THE CAVITY HEALING IN PULMONARY TUBERCULOSIS

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(Received on June 18, 1955)

INTRODUCTION

None doubts the possibility of cavity healing now-a-days. But there have been discussed many times on this subject and the conception has undergone many changes since the end of the last century till now. It is convenient for our study to divide the period of the transition into three.

The first period was the dawn of this study. Albert(1) quoted that Andral(2), Carswell(3) and Laennec(4) had described the possibility of cavity healing, but this possibility was not proved. v. Hansemann(5) demonstrated for the first time the autopsy cases of healed cavity. Fischer(6) and Lessing(7) also added some cases.

Graeff(8) expressed his opinion at a meeting of the Tuberculosis Society at Bad Elster, that a tuberculous cavity sized over a cherry could not heal without surgical treatment and would be the cause of death to the patient. His conception stirred up great deal of discussions and was reputed severely and the society passed a resolution against his idea. But his idea gradually gained ground and remained till now.

On the other side, it had been widely said among the clinicians in those days, that cavity may exist as only an accompanying harmless change having nothing to do with the phthisis. More over, the cavity which has a demarcation layer in its wall and discharges necrotized mass, can be called a sort of healed state.

But there-after, the clinical statistics of the prognosis of the patients with cavity formations revealed very disappointing results according to Lydtin(9), Grau(10), Ritter(11), Bacmeister(12) and v. Düring(13). As they showed the mortality of 64% up to 97.3% the conception of the clinicians began to accept Graeff's opinion after many discussions for 6 years. At the same time, it was clinically clarified that the cavity having better prognosis belongs to Ranke's second period of high allergy of the disease (Bacmeister, Lindig(14), May(15)
The second period of the discussions on cavity healing was of confirmation. As Schmincke\(^{(17)}\) had said that clinicians can study only the healing process and pathologists on the other hand only the end point of the lesion. Graeff proposed in the confirmation of cavity healing that it needs to let a cavity shadow in the roentgenogramm correspond to the pathological feature of post mortem examination. The method of study on this subject was standardized by him for the first time. In 1935 he\(^{(18)}\) had written extensively on the pathology of cavity and its healing processes.

Alexander\(^{(19)}\) classified the types of cavity into an elastic cavity and a thick-walled cavity for convenient of the practitioners. He analyzed the factors which caused healing, and tried to explain that healing is promoted by combination of several factors. From 1935 to 1940 many healed cases with miscellaneous healing types were reported (Table 1).

Coryllos\(^{(20)}\) maintained that the occlusion or the kinking of drainage bronchi are most important to cavity healing. His theory has been widely admitted for long time.

It was Wurm\(^{(21)}\) who published the most interesting study on cavity healing. He clarified the definition of healing as the disappearance of three factors which term cavity. Pinner\(^{(22)}\) examined carefully cavity healing, and classified from pathological view points, by the grades of healing into complete and incomplete healing.

Pagel\(^{(23)}\) added a new clinical healing type, the bronchial plugging.

By this time approximately all types of healed cavity found at autopsies had been completed, and also the analysis of healing factors and the classification of healing processes had been extensively studied.

The third period is characterized by artificial promotion of the healing with antibiotics such as streptomycin, PAS, INH, Tb-1 and so on. In this period the treatment of tuberculous cavities is shortened. Moreover a new healing type appeared due to the effect of the drugs (Tokugawa\(^{(24)}\)).

In our country there are a few pathological studies on cavity healing. Aoki-Tokugawa-Kageyama\(^{(25)}\) have noticed the meaning of bronchial artery playing an important role in cavity healing especially by thoracoplasty, and concluded that the dilatation and the hypertrophy in cavity wall aid it highly. One of their co-workers, Hisada\(^{(26)}\) proved an evidence by the casting of the artery with plastic.
Table 1
The Cavity Healing by Morphological Examination*

<table>
<thead>
<tr>
<th>Authors</th>
<th>Open Healing</th>
<th>Cicatization</th>
<th>Encapsulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albert</td>
<td>1931</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pagel</td>
<td>1932</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Alexander</td>
<td>1935</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Graeff</td>
<td>1935</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>McPhedran-Long***</td>
<td>1935</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sweany**</td>
<td>1935</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Amberson**</td>
<td>1936</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Pagel-Robinson**</td>
<td>1936</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>v.Kowarwski**</td>
<td>1937</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Finner a)***</td>
<td>1937</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Finner b)</td>
<td>1940</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Derschied-Toussaint***</td>
<td>1938</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Pagel-Robert***</td>
<td>1938</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wurm</td>
<td>1938</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Pagel-Simmonds***</td>
<td>1939</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Auerbach-Green***</td>
<td>1940</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pagel-Simmonds***</td>
<td>1942</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Kita**</td>
<td>1949</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Miyagawa**</td>
<td>1949</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Kajita**</td>
<td>1950</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tokugawa-Kageyama-Aoki****</td>
<td>1952</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Deme-Inaba-Nishimura**</td>
<td>1953</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Auerbach-Katz-Small****</td>
<td>1953</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Jensen*****</td>
<td>1953</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Tokugawa******</td>
<td>1954</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Johnsen-Hewitt****</td>
<td>1954</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

10 (15.2%) 17 (25.7%) 39 (59.1%) Total 66 cases (100%)

* The Pagel's table (1939) was referred here.
** Amberson's case was described as an hydrops of cavity.
*** Pagel described as bronchial plugging.
**** The fourth case of authors is thought as a healing with carnification.
***** Jensen's case of a healed cavity is suspected at the same to be a pulmonary cyst.
****** One of 3 healing cases with cicatization was reported as healing with carnification.

As seen in a Table 1 there have been reported 66 morphologically examined cases of cavity healing, among these cases there were encapsulations 59.1%, cases of the cicatization 25.7% and cases of open healing the least with 15.2%.

In our study we used autopsy materials which had shown excavation in roentgenograms. After the confirmation of cavity location by the method of lung tracing we examined especially the histological specimens stained by Mallory's connective tissue staining. This method preliminarily treated with 2% K₂Cr₂O₇ is especially excellent for the study of caseous substance (Aoki).
DEFINITION AND TYPES OF CAVITIES

According to the Graeff's(18) definition of tuberculous cavity it is primarily thought to be a closed cavity. He thought an existence of a cavity in roentgenogramm without discharge of bacilli in phlegm, but it is not acceptable according to careful serial examinations with recent methods of cultures. Otherwise, pathologically Graeff's primary closed cavity cannot be distinguished from the secondarily closed cavity, because both cavities contain dissolved amorphous caseous substance with bacilli, and the arbitrary bronchus is cicatrially obliterated.

It is reasonable to regard that a primary closed cavity is nothing other than a closed state of open cavity. That is to say, a primary closed cavity is one that had already started a healing process to a certain extent.

It is convenient for us to have a reference to the Wurm’s conception. The writer wants to give a definition of cavity, from the stand point of pathology as follows.

A cavity consists of three conditions. It consists of tuberculous tissue grown in lung, with an ulcerated lumen and communicated outside by draining bronchi.

As Graeff formerly said, the confirmation of a cavity in X-ray film is very important in order to follow the post-mortem morphological feature, so we do not treat small cavities in this study which had not been roentgenologically revealed. The type of the cavity is, since Alexander briefly classified into two types, namely an elastic cavity and a thick-walled cavity. But of late the so-called tuberculoma, which had been brought up as round foci or encapsulated caseous foci for a long time, became a new theme in therapy. In tuberculomas

Scheme 1 The Three Types of Cavities
it occurs often as an excavation which converts into a sort of cavity. In other words such an excavated lesion it-self is a tuberculoma in one hand, and at the same time a cavity. This cavity type of the tuberculoma must be distinguished from the thick-walled cavity histologically, since the treatments of each is not the same, namely the former requires thoracoplasty and not resection, but the latter its resection only. It seems important pathologically and clinically in study of cavity healing to name the excavated tuberculoma. We call it fibrous cavity (Scheme 1).

The fibrous cavity is encapsulated with a thick fibrous capsule, and the inner caseous substance has an ulcerated lumen in the centre in typical cases. Fibrization of the caseous mass is intense and therefore the consistence becomes as firm as a gumma in some cases. Silver-impregnation and Mallory's connective tissue staining reveals this change very distinctly. Tuberculous tissue involving atrophic giant cells and epitheloid cells is scant in the narrow layer beneath the capsule. Excavated portion communicates directly with the drainage bronchus and tubercle bacilli are proliferating over the internal surface.

The name 'fibrous cavity' is originated from the foregoing characteristic of marked fibrization of the caseous mass.

It is necessary to clarify the mutual relationship between the thick-walled cavity and the fibrous cavity. The former yields when an elastic cavity increases its thickness of capsule by getting old in the lung tissue, or derives from a solid caseous lesion when this lesion loses its necrotized portion within by the early dissolution. But in the fibrous cavity the dissolution is markedly delayed and very slight. The excavated lumen is small compared to the volume of the whole lesion.

Case record of fibrous cavity

| aged 31, woman. Onset of disease 1947. Remittent fever since admission to our hospital continued to death. Vital capacity 1,100 cc. BSR at all times highly accelerated. Despite the streptomycin injection 20 g died from intestinal tuberculosis and laryngitis tuberculosa. |

Autopsy:  (Fig. 1) The right lung has 3 cavities and the left one middle sized cavity which are of very thick walled measured 1 cm, greyish yellow and firm like gumma. The one in the right middle area corresponds apparently to the doughnut-like shadow of the roentgenogramm. In the wall of the one in the right lower lobe we can see the annular ring in the caseous mass. These cavities have large lumina which communicate directly with the bronchi. The inner surface is smooth or coarse due to ulceration. The thick cavity wall is encapsulated with a thick capsule outside, but the cicatric shrinkage is nowhere
shown.

Microscopic changes: Figure 2 shows the histological findings stained by Mallory’s staining of the caseout substance of a middle cavity in the right lung. The proliferation of collagenous fibre is remarkable which reveals more strikingly by Bielshowsky’s silver impregnation.

The exudation of the fibrinous fibrills is at some portion seen in the previous alveolar lumina and the previous walls of blood vessels. The inner surface is mostly dissolved and numerous acid fast bacilli are proliferating here, living giant cells and epitheloid cells accumulated in a thin layer beneath the capsule.

It is apparent that they cannot shrink and cannot be an object of thoracoplasty.

DEFINITION OF CAVITY HEALING AND THE GRADING OF THE HEALING

The definition of cavity healing has altered in many ways since the beginning of the twelveth century. Formerly it was said a paradoxical conception that the excavation itself should be an healing, since the necrotized mass had been hereby cleaned away. But the healing of cavity should be from the pathological view point, as Schmincke said, disappearance of any tuberculous tissue changes and conversion of cavity lumen to the connective tissue.

Graeff thought that the cavity reduction (Rückwandlung) is the cessation of progressive destruction which improves clinical state in the patient and is called the onset of reparation. Therefore the reduction is the complete healing (Ausheilung der Kaverne), although the term is not exact and not fitting. It seems to us that he might have termed thus since he had not have a case of pathological healing, but his definition is unsatisfactory at present.

Pagel recognized pathologically the cavity healing, and he distinguished the appearance of the healing from the healing process which causes the disappearance of destructed tissue and the stabilization of cavity and the regeneration of tissue. The healing process advances only when the tissue destruction stops after the fixation or demolition of bacilli.

Wurm defined the healing as the vanishing of his three factors.

The healing is, from our view point, to lose its tuberculous tissue of the lung, the ulcerated lumen and the drainage bronchus (Table 2).

The feature of healing is divided into 4 types, in which every factor vanishes (see TYPES OF CAVITY HEALING). And every cavity type reaches to the definite healing type.

There are three grades in the cavity healing. “Complete healing” is of-course
### Table 2

<table>
<thead>
<tr>
<th>Types of Healing</th>
<th>Tuberculous tissue disappear</th>
<th>Drainage bronchus disappear or organized fibrous tissue</th>
<th>Calcification</th>
<th>Shrinkage</th>
<th>Encapsulation</th>
<th>Brochial plugging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathological healing grade</td>
<td>Complete healing</td>
<td>Incomplete healing</td>
<td>Clinical (small lesion)</td>
<td>Clinical (big lesion)</td>
<td>not healing</td>
<td>not healing</td>
</tr>
</tbody>
</table>

- Bacilli (+)
- Bacteria, cavities
not restituio ad integrum (v. Hansemann), but is used here in convenient sake to distinguish from the other grades. The healing of cavity in this grade cannot aggravate again since bacilli are herein absent.

Open healing and healing with cicatrization (forming radiating scar) come under here. Wurm looked upon open healing as incomplete, but I think it is complete since the recrudescence of itself does not occur. The other one is of-course complete.

Blocked cavity or encapsulation of cavity may aggravate easily, so the healing is incomplete.

Pagel treated bronchial plugging as a healing type. Although this may be a forestage of healing, the present status allows the discharge of bacilli, consequently it may be fitted as not healing.

FACTORS OF CAVITY HEALING

Healing of cavity requires many factors, but it had not been formerly recognized that the cooperation of the factors is needed. Alexander and also Pinner studied such problem carefully. Now the writer attempts to propose his conception after readjusting the factors proposed by the former investigators. It seems better for us to divide the miscellaneous factors into a group of primary factors and a group of cure promoting factors.

A. Primary Healing Factors.

The primary healing factors act in the reactive tissues of cavity wall, and their action is not limited there, but act in any form of the other solid tuberculous lesions. In other words their action alone does not insure cavity healing by themselves.

1) Natural Immunity.

2) Acquired Immunity.

The actions of these factors are not limited to cavity healing. Therefore, though important as they are, they are omitted from our discussion.

3) Hypertrophy and dilatation of bronchial arteries.

This subject called an extensive attention lately. The tissue reacts very briskly, since systemic blood is supplied to the proliferated capillaries in the cavity wall through the bronchial arteries.

Venous congestion was formerly regarded as important, but it might have been mistaken for the feature of the dilatation of bronchial arteries.

According to Aoki-Tokugawa-Kageyama the above mentioned blood supply may appear easily when the pressure of pulmonary artery drops even a little
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by collapse therapy, and the healing mechanism of this treatment consists herein.

4) Local Anemia.

This factor had been thought to increase natural resistance in tuberculous pulmonary lesion, but the compensation of pulmonary circulation is raised through bronchial artery, therefore this does not exist.

5) Stasis of Lymph Current.

It is said that this factor causes tissue fibrosis, but the stasis results in the decrease of tissue resistance in general as seen in the fact that the tissue elephantiasis is weak against infection of bacteria.

6) Rest of the Lesion.

This is of course the most important in every disease. Fales-Beaudet and McMahon-Kerper reported many cases of remarkable improvement and closure of tuberculous cavity smaller than a medium size in over 50% by the bedrest therapy only. But the significance of this therapy is not yet morphologically proved.

B. Cure Enhancing Factors.

In this discussion of healing of tuberculous cavity some enhancing factors should be added to the primary factors.

1) Shrinking of Cavity Lumen.

This lessens the free surface of cavity which allows vigorous proliferation of tubercle bacilli.

a. Elastic shrinkage.

Elastic shrinking of smooth muscle in alveolar wall is carried out under control of the autonomic nervous system. Bronckhorst described the importance of this shrinkage and explained a significance of rapid shrinking of elastic cavity. Simon tried to prove this theory of elastic cavities, but without success.

Dumarest-Kamsler and Jaquerod said that the reflex emphysema occurs around the lesion at the time when the alveolar muscle contract and the former aids the shrinking of the lesion.

But how to estimate the meaning of this alveolar shrinkage shall be further examined.

Shimada, Hilber and Tiemann published that the real hyperplasia of the lung tissue around the lesion compensates the defect of the tissue and aids its contraction.

b. Cicatric shrinkage.

This occurs in thick-walled cavities, and causes to press out caseous sub-
stance from the lumen. But this shrinkage cannot be expected in fibrous cavities due to the histologic structure (see after).

2) Obstruction of drainage bronchus.

This is caused by the cicatrical closure of the bronchial lumen by the mechanical compression, and by the kinking or by stopping with caseous mass as well as the bronchial calculus.

When cicatric closure precedes to the cavity healing, a blocked cavity as an incomplete healing or clinical healing will be resulted. As tubercle bacilli are not discharged in this status, the bronchial closure has been most important to cavity healing according to the classical healing conception. Coryllos proposed that a cavity becomes stable when tubercle bacilli fall into asphyxia by deficiency of oxygen after bronchial closure.

Bronchial plugging with caseous mass is only a status of temporary stability of cavity.

3) Cleaning of cavity lumen.

The cleaning away of caseous mass is the most important of all healing factors, because caseous mass is very difficult to be treated by human lung tissue. When the cavity is cleaned thoroughly without shrinking, it may reach to open healing. Consequently the thick-walled cavity heals by cleaning, while the fibrous cavity which has fibrous mass does not.

4) Antibiotics.

The healing power of antibiotics consists in the suppression of proliferation of bacilli, in other words it is to decrease relatively the virulence of bacilli against the resistance of the host.

But Aurebach-Katz-Small and Tokugawa each had one case of cavity healed by the effect of streptomycin.

As antibiotics improves more and more, such a healing type may occur frequently.

TYPES OF CAVITY HEALING

The healing types of tuberculous cavity have been formerly divided into three types, namely the open healing, the healing with radiating scar and the healing by inspissation. Pagel added a new healing type, the hydrops of cavity, which had been described by Amberson(24) and the cavity is filled with a serous fluid mixed with cholesterin in the closed lumen. It seem to us that this healed cavity is nothing other than an inspissated cavity which contains secondarily dissolved fluid of caseous mass. It is reasonable to divide the healing with cicatriziation further into the cicatric shrinking and the carnification.
The former is identified as the one hitherto called healing with radiating scar, but the latter is a recently observed new healing type.

A. Open healing.

In a healed cavity of this type the lumen of the cavity and the draining bronchus are open, its surface loses the tuberculous specific changes and is epithelized. It is otherwise called the healing of the cavity wall.

In the literature v. Hansemann, Fischer, Giegler, Pagel, Auerbach-Green, Kita, Johnsen-Hevitt and Alexander have described this healing type.

The open healing occurs in cavities of medium sizes or over, and in the most cases it is in the atelectatic lung tissue retracted by the adjacent pleural peel. The external layer of the wall itself consists of surrounding atelectatic tissue. The second layer is the cicatric zone in which capillary net is developed supplies systemic blood from the bronchial arteries. The third layer consists of infiltration of lymphocytes and collagenous fibres, but as healing process advances, it changes to a pure cicatric tissue. Giant cells and epitheloid cells of the layer disappear at last in the same way. The epithelium grows from the draining bronchus and spreads over the surface of the wall. It is cylindrical adjacent to the hiral portion, and squamous in the peripheral portion of the cavity lumen. But the basal membrane is not seen in any case.

In gross finding the epithelized cavity might be at times difficult to distinguish from bronchiecstatic cavities or emphysematous blebs. But in this healed cavity pyogenic infection caused by saprophytes such as streptococci, staphylococci, pneumococci and others of the bronchus causes detachment of the regenerated epithels of the wall here and there in the lumen. These portions are by microscopic examination necrotized, filled with enormous amount of leucocytes and lymphocytes. Such non-specific infection occurs in over medium sized cavities very often, therefore the lining of the inner surface with epithelium comes off. As the result of these facts it can be said that the complete epithelization is not necessary to the terms of open healing, but only the disappearance of specific tissue changes.

Case record.

[Name aged 26, woman. Onset of the disease supposed to be in 1952. Since admission to our hospital until death subfever continued. BSR continuously accelerated, also phlegm was much containing tubercle bacilli (G 2–7). Far advanced excavation of right lung was well shown in roentgenogramm (Fig. 3). Chemotherapy with INH 1.9 g and Tb-1 56 g during three years. Died on]
Right lung is wholly excavated, but its ventral portion is divided into an upper and lower part. Inner surface of the upper part is coarse and abscess-like, but in the lower part, except its basal portion, smooth and greyish. Some wave-like risings run from the hilum to periphery. Exudative fluid is accumulated. Drainage bronchi of over subsegmental bronchi are in total 6, and other five are closed cicatrally.

Microscopic changes: The upper part involves tuberculous tissue with much tubercle bacilli over the surface. The lower part is completely free of any specific tissue change, lined by cylindrical epithels adjacent to the hilum and by squamous epithels on the costal side (Fig. 5 &7). We see remarkable appearance of newly grown dilated capillaries beneath the epithel. Lymphocytes are therein scanty. But in the basal portion the wall has no epithel, is enormously rich in leucocytes and lymphocytes. Misecellaneous bacteria could be stained here.
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In the lower part of this cavity the cleaning of the cavity lumen was performed thoroughly through several big drainage bronchi and the tissue destruction had, except small portion, progressed to the mediastinal and the thoracic wall, where the tenacious resistance of the mesenchymal tissue checked the advance of destruction. (Fig. 6) But it is thought that the administration of Tb-1 56 g for 3 years aided actively in the healing of this case.

B. Healing with scar formation.

The cavity healing by this type loses its tuberculous tissue changes and cheesy substance, the lumen is converted to a fibrous mass, and draining bronchi are cicatrally obliterated.

There are two subdivisions. The one, described till now as the healing with radiating scar, is characterized by accompanying cicatric shrinkage of cavity, so we call it here the healing with cicatric shrinkage in convenience to distinguish from the other. The other one is a new healing type which we call the healing with carnification, and is characterized by filling of lumen with carnificated or scar tissue, also with no or only slight shrinking.

1) Healing with carnification.

The appearance of this type had been formerly predicted by Alexander and Pottenger(59), but emphatically denied by Graeff and Wurm. Cavity lumen is filled with carnificated tissue and the shrinking is not shown or occurs slightly.

Case record

_??_ aged 21, male worker, Japanese. Tuberculin R. converted in June 1943. 300 cc hemoptysis on February 17, 1946. Admission to the Saitama National Sanatorium 1947. Since January 1949 Monaldi's cavity drainage had been continued against an egg sized cavity of the right apex (Fig. 8–10). Eleven months later an annular shadow of the cavity in roentgenogramm changed for homogenous opacity, the draining tube was then removed. The exudate from the rest fistula yet proved to contain tubercle bacilli, but the fistula closed at last by the continuous intramuscular application of streptomycin 45 g. On July 26, 1949 plombage with plastic balloon was performed against a medium sized cavity in lateral portion of left upper lobe. As the sputum examination remained yet positive, right thoracoplasty was done on May 19, 1950 on suspicion of healing of the mentioned cavity of the right upper lobe, and he died on the next day.

Autopsy: _??_ 4×1, 3 cm sized, elliptic formed, gray and firm fibrous mass connected with two bronchi, r.B1 and r.B2, either of which revealed stenosis
with cicatization adjacent to the mass. Right upper lobe had shrunken markedly. In the lateral portion of left upper lobe was found another encapsulated lesion, but this will be described in the paragraph of the healing with encapsulation (Scheme 3, Fig. 11-12).

Scheme 3

Microscopic changes: The firm elliptic mass reveals fibrous tissue consisted of coarse collagenous fibres in Mallory's staining. (Fig. 13-14). Also were found marked proliferation of collagenous fibres, but neither necrosis or tuberculous cells, nor tubercle bacilli were found elsewhere in the mass. We found a circumscribed fibrosis, which corresponded to the former draining canal, runs across the narrow atelectatic induration to the pleural peel. The right B₁ and B₂ closed by cicatric obstruction just before the ellipsoid, and the mucosa is lined by normal cylindrical epithel thoroughly and free of inflammation.

Such a new healing type was seen in a fourth case described by Auerbach-Katz-Small, which was affirmed by lung resection after chemotherapy with intramuscular injection of streptomycin 100 g. But the healing of our case did not occur only with chemical treatment, but is aided by the cleaning of cavity with Monaldi's cavity drainage. It seems to us that more case of this healing type will be added by the progress of chemical treatment.

2) Healing with cicatric shrinking.

In this type cavity loses its lumen by marked shrinkage of the wall forming a radiating scar, tuberculous tissue is thereby absorbed and the draining bronchus
obliterated by cicatrization.

Formerly many authors have reported about this healing type, McPhedran-Long, Sweany, v.Kowarwski and Kita each one case, Tokugawa 2 cases and Pinner 3 cases.

In some cases caseous substance remained yet scantly amidst the radiating scar, and a few epitheloid cells and giant cells surround it, but in some other cases it was calcified completely (Gilbert, Wurm, Pinner), or absorbed (Gilbert, Auerbach-Green, Pinner).

It is necessary for this healing type to be accomplished that the involved caseous substance is cleaned away and the shrinking of the wall are easy. Accordingly the cavity type must not be fibrous, but elastic and thick walled cavity.

Case record.

[Redacted] male 25 aged. Period of conversion of Tuberculin R. is unknown. Right lung infiltration by roentgenogramm in January 1946. Hemoptysis 50 cc in April 1948, and some medium sized cavities were discovered radiologically in the right supraclavicular portion (Fig. 15). Right thoracoplasty with resection of 7 ribs against them on January 13, 1949 (Fig. 16). Hemoptysis by recrude-

![Scheme 4](image-url)
ence of the lesion in left upper lobe on December 20, 1950. Left thoracoplasty on June 27, 1952. Died from acute pneumonia on January 9, 1953.

Autopsy: Marked collapse of right upper lobe, therein two small scars belonging to rami apicales were found, and the lower one contained very small greyish yellow clay-like caseous mass (Fig. 17, Scheme 4).

Microscopic changes: Corresponded to the cavity shadow of the X-ray film we see an amorphous granular caseous substance with partial calcification at the lower end remained in the scar tissue of the former cavity wall. An giant cell and atrophic epitheloid cells with lymphocytes are surrounding the caseous content as seen in Fig. 18. No tubercle bacilli were found.

It is supposed that the caseous substance or such a small amount of this case will be calcified before long, or the tuberculous tissue change will be substituted for a scar of the healed state as seen in the case reports of the former authors.

C. Healing with encapsulation.

This type of healing, otherwise named as formation of blocked cavity or the inspissation of cavity, shall be classified as the incomplete healing.

This healed cavity is closed by the cicatric obliteration of the drainage bronchi, but involves caseous substance with tubercle bacilli. Consequently the risk of recrudescence still remains.

Many authors have described cases of this healing type. (Gilbert, Graeff, Derschied-Toussaint, Wurm, Kita, Deme-Inaba, Nishimura, Auerbach-Green, Tokugawa-Kageyama-Aoki, Tokugawa). Healing with encapsulation occurs in a thick-walled cavity and also in fibrous cavity. But the morphological finding is not the same. In the former the cavity content is an accumulated amorphous or semi-fluid caseous substance and flows out from the cut-surface on section. The consistence is elastic and soft. But when the lesion get older, and it loses its moisture, and it is called a pasty cavity (Hart(60), Hübschmann(61)) or atheromatous softening of the cavity (Schürmann(62)). The morphological feature of the latter differs from the former, and according to the degree of softening the firm consistence becomes soft and more elastic.

The lesion is encapsulated with a fibrous capsule and the greyish yellow caseous cut-surface shows fibrous at the peripheral portion and the amorphous substance in the centre. Tubercle bacilli are proliferating by choice on the boundary of these two portions forming mulberry-like agglomeration. By Mallory's staining the fibrosis is not revealed in the amorphous portion, but only in the firmly consisted fibrous portion, wherein elastic fibres are proved
corresponding to the stroma of alveolar walls and blood vessels. Calcification is often markedly appears in the amorphous portion, but is delayed in the fibrous part. Nishiyama's\(^{63}\) new staining method brings out distinctly calcification in even in the latter part.

Coryllos asserted that the obstruction of the drainage bronchus is the indispensable factor in cavity healing for the reason that tubercle bacilli living within falls into asphyxia by want of oxygen. His opinion had been accepted for a long time, but our new finding so described above makes it untenable any longer. If observation is continued for a long period, an encapsulated cavity often opens and flares up. Therefore this type must be an incomplete or clinical healing.

**Case record**

An encapsulated cavity in the left lung of the same case described in the cavity healing with carnification. It situated in the left S\(_1\) and was caused by the left plombage with acrylate balloons (Fig. 11).

Autopsy findings: A small-bean sized blocked cavity encapsulated with a thick capsule (Fig. 12). It contains amorphous caseous substance in a greater part and the dense and smaller part in the periphery which cannot be stripped off. The former is accumulation of previously softened caseous substance and the latter is fibrous. This lesion is consequently an encapsulation of a fibrous cavity.

Microscopic findings: In the figure of Mallory’s staining we see caseous substance in the amorphous portion which consists of a mass of greyish-violett granules, and in the fibrous portion collagene fibres run along the persisted alveolar structure or are proliferated in the alveolar lumen (Fig. 19). Elastic fibres are only seen in the latter portion. A small quantity of acid-fast tubercle bacilli are stained at the boundary between two portions. Just beneath the capsule is a thin layer of specific granulation tissue which involves living giant cells and epitheloid cells in mass. The drainage bronchus is cicatrally obliterated.

**D. Bronchial plugging.**

Pagel named a healing type as bronchial plugging, in which cavity is closed by the occlusion of the draining bronchus with dry caseous substance or a calculus. Pagel reported 9 cases and Tokugawa two cases. One of the Tokugawa's case was of bronchial calculus.

This healed cavity is morphologically the same as blocked cavity, but is caused by bronchial stopping. The drainage bronchus still reveals caseous bronchitis, and the cavity still discharges tubercle bacilli.
According to the Graeff's study even the calculus may dissolve in the tissue under p.H. 6.0. Thus calculus is unstable, and it should belong to a class of no healing.

Case record.

25 aged farrier. Onset of the disease began by infiltration of right lung in April 1945. Since December 8, 1948 right pneumothorax lasted for 4 months. A medium sized annular shadow in the right segment S2 was discovered by roentgenogram, against which right plombage with plastic balloon was performed on September 3, 1949 (Fig. 20). But empyema developed and died from empyema plasty.

Autopsy findings: Right lung remarkably collapsed by the pressure of plombage balloon, and at the lateral site of the upper lobe a destructed caseous lesion is cropped out to the empyema cavity. Bronchi of the upper lobe bent downwards and a blocked cavity connected with the point of r.B2. The wall of the bronchus is narrowed by the swelling of granulation tissue and the pressure by plombage. The lumen communicates with the blocked cavity, but is filled with caseous mass (Scheme 5, Fig. 21).

Microscopic changes: In the wall of blocked cavity we see still specific granulation, and the drainage bronchus shows caseous bronchitis.
Although in such a bronchial plugging the healing process has set in, but is very severe to reach complete healing.

Bronchial plugging is to regard as not healing in the light of strictly applied term.

SUMMARY

In the introduction the short history about the study of cavity healing was described. And the writer gave a name of fibrous cavity to the tuberculoma holding excavation in the second chapter.

The discussions were presented on the relations between cavity types, healing types and healing grades.

The writer analyzed the healing factors and inquired about the relation to the healing types.

When the cavity healing had been thought as incurable, even the excavation itself was regarded as a feature of healing. After many healed cases by encapsulation appeared, the conception of healing changed to the shunting off of the lesion. Recently the chemotherapy has greatly advanced, but the cavity healing of the most cases is still the shunting except few cases. The fact that the cavity treatment has converted to the resection by the advanced surgical technique with the aid of anaesthesiology and antiobiotics, shows also the difficulty of the healing of lesion itself. But a few cases of new healing type, the cicatric healing with carnification, appeared as seen in this paper. More the chemotherapy advances, more the healing type of cavity will change.

(I would like to express my gratitude to Dr. T. Nakazawa and Dr. T. Kojima, of the National Saitama Sanatorium, for his courtesy for the opportunity to examine the cases of 1, 2, and 3 in autopsies.)

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b) — (22)
33. Derschied-Toussaint: quoted by Auerbach.


ILLUSTRATIONS

All illustrations of the lung including microscopic photogramms are corresponded to the frontal section as it is in the thorax.

Fig. 1 Fibrous cavity. The three in the right lung and the one in the left show very thick and firmly consisted wall.

Fig. 2 High magnification of the wall of the middle cavity of right lung by Mallory's staining. Proliferation of collagenous fibres in the caseous mass remarkable. Some necrotized giant cells and epitheloid cells are shown.

Fig. 3 A roentgenogramm of a case of open healing, 3, 20, 1953. The right lung is thoroughly destructed, but seems in this photo to be divided into 2 cavities.

Fig. 4 The same case. Inner surface of the upper part of the cavity is lined with a thin caseous débris, in the lower part smooth. The persistence of lung tissue with naked eye cannot be observed.

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Fig. 5  The wall adjacent to the hilum is lined by ciliated epithel without basal membrane, and the submucosa are scar tissue.

Fig. 6  The lateral portion of the lower lobe cavity is completely lined with squamos epithel. Cicatrization of the layer beneath the epithel is accomplished.

Fig. 7  The basal portion is thoroughly free of tuberculous cells. Infiltration of leucocytes and lymphocytes are remarkable. The cutsurface of necrotized small vessels scatter here and there.

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Fig. 8 A roentgenogram of a case of healing by carnification; 1, 19, 1948. An egg-sized cavity in the infraclavicular portion of the right lung is shown.

Fig. 9 The same case. 3, 9, 1949. Monaldi's cavity drainage is continued.

Fig. 10 The same case. 5, 16, 1951. The cavity converted to a diffusive opaque shadow.

Fig. 11 The same case. The right upper lobe is covered with intercostal muscle and thick peel. The left upper lobe is collapsed by balloon plombage, wherein some encapsulated caseous lesions are seen.

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Fig. 12 The third cut surface. An ellipsoid of fibrous mass of the previous cavity beneath the thick peel.

Fig. 13 Mallory's staining of the elliptic fibrous mass. Some maculas which consist of hyalinized collagenous fibres are scattered, tuberculous tissue changes exist nowhere.

Fig. 14 High magnification. Coarse collagenous fibres are specific to carnification.

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Fig. 15 A roentgenogramm of a case of healing by cicatric shrinkage. 12, 11, 1948. Three small cavities are located upper to the right clavicula.

Fig. 16 The same case. 6, 22, 1950. Collapse of the right lung good, wherein no rest cavity.

Fig. 17 A section of the right upper lobe. One zonary cicatrix with a tiny greyish yellow caseous mass.

Fig. 18 Low magnification of the scar by Mallory's staining. A band-like structureless portion in the centre is the rest of caseous mass of the previous cavity. Calcification is seen near the lower end.

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Fig. 19 A case of healed cavity by encapsulation is the lowest caseous lesion of the left lung seen in Fig. 12. The dissolution is wide, but the fibrous caseous portion arrest the destruction in the right quadrant.

Fig. 20 A roentgenogram of a case of bronchial plugging. 7, 17, 1949. A middle sized cavity of the right upper lobe.

Fig. 21 The same case. The drainage bronchus r-B3 is remarkably bent downwards by balloon plombage, and communicates with a caseous lesion of a previous cavity, is narrowed and filled up with dried caseous mass.

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