severity to cause chemical burns of the bronchial mucous membrane with destruction of the ciliated epithelium. We have had the opportunity to make bronchograms on all of these patients, some of them repeatedly over the past four years, and to bronchoscope
many of them, taking biopsies of the bronchial lining. All of the
denman patients with proved exposure have developed a severe bronchitis
characterized in the bronchograms by a roughening of the bron-
chial contours. A large majority of them are developing bron-
chietasis. Several have asthmatic symptoms with the production
of a marked pulmonary emphysema.

It is significant to note that those patients with impaired
bronchial drainage as indicated by loss of ciliated epithelium from
the biopsy specimens and roughening of the bronchial walls on
bronchograms suffer as severe symptoms and disability as do
those who show evidence of true cylindrical and saccular dilata-
tions of the bronchi. It forms the basis for our contention that
the dilatation per se is not so important a factor as the functional
impairment in bronchiectasis.

Diagnosis

It is not within the scope of this paper to discuss in detail the
diagnosis of bronchiectasis. The characteristic history, physical
findings and laboratory data are well described in many text books.

We would like to emphasize, however, the importance of good
bronchograms in proving the diagnosis. Since bronchiectasis may
exist in isolated segments, a good distribution of oil must be
obtained. It should be so introduced and the patient sufficiently
anesthetized that it is possible to fill the bronchial tree without
producing a cough which clouds the picture by blowing oil into
the alveoli. The x-ray films must be sufficiently penetrated to
show the iodized oil through the heart shadow and behind the
diaphragm. The patient should be positioned so it is possible to
identify each affected segment of each lobe.

Having tried all known methods of making bronchograms, the
authors have found the "dribble method" as effective as any of
the more complicated procedures, at the same time causing less
discomfort to the patient and requiring a minimum of time. The
procedure consists of simple seating the patient on a stool in front
of a fluoroscope and dribbling two eyedropperfuls of one half per
cent pontocaine through one nostril while the tongue is held ex-
tended and the patient breathes through his mouth. The solution
is directed by tilting the patient laterally, first to the right and
then to the left. Immediately following this, the warmed iodized
oil is slowly instilled in the same fashion over the course previously
anesthetized by the pontocaine. When fluoroscopy shows that
the desired bronchi have been well filled, appropriate x-ray films
are immediately made.

In our experience, if bronchiectasis is present it can usually be
demonstrated at one sitting with the use of 20 cc. of iodized oil.
This is adequate to fill the lower lobe, middle lobe and lower branches of the upper lobe on the right, together with the entire lower lobe, lingula and a few other branches of the upper lobe on the left. At this original examination the right lung is filled first so that a right lateral film will demonstrate the lobar and segmental distribution of the oil without interference from shadows in the contralateral lung. It is much easier to identify the bronchi on the left from the ensuing postero-anterior film, at least adequately for the original diagnosis. When resection is contemplated, the bronchograms are readily repeated directing the oil into those branches not previously filled and making the appropriate films to demonstrate the segmental distribution of the bronchiectasis present.

We are beginning to believe that when some type of resection is anticipated from the start, it is perhaps best to fill one lung completely and obtain postero-anterior and straight lateral x-ray films, followed in a few days by this same procedure on the contralateral side. This gives us our best conception of the segmental distribution of pulmonary disease. Utilizing a procedure as simple as the “dribble method,” requiring less than 15 minutes, there is no objection to this very effective two stage procedure.

Treatment

Medical treatment of bronchiectasis consists of a routine of mechanical aid to the cleansing of the bronchi, combined with appropriate chemotherapy, and general support. Postural drainage at frequent intervals is essential, supplemented by expectorants such as ammonium chloride, gr. LX, daily and a high fluid intake to keep the bronchi moist. Since the damaged bronchi are incapable of rejecting the coal tar by-products of smoke, the patient cannot indulge in smoking. Repeated bronchoscopic aspirations of secretions are useful in some advanced cases. The choice of sulfa drugs, penicillin or streptomycin depends upon the flora demonstrated in sputum cultures, but all are reserved for those periods during which the patient most greatly needs them. General resistance is maintained by assuring the patient a high red blood cell count and hemoglobin, high protein and adequate vitamin intake.

Surgical therapy consists of removing involved lobes or segments of lobes after complete mapping of the bronchial tree with bronchograms indicates that the disease process is limited to areas of not too great extent to be totally excised. The advent of segmental resection has enlarged the group of patients who may be permanently relieved of their disease by surgical means.

All forms of collapse therapy are to be condemned as dangerous
and ineffective, except the occasional use of a temporary phrenic nerve interruption to check hemoptysis.

**SUMMARY**

The enlargement of the bronchi is not the significant aspect of the disease called bronchiectasis. Of greater importance is the loss of the cleansing mechanism of the bronchii, leading to the retention of infection, mucus and foreign matter. Retention causes progression of the disease, toxic absorption, recurring pneumonitis and many other complications.

Treatment is directed especially towards providing drainage constantly, supplemented by chemotherapy and all supportive measures which will increase the resistance of the patient. Where resection of all involved lobes or segments of lung is feasible, it offers permanent cure of the disease.

**RESUMEN**

En ensanchamiento de los bronquios no es el aspecto significativo de la enfermedad llamada bronquectasia. De mayor importancia es la pérdida del mecanismo de limpieza de los bronquios lo que conduce a la retención de la infección, del moco y de los cuerpos extraños. La retención produce el progreso de la enfermedad, la absorción tóxica, la neumonitis recidivante y muchas otras complicaciones.

El tratamiento se dirige especialmente hacia el fin de proporcionar canalización constantemente complementada con la quimioterapia y por todas las medidas auxiliares que aumenten la resistencia del enfermo. Cuando la resección de todos los lóbulos o segmentos del pulmón enfermos es practicable, esto significa una cura permanente de la enfermedad.

**REFERENCES**

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**Discussion**

RALPH ADAMS, M.D., F.C.C.P.

Woodbury, Tennessee

The point made about fibrosis in the areas surrounding the dilated bronchi is a critically important one. I am afraid that in
the last year, more patients have been harmed by segmental resection than were helped by it. Up until the last year, I think the reverse was true and the reason is that too many surgeons have tried to become prima donnas and see how little bronchiectasis they can remove instead of how much. It is true that the segment can sometimes be taken as the pathological unit of the lung as it is the functional unit but from a surgical standpoint you must remember that the division as distinguished from the segment is usually the smallest acceptable resective unit.

The second point about cough sensitivity, is absolutely true. There is a simple test which you can make yourself if you will through your bronchoscope and see the exudate welling back and forth in the primary bronchus, patient not coughing, although scarcely anesthetized. If you put India ink into a patient's normal lower bronchus, in five minutes you will see definite progression of that ink upward. In the chronically diseased bronchus, you will not; we have carried it for as long as 15 minutes.

The third point which Dr. Carr indicated but did not stress, from a physiological point of view, is an observation from point of time. It can be stated axiomatically as it has been before, if a patient has bronchiectasis before he is 10, he will be dead before he is 40 for the reason that he indicated, the persistence of fibrotic tissue that might well have been removed in the beginning.

DAVID H. WATERMAN, M.D., F.C.C.P.
Knoxville, Tennessee

I would like to mention a personal debt to Dr. Carr that I have always felt. In 1941 he showed me his method of introducing oil into the bronchial tree and emphasized the importance of stereos. I think all of us have come to the point where we use very few stereo x-rays at the present time routinely but certainly with a well built bronchial tree, a stereo is a beautiful sight to behold and the individual branches that are involved stand out so clearly that until you have seen one, you can't appreciate the value of a good bronchogram.

I would also like to mention that the point he made of filling all segments of the bronchial tree cannot be overemphasized because from a surgical standpoint, we want to know exactly which bronchi are involved, either to a greater or lesser extent, and which ones are negative. The negative information is just as important as the positive.
I would like to ask whether bronchiectasis is a progressive disease. Has Dr. Carr ever actually watched dilatations in new portions of the lung that weren't there when he first saw the case. I am asking about chronic bronchiectasis.

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JOHN S. HARTER, M.D., F.C.C.P.
Louisville, Kentucky

I would like to ask Dr. Carr what the significance is and the cause of nodulation that sometimes is seen in bronchiectasis in cases that are rather progressive; they are going downhill, losing weight, etc.

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Closing Remarks

Duane Carr, M.D., F.C.C.P., Memphis, Tennessee: We have tried all known methods of making bronchograms, even to the injection of oil directly by needle into the trachea and which we subsequently abhorred. We passed catheters, both bronchial catheters and intratracheal tubes, and in the adult or in the cooperative patient, we have found the most satisfactory method to be the simple dribble method. The medicine dropper is put just inside the nares, the tongue is held out and the patient is requested to breathe through the mouth and the tongue is held to prevent swallowing. About two droppers full of one-half per cent pontocaine with 10 drops of adrenaline mixture is instilled into the nostril with the patient tilted to one side, and then the same procedure with the patient tilted to the contralateral side. Then the warmed oil in the syringe with a rubber tip is used and the tip of the catheter is passed over the first hump of the nares. The oil is allowed to run back the pharynx with deep quiet breathing. Oil doesn't run by gravity in the upper lobes but it is drawn in these lobes by the respiratory act, and you can fill them perfectly well by simply tilting the patient and the lobe into which the oil is guided is controlled entirely by position of the patient.

The deep quiet breath means that if the patient is breathing quietly without making any rasping noise, the larynx is relaxed and open. The oil runs in freely. The oil is instilled at the rate of about 1 cc. for every two breaths. Then of course we have fluoroscoped the patient to see when we have an adequate filling or have filled the portion of the lung we most particularly desire.
You will never get oil pneumonia if you empty the oil out immediately after getting the bronchogram.

We make no attempt to fill the entire bronchial tree at one sitting. One of us had that done to him and the dyspnoeic effect was truly distressing, and consequently in our ordinary diagnostic screening of bronchograms, we fill both lowers, the right middle, the lower segment and both uppers at the first sitting. Now if we contemplate surgery from the start, we will fill one lung completely and make PA and lateral films and at a different sitting entirely fill the other lung and make PA and lateral films. The total procedure from anesthetization to the taking of the films takes not over 10 to 15 minutes. There is no valid objection to dividing it in that fashion.

Dr. Waterman is quite correct that when we make stereoscopic films, it is easy to identify all of your segments individually and in at least one instance we showed a persistent block of a peripheral bronchus by stereoscopic film that we never would have spotted on ordinary examination. I am in perfect agreement with what Dr. Adams said in not going overboard for segmental resections when the segment showed dilatation and there was damage in the adjacent segments of the bronchi. In regard to Dr. Goldman's question we have seen repeatedly, particularly in mustard gas cases, progression of bronchiectasis from one segment to another. In one case there had been sufficient bronchiectasis in spite of measures directed at treating it that death ensued.