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Initial Lesion of Adult Secondary Pulmonary Tuberculosis and Bronchial Segments

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Introduction

It is the adult secondary pulmonary tuberculosis that we most frequently see at the daily clinic. There are many kinds and natures of the disease, from the cases that seem to have fallen ill soon after the primary infection, not long after of tuberculin reaction becomes positive, to the ones that seem to have turned positive at least one year ago and have safely passed through the primary infection from the clinical point of view, but have become worse on some occasions. Lately the knowledge of tuberculosis and the medical mass examination have become wide-spread and we can earlier determine the time when a patient first fell ill and the secondary pulmonary tuberculosis began. So it has become possible to give them earlier and more complete medical treatment.

Especially today it can be said that by segmental resection, by enucleation of tuberculoma, and by cavernectomy (Nagaishi, Teramatsu, Yasubuchi and Yoshizumi) lesions can be partially cut off when they are wider spread and before there are significant bad changes in the draining bronchus. Here we intend to say that it is very necessary to find very early the lesions which will become cavities or which are likely to become cavities and to know the position of the focus of tuberculosis in relation to the bronchial segments from the stand point not only of pathological anatomy but also of roentgenology. In other words it has become very necessary to determine

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the position of the initial lesion in cases of secondary pulmonary tuberculosis before chronic tuberculosis develops; and the relation of the focus to the bronchial segments must be re-examined from the stand point of thoracic surgery. Until recently studies on the bronchial segments have been made only by roentgenologists and pathologists. This is the aim of our inquiry: to examine the initial lesion of secondary pulmonary tuberculosis mainly in relation to the bronchial segments.

I) The objects and methods of research

The examples are 319 cases (185: men and 135: women, aged 17-43) from among the out-patients and in-patients of the Tuberculosis Research Institute of Kyoto University. The times when their tuberculin reactions became positive are known and the site of the initial lesion of secondary pulmonary tuberculosis could be confirmed roentgenologically by tracing back the time they first fell ill. We omitted the cases in which the focus of the disease could be seen in both lungs. We examined the cases roentgenologically to determine the nature and size of the initial lesions. The bronchial segments involved were determined in 89 cases and the positions of the focus of the disease were confirmed directly and clearly at operation by the methods of thoracotomy, lobectomy, enucleation of tuberculoma and cavernectomy, or cavernostomy. At that time we did not include those that had only a little material to examine or those in which the nature of the disease was too much complicated. Statements on the bronchial segments follow the divisions described by Jackson Huber. 33.3% of the cases were asymptomatic and were first discovered by mass X-ray examination, 45.3% of them were first seen less than a year after the tuberculin reaction turned positive of.

As to the methods of inquiry, each patient had at least ten successive dorso-ventral X-ray pictures. In addition 65 patients had lateral roentgenograms, bronchograms or tomograms. After resection, lung specimens were made solid by formalin and we determined the bronchial segments by making thin slices of frontal cut about 0.5 cm. thick. We also tried to make as accurate and definite observations as possible by injecting colored methylmetacrylate mixed with iodized oil—a different color for each bronchial segment—into the 7 bronchial segments.

II) Results of the Investigation

I) THE EXAMPLES AND THE NATURE OF THE DISEASE: There are not notable differences between the left and the right lungs except that there are a little more right-side diseases than the left, and in the left, transparent

parts and the parts that are supposed to be cavities are seen a little more in number than in the right (See Table I).

Table I Examples and nature of tuberculous lesions.

Right side	{those with no transparent part	134	175	319
	{those with transparent parts	41		
Left side	{those with no transparent part	91	144	
	{those with transparent parts	45		

2) THE SIZE OF THE LESION: Most of the foci are 1-2cm. in diameter, but 16 examples are larger than 2cm., look like mist and their boundaries are unclear shadows and their diameters are about 8cm. when largest (See Table II).

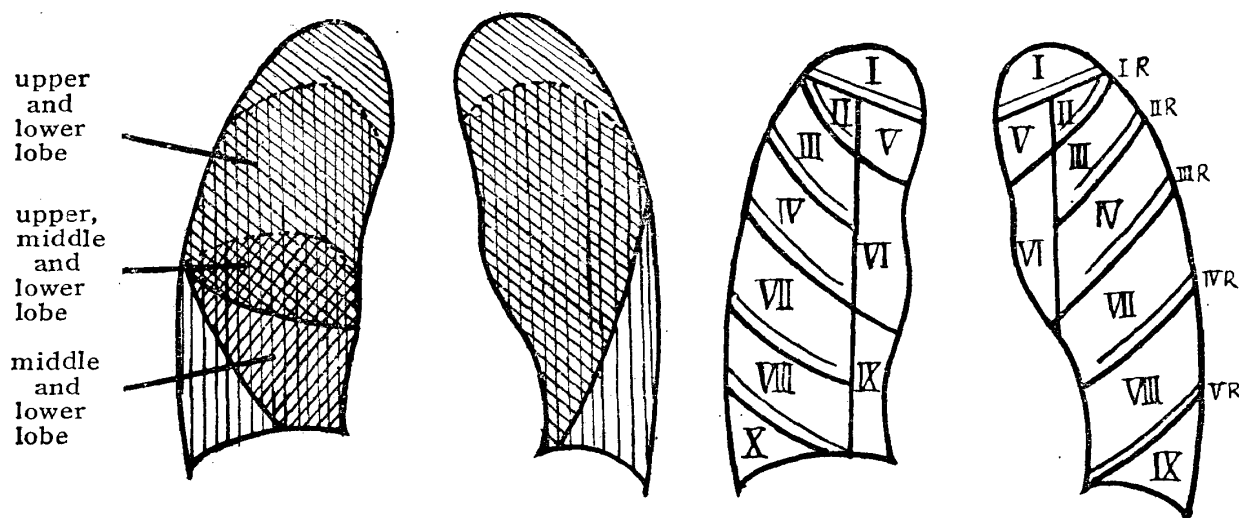
Table II Size of the initial lesion of secondary pulmonary tuberculosis.

{Small finger tip size	use cm	23
{Thumb tip size		155
{Nut size		122
{Larger than nut		16
Total		319

3) POSITION OF THE LESION

a) *Method of dividing the lung field.* We have seen many former methods of dividing lung-fields, but they were not useful for our purposes. In the roentgenogram we drew a line parallel to the spinal column about the center of the clavicle, and divided the left lung into 9 sections and the right lung into 10 sections fundamentally based on the usual method of dividing lung-fields using clavicles and the lower border of the frontal ribs (See Illustration I).

Illustration I Division of lung field

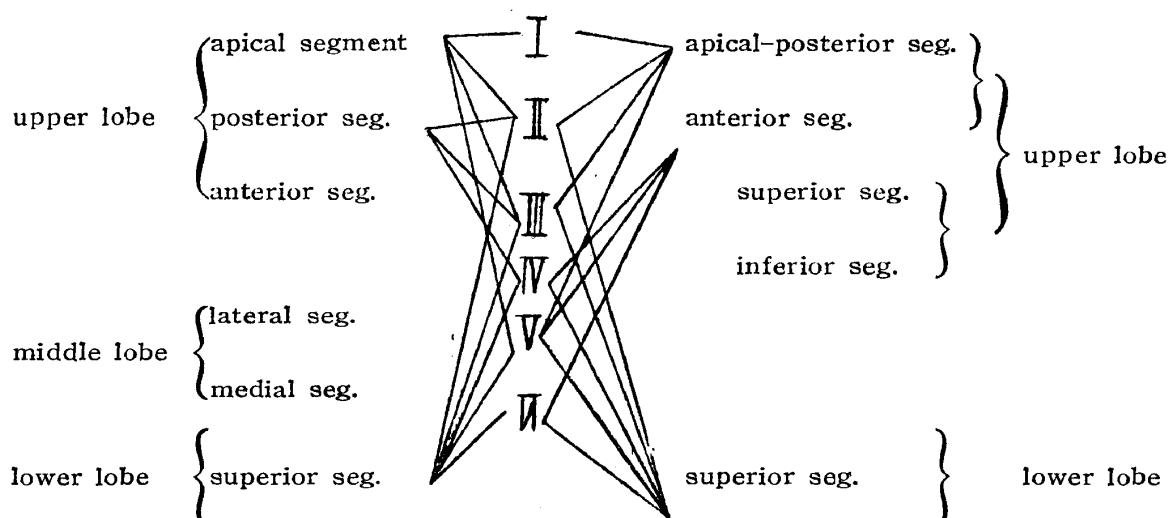


In this method the height of the roentgen tube is a factor to consider; for example, if we take the left lung there may occur a difference position of about one intercostal space in the lower border of the apical-posterior segment of the upper lung and the upper border of the superior segment of the lower lung depending on the height of the X-ray tube. So we must take into consideration the height of the tube even when we examine old photographs, and we must, of course, place the tube at the level of the 6th thoracic vertebra when we take photographs to determine the position of a lesion.

In the method of dorso-ventral photographing, it is known that the upper and the lower lobes of the left lung and the upper, middle and lower lobes of the right lung are partially overlapping (See Illustration I). But when we put methylmetacrylate into excised lungs and examine the bronchial segments and compare them with what we see during thoracotomy of living patients, it is not so complicated. The initial lesion of secondary pulmonary tuberculosis has, as we mention hereafter, two or three characteristics that are likely to limit it to two or three bronchial segments. So if we apply suitable tomography, bronchography and lateral X-ray photography, it is comparatively easy to decide clinically within the necessary limits the bronchial segment involved.

Table III shows the important relationship between the lung fields and the bronchial segments (See Table III).

Table III Relation between several bronchial segments and lung-fields



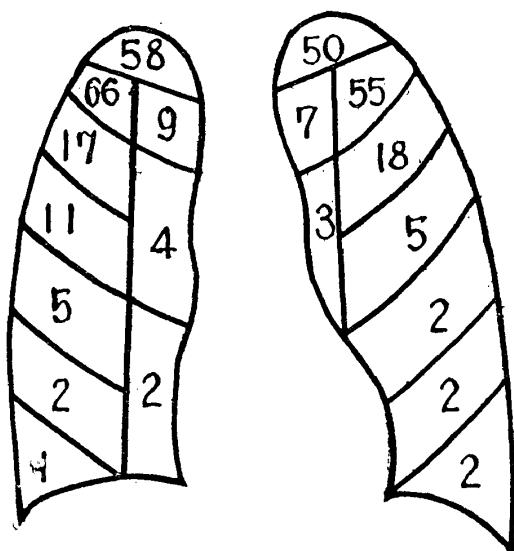
The explanation is that in the second lung-field the apical and posterior segments of the upper lobe of the right lung always throw shadow just as the apical posterior segment of the upper lung in the left lung, and rarely it happens the superior segments of the both lower lungs occupy the field,

and in the latter case there is often observed pleural adhesion, especially on the upper back side of the lungs and between the upper and lower lungs.

The third lung-field is occupied by the apical and posterior segments of the upper lobe and the superior segment of the lower lobe in the right lung, and by the apical-posterior segment of the upper lobe and the superior segment of the lower lobe in the left. In both lungs superior segments of the lower lobes have relation to the second, third, fourth, fifth and sixth lung fields and they occupy a wide part in them, but by the special photography or thoracotomy at the time of operation, and sometimes by the ordinary dorso-ventral X-ray while using the method of pneumothorax we can often confirm outlined images of the lungs and by this we can find to which lung the focus of the disease belongs. For instance, there is a case where after the collapse of the lung to a middle degree the focus of the disease previously supposed to be in the 3rd and 4th lung fields before pneumothorax was found to belong in reality to the superior segment of the lower lobe. Also we can see that most of the foci of the disease and cavities in these superior segments move to the hilus or the lower part of the hilus after pneumothorax.

b) *The usual sites of initial lesions of adult secondary pulmonary tuberculosis according to this method of dividing lung fields.* Illustration II shows the number of lesions seen roentgenologically in each lung-field among from the cases 319. Clearly the greatest number occur in the upper lung fields—that is to say, in the left lung 130 lesions (40.75%) are seen in fields I, II, III, & V, and in the right lung 150 lesions (46.02%) in the corresponding lung fields (See Illustration II).

Illustration II Position of Initial lesion of secondary pulmonary tuberculosis (Classification by lung field)



We analysed 61 cases and investigated the positions of the lesions in the upper lung fields by dorso-ventral X-ray, lateral X-ray, tomography or bronchography. We found the lesion in upper part or in the front center part of the lung in only 7 out of 67 cases (10.7%) and these 7 all were in the first lung-field, none in the fifth lung-field. By studying these cases we were led to believe that the lesions of secondary pulmonary tuberculosis are likely to start in the upper posterior regions of both lungs.

c) *Classification of initial lesions of adult secondary pulmonary tuberculosis and bronchial segments.* By thoracotomy or examination of resected lung specimens it was confirmed definitely in 89 of the 319 cases that the initial lesions were actually in the bronchial segments in which they had been found by X-ray. Among them there were 6 cases that seemed to have only one cavity X-ray, but turned out to have more than two equal sized cavities adjacent to each other, so although the number of patients is 89, the number of the lesions is 95. When we examined the resected lung specimens after injecting colored methylmetacrylate into the bronchi (transparent part seen by X-ray is rather large than this) we found that it is not unusual for cavities larger than 2 cm. in diameter that are near the edge of a bronchial segment to have more than two drainage bronchi that belong to the adjacent bronchial segments. Doubtful cases are sometimes omitted. The kinds of the operation are shown in table IV and the results of the inquiries in table V (See table IV and V).

Table IV Kind of operation.

Lobectomy	52
Partial resection	2
Cavernectomy	12
Cavernostomy	21
Thoracotomy	2
Total	89

Table V Classification of position of initial lesion of secondary pulmonary tuberculosis.

Right lung		Left lung	
upper lobe	{ <u>Apical segment</u> 37	upper lobe	{ <u>Apical-posterior seg.</u> 23
	{Posterior seg. 5		{Anterior seg. 1
	{Anterior seg. 1		{Superior seg. 1
	{Inferior seg. 0		
middle lobe	{Lateral seg. 1	lower lobe	{ <u>Superior seg.</u> 5
	{Medial seg. 0		{Anterior-medial-basal seg. 5
			{Lateral-basal seg. 1
			{Posterior-basal seg. 1
lower lobe	{ <u>Superior seg.</u> 13		
	{Medial-basal seg. 2		
	{Anterior-basal seg. 1		
	{Lateral-basal seg. 1		
	{Posterior-basal seg. 0		

According to these results, in the left lung lesions in the apical-posterior segment of the upper lobe and in the superior segment of the lower lobe are overwhelmingly numerous; in the right lung the great majority are in the apical segment and posterior segment of the upper lobe and the superior

segment of the lower lobe. In table V are seen the number of lesions found in these five bronchial segments comparing in relation to lung fields the operative findings with the X-ray taken before operation (See table VI).

Table VI Relation of bronchial segment and lung-field where secondary pulmonary tuberculosis is likely to begin

Right lung	apical segment 37	I	12	27.3%	Left lung	apical-posterior seg. 23	I	4	17.4%
		II	23	52.2 "			II	15	65.2 "
		III	5	11.4 "			III	3	13.1 "
		IV	4	9.1 "			IV	1	4.3 "
	posterior seg. 5	II	1	20.0 "		superior seg. 5	II	1	12.5 "
		III	2	40.0 "			III	2	25.0 "
		IV	2	40.0 "			IV	3	37.5 "
	superior seg. 13	II	1	7.7 "			V	1	12.5 "
		III	2	15.4 "			VI	1	12.5 "
		IV	7	53.8 "					
		V	1	7.7 "					
		VI	2	15.4 "					

According to table VI almost all the lesions in the apical segment of the right lung and the apical-posterior segment of the left lung cast their shadows on the second lung-field, and they are seen most frequently in the superior segments of the lower lobes of the both lungs.

III) Discussion

It is said there are distinct clinical and immunological differences between primary tuberculosis and secondary pulmonary tuberculosis and these must depend upon the different modes of reaction of the living body infected by the tubercle bacilli. Ghon showed that the distribution of the first lesions are seen all over the lungs in children and Puhl and Kutsukake saw them chiefly in the lungs of dead bodies. Puhl investigated secondary infection which is comparatively readily healed, and he reported that the distribution of lesions is preponderantly seen in the upper lung in contrast to cases of primary infection. Most opinions of scholars seem to agree with this report.

Kumagai, Naitō, Chiba, Tokorozawa and Malmros-Hedvall made precise clinical studies on the pathogenesis of adult tuberculosis and it is said that from the epidemiological point of view, in Japan and Switzerland it is somewhat different from that in other western European countries. In other word Malmros says 50% of adults are not yet infected clinically. So it is important to start with a definite idea at the difference of age in distinguishing between primary and secondary tuberculosis as well as a knowledge of the region and races of the patients when we investigate the

pathogenesis and the distribution of lesions. So we selected as the objects of our investigation those who knew definitely the time when their tuberculin reaction became positive and who could be traced back roentgenologically and clinically, and we omitted those that were clearly thought to be cases of primary tuberculosis.

The pathogenesis of tuberculosis has been under discussion for many years. Assmann and Redeker noted the shadows of the initial lesions that appeared mostly behind the clavicle and called them "early infiltrates". Apart from so-called "Simon's foci of tuberculosis" in the early cases of children's tuberculosis, Simon and Redeker mentioned that the apices and the upper part of lungs behind the clavicle are especially apt to develop the lung fatigue (early lesions).

Malmros and Hedvall (1938) said that some of the early lesions in the upper lung-fields (most of them are in the first intercostal space and upper part of clavicle) appeared soon after the primary infection, i. e. subprimary initial lesions which are sure to become cavities, but Redeker and Braeuning (1939) also included the early lesions at the apices of the lungs which Malmros mentioned in the category of "early infiltrate." As we mentioned before, 45% of the 319 cases which we investigated fell ill within a year after their tuberculin reaction had become positive; after this their disease became worse. It is worth observing that 33.2% of them were found in mass-examination surveys and had no realization of their own disease. That is to say most of 45.3% of the cases which fell ill soon after the tuberculin reaction turned positive are considered subprimary initial focus, and moreover in view of their clinical progress almost all seems to be included in the group of early infiltrate mentioned by Redeker. In other words the early lesions that we took as the object of our investigation are what have been watched as a foothold from which adult secondary pulmonary tuberculosis develops. But what is the anatomical relations between the tuberculous lesions in the upper part of the lungs? Until recently this type of investigation has been described only in roentgenological and pathological terms, since there was not a direct surgical method. Even detailed descriptions have only mentioned generally the upper part of the upper lobe or the upper part of the lower lobe. Consequently, we tried to divide the areas where tuberculous lesions are likely to develop according to bronchial segments. We must take into account the fact that our 89 cases are operative cases and therefore the degree of variation is limited. But as 89 cases out of 319 showed indications for operation we need not treat all of the results of operation in a special manner. This will be evident if we see correlation of the 2nd illustration, table III and table VI. In other

words, the most important point is that as regards the five bronchial segments where most of the early tuberculous foci are seen (including the superior segments of the lower lobes) the individual results of analysed roentgenological shadows taken before operation and the impression received of all cases as to the distribution of the early lesions according to the lung-fields are generally the same, and also we must note that there were many cases where we could operate comparatively early on the tuberculoma or enucleate tuberculoma and work out cavernectomy for isolated cavities that were feared to become worse in a short time and for foci that were going to be cavities.

Next there are a few new points to consider: one is that the number of bronchial segments in which secondary pulmonary tuberculosis is likely to originate especially in the superior segment of the lower lobes is unexpectedly large, and another is that the first lesions of secondary pulmonary tuberculosis are apt to occur in this region. It is very necessary to determine which bronchial segments are involved by using tomography, lateral X-ray and bronchography when we examine cavities which seem to be near the hilus in routine dorso-ventral X-ray, because frequently cavities which seem to be at the hilus, they are not actually there, but are in the superior segment of the lower lobe. We have thus found, as reported above, that we can identify the position of the initial lesions of secondary pulmonary tuberculosis viewed from bronchial segments.

Conclusion

Among the out-patients and in-patients of the Tuberculosis Research Institute of Kyoto University we took 319 cases which we could investigate clinically and roentgenologically with a definite diagnosis of secondary pulmonary tuberculosis which we could trace back to the onset of the disease, thus confirming the position of the initial lesion. We reached the following conclusions after studying these 319 cases and in 89 cases of which we could identify by operations of the lesions.

1) The earliest lesion of adult secondary pulmonary tuberculosis is overwhelmingly frequently found roentgenologically in the upper lung-field, and anatomically seen in the left lung in the apical-posterior segment of the upper lobe or in the superior segment of the lower lobe, and in the right lung in the apical segment and the posterior segment of the upper lobe or in the superior segment of the lower lobe.

2) Moreover the five bronchial segments mentioned above are the most suitable places technically to perform the segmental resection and the partial resection, esp. the enucleation of cavity or tuberculoma, so if we find

tuberculous lesions in these segments and they seem to be in danger of becoming worse, it is very important to operate on them as soon as possible by the partial resection, esp. by the enucleation of tuberculoma or cavernectomy.

3) It must be noted that among the tuberculous foci that seem to be situated behind the clavicle, there are many that are actually in the superior segments of the lower lobes besides those in the upper lobes.

4) It is necessary to use tomography and lateral X-ray-photographing, bronchography to decide in which bronchial segment the early lesion of secondary pulmonary tuberculosis is situated, to avoid the defects of dorso-ventral X-ray which produces overlapping of the foci of tuberculosis in each lung.

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