Selective Alveolo-bronchography in Chronic Pulmonary Emphysema

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A new method of bronchography, selective alveolo-bronchography (SAB), was described and recommended for clinical use in establishing correct clinical diagnosis of emphysema. The diagnosis of emphysema was made possible on the basis of morphologic findings in SAB. Further it was possible not only to differentiate emphysema from other chronic obstructive lung diseases, but also to distinguish the two types, centrilobular or panacinar, and to evaluate the grade of emphysema. In the final clinical assessment of these diseases the findings of SAB should be of course supplemented by clinical symptoms including the results of pulmonary function tests.

We think that the present method contributes much to excluding the current confusion in the terminology of chronic obstructive lung diseases and is quite helpful to chest physicians, who have been aware of the difficulty in identifying these diseases.

The current confusion regarding the terminology of a series of chronic pulmonary diseases characterized by a common denominator of airway obstruction, such as asthma, chronic bronchitis and pulmonary emphysema, is embarrassing to most of the chest physicians. The essential cause of such a confusion is that emphysema is originally an anatomical concept, whereas chronic bronchitis and asthma are defined almost exclusively by clinical symptoms. Since emphysema is morphologically defined, it would be the best way for a chest physician to be free from such a confusion by visualizing the anatomical changes of the emphysematous lung while the patient is alive. Although recent advance in pulmonary physiology now enables a chest physician to imagine a fairly accurate picture of the probable morphologic changes in the lungs at the bedside, there are still discrepancies between morphology and function. Therefore, emphysema is still a disease to be finally evaluated at autopsy, but not at the bedside. In other

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words, only pathologists can establish a correct diagnosis of emphysema, because it is possible for them to examine morphologically the autopsied lungs. But, as pointed out by Bates and Christie, it would be undesirable for most of the chest physicians to restrict the use of the word 'emphysema' to the autopsy finding.

Therefore, some chest physicians have endeavored to predict the morphological state of the lungs while the patient is alive, by means of detailed assessment of radiography, including plain chest films in several projections, full lung tomography, pulmonary angiography and bronchography, together with careful examination of clinical history and complete assessment of the function tests, but there is still difficulty in establishing a perfect correlation of clinical and morphologic findings.

The purpose of this paper is to present our new clinical method, i.e., 'selective alveolo-bronchography' (SAB). This method has been recently developed by us for the purpose of direct roentgenological demonstration of morphologic changes in emphysematous lungs in the living state.

We think that our method would be quite helpful for most of the chest physicians who find the current confusion in the terminology of the chronic obstructive lung diseases embarrassing.

**Methods**

After local anesthesia of the upper airway including nares, a special catheter as shown in Figs. 1 and 2 is inserted selectively into a single bronchus of the right lower lobe (usually right B9 or B10) via naris in the supine position.

As shown in Figs. 1 and 2, the catheter is so designed as to have a caliber of 7 mm and its tip usually prewedged in the sub-segmental bronchus. After it is
ascertained that the tip is properly positioned by the television used as a monitor during all maneuvers of SAB, the contrast medium (Hytrast) is gradually introduced by a syringe *via* one of the polyethylene-tubes fixed inside the catheter, as shown in Figs. 1 and 2.

Immediately after the contrast medium appears at the tip of the catheter, air is introduced by the compressor, as shown in Figs. 3 and 4, *via* the other polyethylene tube fixed inside the catheter.

![Fig. 3 Photograph of the compressor.](image1)

![Fig. 4. Diagram of the compressor.](image2)

The two polyethylene tubes are so designed that the contrast medium is almost nebulized at the very tip of the catheter. The driving pressure at the tip is different
according to the phase of respiration, but it exceeds the atmospheric pressure by about 10 cm H₂O at most, although the driving pressure at the compressor is about 1-1.5 atmospheric pressure. After 3 to at most 5 ml of the contrast medium are introduced, all maneuvers of SAB are over. It takes usually 3–5 minutes to complete SAB, and during this period a subject breathes quietly in the supine position. Immediately after SAB is completed, the pulmonary region, in which the contrast medium has been introduced, is stereoscopically radiographed, so that a three-dimensional aspect of the region is visualized under a magnification of four times. The radiological conditions necessary for the enlargement are as follows: The focus, current and voltage of the roentgen-tube are 50 μ, 3 mA and 110 kV, respectively. The distance between the tube and subject and that between the tube and film are 30 cm and 120 cm, respectively. The shutter-time is 0.18 sec.

For the stereoskopical radiography the subject is shifted by 2 cm from the center line of the corresponding pulmonary region to the right and left at each exposure, since our roentgen-tube is fixed. In order to exclude the diaphragm from the region of SAB, a suitable lung volume is selected, when these x-ray films are taken. Because SAB is usually carried out in a single bronchus to the right lower lobe, the diaphragm sometimes over-lies the corresponding pulmonary region and makes the film unclear.

The reasons why we select the right lower lobe are as follows: 1) Technically, the insertion of the catheter is easier in the lower lobe than in the upper or middle lobe. 2) The effect of heart pulsation on making the film unclear is less in the right lobe than in the left one.

Until now we have already carried out SAB in 168 subjects, including healthy ones as well as patients with chronic obstructive lung diseases.

Since SAB is completed in a very short time (5 minutes at most) and the contrast medium is introduced only into a single bronchus and its alveolar region, and moreover the volume of the introduced contrast medium is relatively small (3–5 ml at most) compared with ordinary bronchography, the physical loads to a subject is insignificant in SAB. In 168 subjects, we have never experienced noticeable side-effect of SAB.

**RESULTS AND DISCUSSION**

Since SAB as a new clinical method to prove directly the morphologic changes of emphysematous lungs was recently developed by us, we have made every effort to interpret correctly the pulmonary appearances in SAB from 168 subjects, taking into consideration complicated patho-physiology of emphysema. For this purpose, we referred not only to precise pulmonary function data, clinical features, plain chest roentgenograms and full lung tomography, but also to post-mortem examinations of alveolar structures, including celluloid-macrosection, barium embedded preparation and ‘Softex’ or soft x-ray film.
Moreover, we often used the stereoscope in order to avoid erroneous interpretation due to multilayered superposition of alveoli and airways on the pictures of SAB.

Among 168 subjects, we had recently an opportunity to justify our interpretation of SAB by means of post-mortem examination in a patient. We had diagnosed panacinar emphysema from the appearance of SAB, while this patient had been alive. The details of this patient will be discussed later.

After careful analysis, including that of this case, we established our standard in evaluating the appearances of SAB as follows (Fig. 5–11).

1) Young healthy lung (Fig. 5)
2) Senile lung (Fig. 6)
3) Early stage of panacinar emphysema (Fig. 7)
4) Far advanced panacinar emphysema (Fig. 8)
5) Centrilobular emphysema (Figs. 9 and 10)
6) Emphysematous bulla (Fig. 11)

In this way, we defined our standard in the appearance of SAB in healthy young lung, senile lung, panacinar emphysema, centrilobular emphysema and emphysematous bulla. These standard films enable us to make the diagnosis of emphysema on the morphologic basis while the patient is alive. Moreover, it is possible to some extent to differentiate two fundamentally different types of emphysema described by Gough in 1952, and also to estimate the grade of emphysema.

There may be a question whether SAB correctly reflects the morphologic state of the lung. A clear answer to this question would be given by the following case, in which clinical SAB was assessed by the post-mortem examination.

Case 1: A 67-year-old businessman complained of dyspnea on exertion over a 20 years' period and cough with sputum, especially when he caught cold. Dyspnea had become increasingly severe over last 2 years. The sputum was usually scanty and mucinous.

The clinical diagnosis of emphysema was made by physical examination, radiology and pulmonary function tests as shown in Table 1. SAB was performed a few days after his admission. The appearance of SAB, as shown in Fig. 12, was of panacinar type of emphysema. Three months after his admission, radiography revealed an abnormal shadow in the right upper lobe. The clinical diagnosis of lung cancer was substantiated by cytologic examination. He died of lung cancer and cor pulmonale half a year after SAB. The resected right lower lobe corresponding to the pulmonary region of SAB was found to have 'panacinar emphysema' by direct morphologic examination, as shown in Fig. 13.

This was the only case, at present, in which we could confirm our interpretation of SAB on the morphologic basis, but we expect to assess SAB by further experiences in postmortem examinations.

We now regard the interpretation of SAB in patient with moderately or far advanced emphysema as well substantiated, but it is still sometimes quite difficult clearly to differentiate the early stage of emphysema especially of panacinar type from a senile lung, although this difficulty can be overcome to some extent by a careful evaluation of patient's clinical history, physical examination, radiography
and pulmonary function tests.

As to the pathogenesis of emphysema, our results suggest that emphysema develops in the majority of cases continuously from the senile lung, even though the speed of development will differ from case to case. Concerning the typical appearance of centrilobular emphysema in SAB as shown in Figs. 9 and 10, we think that this appearance is comparable to ‘peripheral pooling’ in the bronchographic features described by Simon and Galbraith in 1953 for the first time, and subsequently proved by Reid in 1955 and by Leopold and Seal in 1961 on the morphologic bases. Reid proved that ‘peripheral pooling’ is brought about by accumulation of the contrast medium in the centrilobular emphysematous space. We have not yet our own experience to prove this, but the similarity of the appearances in SAB and bronchographic feature justified the interpretation of centrilobular emphysema in SAB.

As already shown, SAB reveals not only the abnormality of the alveolar structure but also that of the conductive airway including terminal bronchioles. Therefore, we can now distinguish and correctly diagnose broncho-bronchiolar diseases, which are otherwise very similar to emphysema in their clinical features and in pulmonary function tests. Chronic bronchiolitis obliterans, described by Lange in 1901 for the first time, belongs also to this group of broncho-bronchiolar diseases. Since the concept of this disease depends also on the morphologic findings, a correct diagnosis has been impossible for chest physicians for a long time. In this respect, it will be worth-while to present a case, in which the diagnosis of chronic bronchiolitis obliterans could be established by means of SAB. Since then, we have experienced 4 similar cases.
Case 2: A 56-year-old male farmer complained of productive cough of 36 years' duration and increasingly aggravating dyspnea on exertion over a 6 years' period. Sputum averaged about 1 cupful a day and was usually purulent. Pulmonary function tests are shown in Table 1, and the appearance of SAB in Fig. 14. As shown in Fig. 14, alveolar structure is utterly obscured. On the other hand, the bronchi and terminal bronchioles show highly advanced inflammatory changes. A week after SAB, we tried to demonstrate the alveolar structure by means of a modified Odema-Ledin's Red catheter, the caliber of the tip being made to 1 mm.

We inserted this catheter carefully into the airway as deeply as possible and sent the contrast medium via the catheter. Fig. 15 shows the result from this patient obtained by this method, and Fig. 16 shows one in a young healthy man. Compared with the appearance in a young healthy man, alveolar structure in this patient is still obscure, and moreover, the terminal bronchiole shows remarkable obstructive change, while other parts of the terminal bronchiole are highly ectatic. From these findings, chronic bronchiolitis obliterans was diagnosed in this case.

References


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Fig. 5. Young healthy lung.

The typical appearance of alveolar structure of a young healthy male is presented. Alveolar structure is shown as very minute dotty appearance. Moreover, both the bronchus and bronchiole exhibit the normal pattern of branching. There is no evidence of inflammation.

Fig. 6. Senile lung.

Typical appearance of alveolar structure of an old healthy female is shown. Alveolar structure is demonstrated as somewhat larger coarse dotty appearance, compared with that of the young healthy lung. This finding corresponds to the duct-ectasis which is morphologically characteristic of the senile lung.
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Fig. 7. The early stage of panacinar emphysema.

The appearance of the alveolar structure at the early stage of panacinar emphysema is presented. Alveolar structure is almost similar to that of the senile lung, but in some parts as indicated by arrows, the alveolar structure assumes different appearance on account of a bunch of coarse round structures.

Fig. 8. Far advanced panacinar emphysema.

The appearance of the alveolar structure in far advanced panacinar emphysema is demonstrated. Normal spherical alveolar structure is lost, and remarkably irregular alveolar pattern is complicated with many linear shadows. There is nowhere round dotty appearance, but the peripheral airways are maintained comparatively well.
Fig. 9. Centrilobular emphysema.

Typical appearance of the alveolar structure in centrilobular emphysema is demonstrated. Alveolar structure is shown as prominent 'pooling' of round, oval, or irregular shape and of varying size. These 'poolings' are usually associated with comparatively large airways and sometimes are surrounded by dotty structures which may be considered to be normal alveoli as, shown by arrows in Fig. 11.
Fig. 10. Centrilobular emphysema.
Fig. 11. Emphysematous bulla.

Typical appearance of emphysematous bulla is shown as enormous ‘pooling’ of the contrast medium. The ‘pooling’ in emphysematous bulla differs from that in centrilobular emphysema in its shape and size; i.e., the ‘pooling’ in emphysematous bulla is usually more irregular and larger than that in centrilobular emphysema. Further, there is no surrounding dotty structure in the former disease.

Fig. 12. SAB of Case 1: panacinar emphysema.

Fig. 13. Macro-section of Case 1: This region corresponds to that shown in Fig. 12.
Fig. 14. Chronic bronchiolitis obliterans: Case 2.

Fig. 15. Chronic bronchiolitis obliterans obtained by the modified Odeman-Ledin's Red catheter: Case 2.

Fig. 16. Young healthy lung obtained by the same method as shown in Fig. 15.