The Re-Examination in the Resin-Plumbage for Pulmonary Tuberculosis**

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Introduction

As I have been offered the opportunity of speaking on the subject of "The Re-Examination in the Resin-Plumbage for the Surgical Treatment of Pulmonary Tuberculosis", I should like to avail myself of this occasion to present a summary report of the researches into plumbage we have been conducting for a little less than 10 years since March, 1947, with the intention of bringing our researches into the extrapleural pneumolysis with the filling of plastic balls to a conclusion and also of throwing some light on further researches into plumbage.

Table 1 Late results of extrapleural lucite ball plumbage

Date of Examination		July 31, 1956	
Objects of Examination		353 Cases	Date of Operation : from March, 1947 to Dec., 1950. Lapse of time after operation: 5 years and 7 monthes to 9 years and 5 monthes
Successful cases		58	(16.2%)
Unsuccessful cases	Living cases	103	(29.2%)
	Dead cases	94	(26.6%)
Unknown		98	(28.0%)
Total		353	(100 %)

I) In the first place, I will speak about the instructions learned from the results of the extrapleural pneumolysis with filling of plastic balls which are too many to present all of them in such a limited period of time as offered for me, and I want, therefore, to limit my subject to those learned from the late results of this procedure.

In Table 1, the late results of 353 cases treated with the plastic ball plumbage in the Surgical Division of the Tuberculosis Research Institute of Kyôto University.

Table 2 Final results of unsuccessful cases after extrapleural lucite ball plumbage

Successful cases			58 (16.2%)		Total 353 cases (100 %)
Unsuccessful cases	Living cases	103 (29.2%)	Finally cured by thoracoplasty combined with removal of plumbage or lobectomy combined with removal of plumbage. 74 (21.0%)	132 cases (37.2%)	
			Persistent inpatients 29 (8.2 %)	123 cases (34.8%)	
	Dead cases		94 (26.6%)		
Unknown			98 (28.0%)		

The post-operative periods of observation at the end of July, 1956 are 5 years and 7 months at the shortest and 9 years and 5 months at the longest.

If we assume "successful cases" as those, which are at work in good general conditions with plastic ball in their bodies, with no tubercle bacillus in their sputa and with no complication, the percentage of the successful cases is 16.2%, while, in unsuccessful cases, the percentage of survived cases is 29.2% and that of died 26,6%. In "survived cases of unsuccessful cases" those are involved in which plumbage alone could not achieve the purpose, and it includes those case which are at present in the same condition as successful cases, by the virtue of thoracoplasty with removing of plastic balls, pulmonary resection with removing of balls, etc., and also those in which the patients are not suffering from any particular complaint, but the balls have been removed all the same. As, beside the above, 28% are uncertain cases whose postoperative data were unavailable, this might not be a well-checked list of late results, but it would be enough to give the general trends.

What was unexpected in our investigation was the fact that successful cases were rather unresponsive to our printed inquiry by post than unsuccessful cases.

This has been made clear by a door-to-door visit on the patients resident in or near Kyôto, who were easier to contact.

Table 3 Comparison of results of surgery between selected cases and all cases

		Selected cases		All cases	
Successful cases		27.3 %	53.1%	16.2%	37.2%
Unsuccessful cases	Living cases	45.5%	Finally cured 25.8%	29.2%	Finally cured 21.0%
			Persistent inpatients 19.7%		Persistent inpatients 8.2%
	Dead cases	10.5%	30.2%	26.6%	34.8%
Unknown		16.7%		28.0%	

Table 2 shows in what conditions the cases which can be regarded as unsuccessful from the direct effect of the plumbage itself are at present. Those cases which have been clinically cured in their final results after the removal of the balls constitutes 37.2%.

Then what are the late results of the so-called selected cases, v.z. those cases in which the operation has been done according to the standard technique given as proper and just suitable to the indication ?

Table 4 Comparison between early results and late results in selected cases.

Date of examination	Successful cases	Unsuccessful cases: Living cases	Unsuccessful cases: Dead cases	Unknown	Total
At the end of Oct., 1949	95.5%	4.5%	0	0	100 %
At the end of Oct., 1953	41.0%	30.0%	5.0%	24.0%	100 %
At the end of July, 1956	27.3%	45.5%	10.5%	16.7%	100 %

As is shown in Table 3 and Table 4, the late results of the selected cases are much more satisfactory than those of all the cases, but, as compared with the near results of themselves, a marked difference to the worse is observed, namely, in the late results at the end of July, 1956, the rate of the successful cases, including even those case which have finally achieved their purposes, is still so low as

53.10%, the rate of died cases amounting to 10.5%.

When we examine what has led to such a deplorable result, we find that the reason can be finally traced to the frequent incidence of the later complications as the perforation of the cavity and the lungs, accompanied by pleural empyema, bronchogenic dissemination etc.. Even in those selected casses, in which good effects have been observed in their near results, being accompanied by no complication their late results are not fundamentally different from unselected cases in the long run.

Table 5 Lapse of time up to the removal of plumbage and reasons for removal of plumbage.

Reasons for removal	Lapse of time up to the removal					
	Lass than 1 year	1 ~ 2 years	2 ~ 3 years	3 ~ 5 years	More than 5 years	Total
Perforation of cairty or lung, extrapleural empyem and others	9.4%	18.9%	13.2%	17.0%	13.2%	71.7%
At the desire of patient or plrysician	0	5.6%	13.2%	7.5%	2.0%	28.3%
Total	9.4%	24.5%	26.4%	24.5%	15.2%	100 %

Furthermore, as you can seen from Table 5, the removal of plastic balls gets the rate of the cases in which the removing is necessary even after the lapse of 3 to 5 years or more than 5 years in such a high rate as 17% or 13.2%, respectively.

The above results oblige us to conclude that it is impossible to guard against the occurrence of complications by the ever used extrapleural filling of hard plastic balls, however carefully the indication may be chosen and whatever care in the operation may be taken. So it can be safely said that the extrapleural filling of plastic balls in its older technique is not a reliable treatment, though the post-operative courses of the cases treated with this technique are not all unsatisfactory.

How, then, will the mechanism in the occurrence of the perforation of the cavity or the lungs be interpreted, which is considered to be a fatal defect of our method among the complications following the extrapleural pneumolysis with filling of the plastic balls ?

The mechanism is the occurrence of the complications is by no means simple, but among the causes of their occurrence the necrosis due to the compression of the operated part by plastic balls can be regarded as the most conspicuous. Besides, when we examine the position of perforation, we find that in general the perforation has the tendency to occur more frequently in the posterior

segment of the upper lobe, v.z. those regions which are most strongly compressed by the balls when the lung collapses after the operation, though this does not apply to those cases whose foci lie too near the pleura. The fact that the filling balls are hard and globular can be regared to prepare the ground for the perforation of the cavity or the lungs, accompanied by the fact that the protective wall between the filling and the lung tissues is naturally thin because the filling is extrapleural, as well as by the fact that the filling ball made of methylmetacrylate irritates the tissue so little that no capsule is formed.

So that, the first question to be settled for the improvement of the plastic ball-filling method is the re-examination in the fiilling material and the regions to be filled.

Since several years the ball-filling treatment has almost ceased to be applied clinically in this country, but the most outstanding and unalterable advantage of this method is that no deformation of the thorax is caused and this makees it both significant and necessary to continue the researches into this method.

II) Then, what efforts have been done toward the improvement of the extrapleural pneumolysis with filling of plastic balls?

We have examined the method, laying special stress on the improvement of the filling material and the regions to be filled in view of the above-mentioned considerations.

I now proceed to speak on what we have investigated during the past full three years since 1951. The first problem was the improvement of the filling material. As our aim was to prevent the necrosis caused by the compression of the pulmonary tissue by the filling material, we turned our attention to the soft and elastic resin.

The names, chemical structures, and properties of the resins used for the examination of the effect on the tissue are listed in Table 6.

Out of these materials, we have tried to select by means of animal experi-

Table 6 Name, Chemical Formula and Property of Substances used for plumbage.

	Polyvinylformal	Polyiso-butylene	Polyethylene	Polyvinyl chloride	Polyvinyl-alcohol	Polymethyl acrylate
Chemical formula	$\left(CH_2-CH-CH_2-CH-CH_2 \atop O \quad CH_2 \quad O\right)$	$\left(CH_2=C<^{CH_3}_{CH_3}\right)_n$	$(-CH_2-)_n$	$\left(CH_2=C<^{H}_{Cl}\right)_n$	$\left(CH_2-CH-CH_2- \atop OH\right)_n$	$\left(CH_2=C<^{H}_{COOCH_3}\right)_n$
Property	white, spongy	colourless, tasteless, odourless, transparent	white, waxy, tasteless, odourless	transparent or semitransparent, tasteless, odourless	white powder soluble gelatinous	colourless transparent
Form of materials of examination	spongy	membraneous	membraneous	lamellar or spongy	gelatinous (30%)	massive
Elasticity	+	+	+	± or +	+	+
Hygroscotic	+	±	−	±	+	+
Acid-resistant	+	+	+	+	+	+
Alkali-resistant	+	+	+	+	+	+

ment a material which satisfies all of the following 4 conditions:

(1) a material whose irritation as a foreign body against the tissue is comparatively slight.

(2) a material whose elasticity and softness hardly changes when filled in the tissue.

(3) a material which possesses the possibility of being gradually absorbed and organized over a long period of time.

(4) a material which does not produce toxin when it disintegrates in the body.

As the results of experiments, it was proved that polyvinylformal was an ideal foreign filling material which approximately fulfils all of the above conditions. So, since January, 1954, this material has been applied also clinically.

Polyvinylformal is a white, spongy resin, soft and elastic as shown in Fig. 1. Fig. 2 is its microscopic picture. This material is made by the action of formalin on polyvinyl alcohol and its softness and elasticity varies according to the degree of formalization.

It has been proved by the result of our experiment that a kind of resin, which has been formalized by about 70%, is most suitable for our present purpose. When it is made into a ball or a cylinder 1 cm. in diameter and filled beneath the skin of an animal, it is found that it is completely absorbed or organized in 1 year and 2 monthes or 2 years.

Fig. 3 shows the post-operative condition after a year and a half, when the filled material is in the process of being organized, but, at this stage, the broken pieces of filling are to be seen here and there, and some cell reaction is to be observed.

Then, what result will be obtained when a much larger filling material is used? I will treat this point is connection with our next subject, v.z. the result of the animal experiment in the improvement of the region to be filled.

As to the improvement of the region to be filled, we examined in the so-called extraperiostal plumbage for this time. The extraperiostal plumbage of resin balls have been already tried — though temporarily — by Dr. Rikuhei Satô of Kôbe Medical College several years ago. Also in the United States, extraperiostal filling with polyethylene balls enclosed in a thin membrane of polyethylene has been tried by Dr. Richard H. Overholt and others. Suggested by these examples, we investigated in the extraperiostal filling of large sized polyvinylformal materials.

In this method of filling, a slight degree of cell reaction is to be observed during the period of several monthes immediately following the filling. The degree of the reaction decreases as time passes, until after six monthes a thick capsule is formed around the filling material as shown in Fig. 4.

This capsule consists of a layer of connective tissues about 2 mm thick and

another layer of connective tissues which have invased to the depth of 1 cm or 8 mm into the interior of the filling materials. Pathohistologically, such a capsle can be devided into 3 layers, the outer, the middle and the inner.

In Fig. 5, the outer layer and the middle one are shown. The outer layer consists of cicatrix-like connective tissue fibers running in a definite direction and connective tissue cells, the middle layer being consisted of the similar elements involving pieces of filling materials scattered as likely as islets.

Fig. 6 is the inner layer. In this inner layer blood-capillary, fibrocytes, fibroblasts, some cell infiltration, ect. can be observed beside the invasion of connective tissue and the new growth of blood vessels with abundant.

After the lapse of 1 year after the operation, the demarcation occurs at the border of the middle and the inner layers and the capsule can be easily detached along this border line as shown in Fig. 7.

In such stage after the operation the remaining filling material becomes to be no longer absorbed, but, if it is taken out and refilled beneath the skin of another animal, it begins to be absorbed again. From those facts we conclude that in case of a large-sized filling the tissues around it come to lose their reaction after a certain period of time.

When we compare the result after 1 year with that of 1 year and a half or more then 2 years, no marked difference can be noticed. So that it may be concluded that the filling settles down to nearly stable state in 1 year and a half after the operation.

In the ribs, which cover the filled part, no significantly marked change can be recognized but a slight atrophy or degeration of the trabeculae of the bone as shown in Fig. 8 and Fig. 9.

As you seen in Fig. 10, there is no mark difference between the case in which only the periosteum at the inner side of the rib has been detached and the case in which the entire periosteum around the rib is detached. But in the case in which the cutting of the rib is followed by the detachment of the periosteum, a marked atrophy of the front part of the rib is brought about as a natural consequence. In plumbage, the periosteum should be, therefore, detached without cutting the rib, even temporally.

The regeneration of bone from the detached periosteum begins to be recognized at about the end of three monthes after the operation and can be ascertained evidently by X-ray examination six monthes after the operation, as shown in Fig. 11.

Different from the extrapleural plumbage, the extraperiostal plumbage leaves not only two pleurae but also various tissues, such as fasciae endothoracicae, periostae, intercostal muscles, etc. between the pulmonary tissues and the filled balls. The nutrition of these tissues is also adequately maintained. As has

been explained, a thick cicatricial tissue containing the regenerated bone grows in that region when polyvinylformal balls are used. So I think it is quite proper that a soft, elastic and absorbable synthetic resin should be used as filling materials and the extraperiostal region should be chosen as the place to be filled.

III) Lastly, I should like to speak on the present state of our extraperiostal plumbage and take up a few problems in connection with it.

In the first place, I will show you the fundamental technique of operation by means of slides.

Fig. 12 shows the stage in which the lung is temporally collapsed after the periosteum is detached.

To collapse the upper lobe to the necessary and sufficient degree, the detachment of the periosteum extending from the rib I to the rib IV is sufficient and this degree of surgical intervention may be given at a sime, as no paradoxical respiration is caused in extraperiostal plumbage.

Fig. 13 shows the stage in which the intercostal muscle and the periosteum are cut at the front and the back ends and a slight extrafascial pulmonary detachment has been performed to rectify the from of the collapse.

Fig. 14 is the stage in which the plumbage has been finished. After the plumbage it is indispensable to remove the exudate by continually sucking through an inserted draining tube in such a way as in case of the pulmonary resection, thus preventing the aseptic extraperiostal empyema.

Fig. 15 is the post-operative X-ray picture. As you can see in it, the form of the thorax is unchanged and the lung assumes a collapsed from apparently similar to that after the thoracoplasty. As for the post-operative clinical, course, no symptom markedly different from the case of thoracoplasty, is recognized, except that the time required for the reduction of fever is a little long and the

Tabel 7 (a) Influerce of extraperiostal plumbage on the pulmonary fanction
(Average of cases followed more than 3 months after operation)

	before surgery	After plumbage	After thoracoplasty
Vaital capacity (%)	100	89.6	79.0
MBC (%)	100	97.5	89.0
Air Velocity Index	0.81	0.91	1.12
Tiffeneau %	100	102.1	80.7
Dead space	26	18.5	23.5

exudate accumulates to such a degree as several punctures are necessary.

Next, I proceed to cardio-pulmonary function. After the extraperiostal plumbage the capacity of the lungs and MBC are only slightly decreased, the air velocity index is not changed, the arterial O_2-saturation is increased and the respiratory dead space is decreased in comparison with their preoperative values as shown in Table 7 (a, b)

Tabel 7 (b) Influence of extraperiostal plumbage on the pulmonary haemodynamics.
(Average of cases followed more than 3months after operation)

	before swgery	After plumbage	After thoracoplasty
Arterial O_2-Saturation	92.5	95.5	93.8
Pulm. Art. Pressure (Systolic)	25.9	17.5	26.6
Pulm. Art. Pressure (Diastolic)	10.5	10.5	12.3
Pulm. Art. Pressure (Mean)	16.8	13.0	18.2
Cardiac Index	3.94	2.40	3.72
Total Pulm. Vascular Resistance	251	272	236

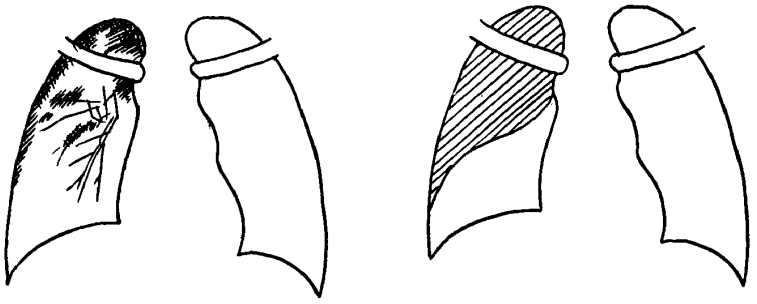
Tabel 8 Changes on respiratory dead space after extraperiostal plumbage in cases loaded hyvercapnoea (CO_2 : 4.5~5.4 vol. %)
(Mean value on cases followed more than 3 months after operation)

	Befor surgery	After plumbage
CO_2 in expired gas (vol. %)	+ 2.52	+ 4.1
Ventilatory volume per minute (%)	+74.4	+41.8
O_2 content of arterial blood (vol.%)	+ 0.97	− 3.3
O_2 saturation of arterial blood	+ 1.4	− 6.9
CO_2 content of arterial blood (vol.%)	+ 5.0	+ 5.1
CO_2 tension of arterial blood (mmHg)	+ 8.6	+10.5
Respiratory deed space (%)	+57.9	+92.5

As you can see in the same table, the functional disturbance after the plumbage is much less than in the case of thoracoplasty with the resection of six ribs. On conducting a load test with carbon dioxide gas, no improvement of respiratory function was observed after the plumbage, as shown in Table 8.

But an increase in the saturation of oxygen in the arterial blood after the ergometric clouding can be seen after the plumbage as shown in Table 9.

Table 9 Exercise loading test after extraperiostal plumbage



Vital capacity before surgery (cc)			2300.00
Vital capacity after plumbage (cc)			2060.00
O_2-saturation of arterial blood	before loading		92.70
	after loading		94.90
Frequency of respiration	before loading		18.00
	after loading		38.00
Ventilatory volume per minute (l/min)	before loading		16.68
	after loading		19.98
Volume of expired gases (vol. %)	before loading	O_2	18.50
		CO_2	1.95
	after loading	O_2	16.80
		CO_2	4.15

We have also compared the effects of the operation on the collapsed state of each pulmonary segment and segmental bronchus both after extraperiostal plumbage and thoracoplasty by selective bronchography of respective pulmonary segments applying Métra's tube and Dionosil.

From the evidence of this comparative examination, we have found that the same degree of the collapse of the lungs as in thoracoplasty is caused to the upper-lobe by the detachment of the periosteum to the above-mentioned the extent and other operations, but collapse of the lunge in the middle-and lower-lobes after the plumbage are generally slight as compared with those after the thoracoplasty.

The above-mentioned facts are also proved by the angiographical findings (Cf. Fig. 16) and by the model of the collapsed lungs (a model constructed on the basis of tomographical findings, which are alike the findings in sections of the chest), as shown in Fig. 17, etc.

On the basis of these results, it is probable that, in plumbage, as compared with thoracoplasty, the collapse of the lungs is caused more selectively.

Furthermore, it is ascertained on the distatography with bronchography, that the motions of the lungs are recognized, though slightly, in the collapsed place after the extraperiostal plumbage (Cf. Fig. 18), though not so distinctly as in the case of extrapleural plumbage. No such motions are observed after the thoracoplasty.

We can easily explain from the above results why the post-operative disturbance of plumbage is slight as compared with that of thoracoplasty.

Next, I will speak on the therapeutic effects of the extraperiostal plumbage.

The number of the cases of plumbage since January, 1954 is as yet only 41. Table 10 is a summary of the subjects of the operation.

Table 11 is the summary of the results.

Tabel 10 Cases of extraperiostal Polyvinylformal-sponge plumbage

All cases	41 (operated after Jan., 1954)
Age	21 -51 Average : 35
Sex	Male 36 Female 5
Lapse of time from onset of disease to surgery	Average : 6 years and 5 months

Tabel 11 Results of extraperiostal Polyvinylformal plumbage

Present status \ Lapse of time after operation	Less than 1 year	1 ~ 2 years	2 years ~ 2 years and 7 months	Total
Fulltime work	0	4	10	14
Housework	0	3	1	4
Parttime work on in sanatorium	15	7	0	7
Dead	0	0	1 (died by purpura)	1
Total	15	14	12	41

Especially in those cases after the lapse of more than 2 years and less than 2 years and 7 months after the operation, the post-operative courses are all good and all the patients are now at work or engaged in household works, except one case which died by purpura unrelated with the plumbage. Besides, it is remarkable that there has occured no perforation of the cavity or the lungs, though the post-operative observation period is comparatively short being only 2 years and 7 months at the longest. In this respect, we can find a great improvement as compared with the extrapleural plumbage.

When we consider about the fact that no perforation of the cavity or the lungs is caused even in the extraperiostal plumbage conducted by Dr. Overholt et al with hard polyethylene balls and polyethylene membrane, and that a thick protecting wall involving the regenerating bone is formed between the filling and the pulmonary tissue as described in the above-mentioned results of our experiments, the extraperiostal plumbage in our technique is concluded to make up the greatest defect of the extrapleural pneumolysis with the filling of plastic balls.

Next, I will explain the indication of extraperiostal plumbage.

As the number of cases treated with this method is yet not so many and the post-operative observation period is comparatively short, the indication of this method is not yet so clear-cut. But we believe that there is no harm in applying extraperiostal plumbage to those cases in which thoracoplasty can expect satisfactory results, as the forms of the collapse of the lungs are almost alike in both treatments.

As the disturbance of cardio-pulmonary function after this plumbage is comparatively slight as compared with that of the thoracoplasty, the application of this plumbage to bilateral pulmonary tuberculosis may be also tolerable and this method may further be regarded as a comparatively harmless treatment of

Tabel 12 Results of some surgical treatments for patients with SM, PAS and INH 10γ resistant tubercle bacilli

Results / Type of operative methods		Successful Cases	Unsuccessful cases		Under observation	Total
			Living cases	Dead cases		
Total cases		115 (51.8%)	69 (31.1%)	2 (0.9 %)	36 (16.2%)	222 (100 %)
items	Lobectomy	82 (53.3%)	42 (27.3%)	1 (0.6 %)	29 (18.8%)	154 (100 %)
	Thoracoplasty	22 (51.1%)	17 (39.5%)	0	4 (9.3 %)	43 (100 %)
	Cavernostomy	11 (44.0%)	10 (40.0%)	1 (4.0 %)	3 (12.0%)	25 (100 %)

high applicability for those cases with highly resistant bacilli.

The results of some surgical treatments on the carriers of resistant bacilli tell us that a high percentage of unsuccessful cases are found both in direct method and thoracoplasty (Cf. Fig. 12).

And as the results of direct method on those patients who are sensitive to chemotherapeutics are far more satisfactory than those of thoracoplasty, it is probable that the direct method is more vulnerable to the bad effect of the resistant bacilli than the thoracoplasty.

The above-cited results are those of the patients who have complete resistance of 10γ to SM, PAS, INH, etc. As the number of the cases of operation on the carriers of highly resistant bacilli is growing larger, there is a possibility that the scope of the applicability of the collapse therapy will considerably extend in the near future. Extraperiostal plumbage, which has the advantage of causing no deformity of the thorax and in which comparatively slighter disturbance of in the cardiopulmonary functions are caused than in case of the thoracoplasty, can be expected to come to possess a high degree of applicability for the treatment of such cases as those with high resistant bacilli.

Conclusion

From what has been stated, we believe that the method of plumbage can be revived as a surgical treatment for pulmonary tuberculosis, instead of being completely valueless, by improving the hard filling materials into softer ones and by shifting the regions to be filled from extrapleural regions to extrapleural regions to extraperiostal ones. That is why I have here presented the outline of the results of our research in this method, hoping that it will contribute to the further researches into this method.

Acknowledgment

In conclusion, it is my pleasure to express my sincere gratitude to President Seiji Kimoto who has kindly offered me the opportunity of giving this special lecture and I also take this opportunity of thanking Prof. Yasumasa Aoyagi, who was kind enough to encourage me during the dark hours when our researches were undergoing their worst ordeal, as well as of appreciating the co-operation of my younger collaborators.

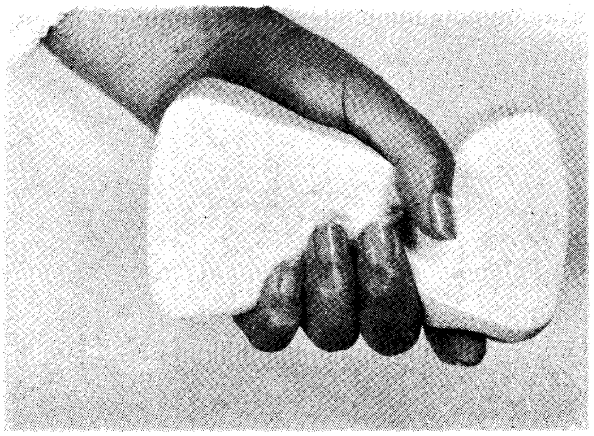


Fig. 1 Polyvinylformalsponge

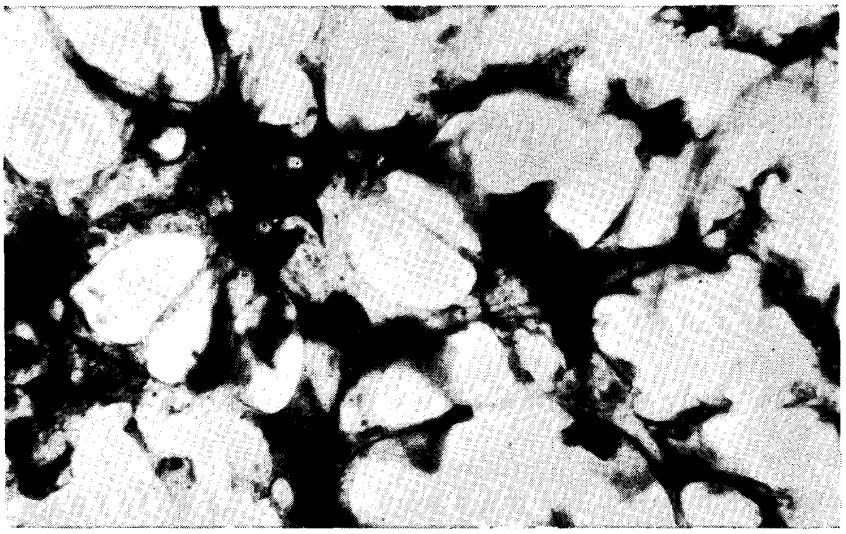


Fig. 2 Microscopic findings of polyvinglformalsponge

Fig. 3 Microscopic findings (1 year after plumbage)

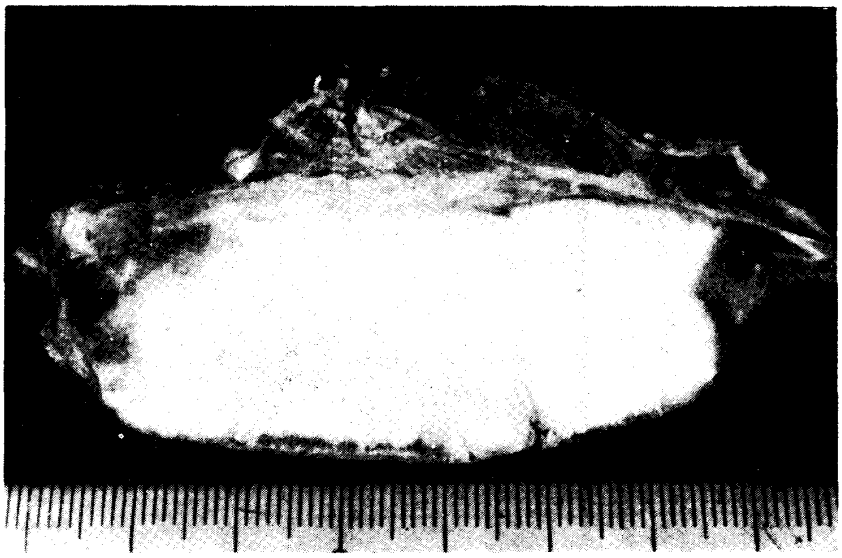


Fig 4 Macroscopic findings (6 monthes after plumbage)

Fig. 5 Microscopic findings (6 monthes after plumbage)

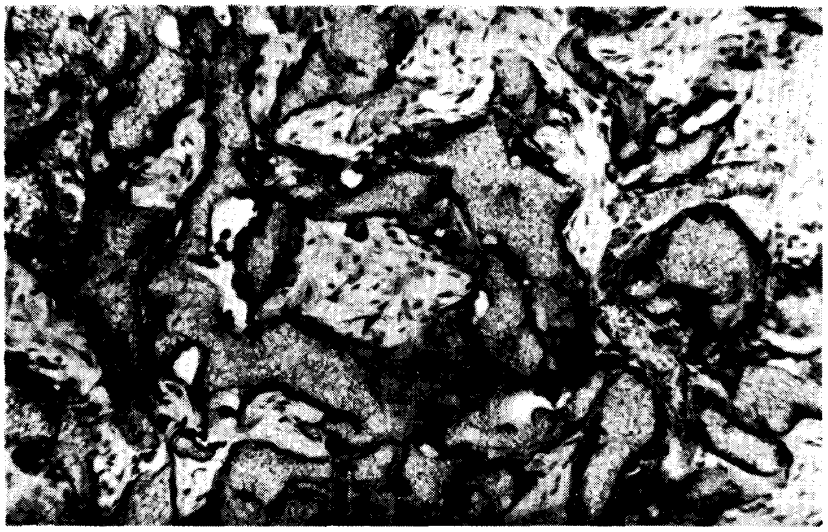


Fig. 6 Microscopic findings (6 monthes after plumbage)

Fig. 7 Microscopic findings (1 year after plumbage)

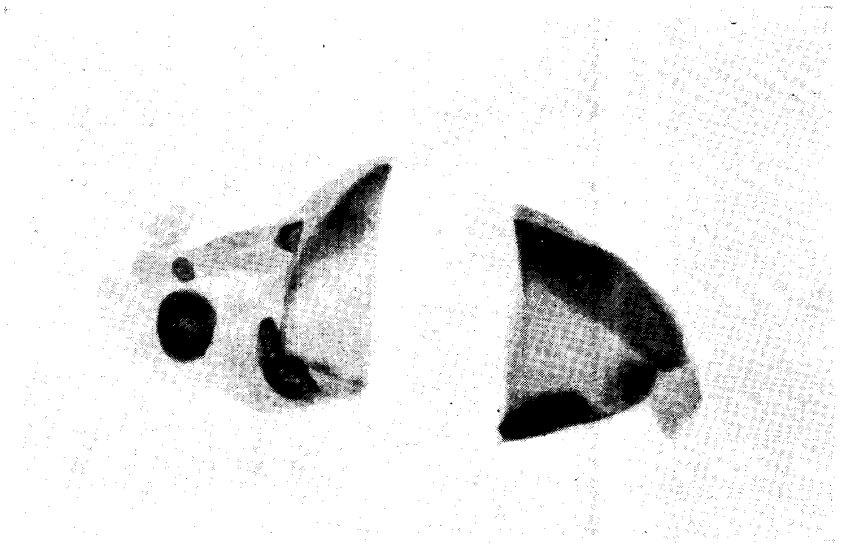


Fig. 8 Changes of ribs (after 6 monthes after plumbage)

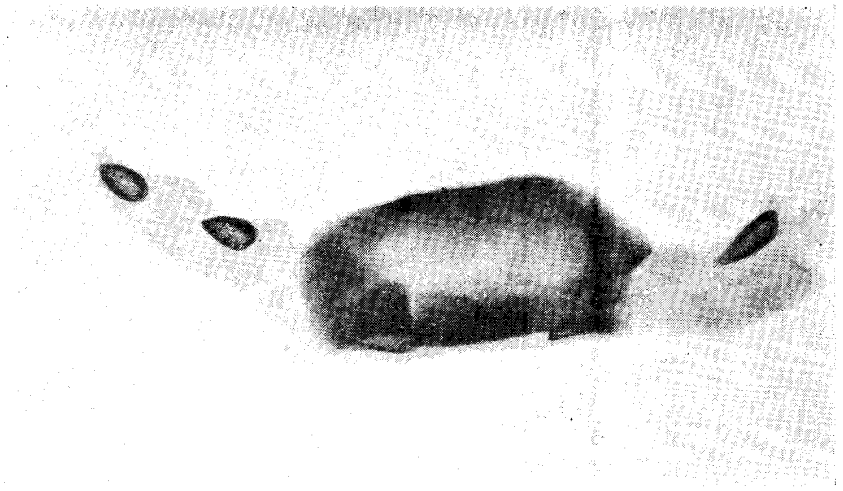
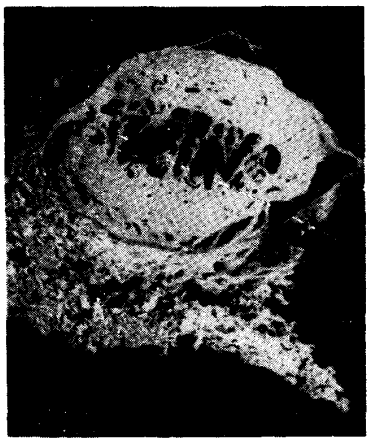
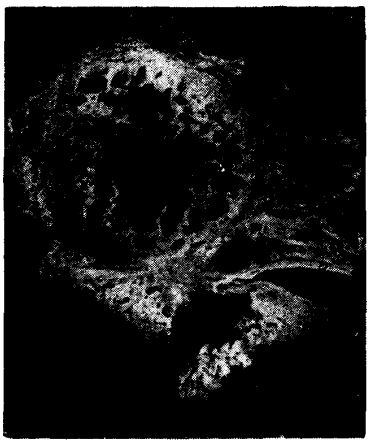


Fig. 9 Changes of ribs (after 6 monthes after plumbage)

Fig. 10 Influences of detachment of periosteum and temporary cutting of ribs on ribs

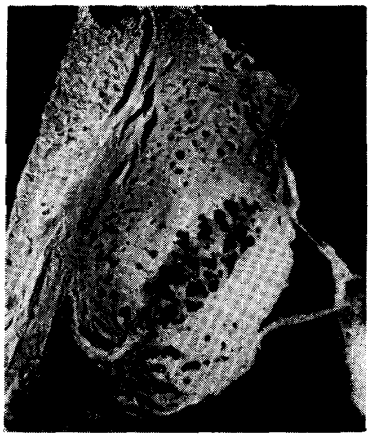


a. after detachment of periosteum (not cutting of ribs)



b. after detachment of one side of periosteum and temporary cutting of ribs

c. afer detachment of periosteum and temporary cutting of ribs



d. after detachment of periosteum (not cutting of ribs)

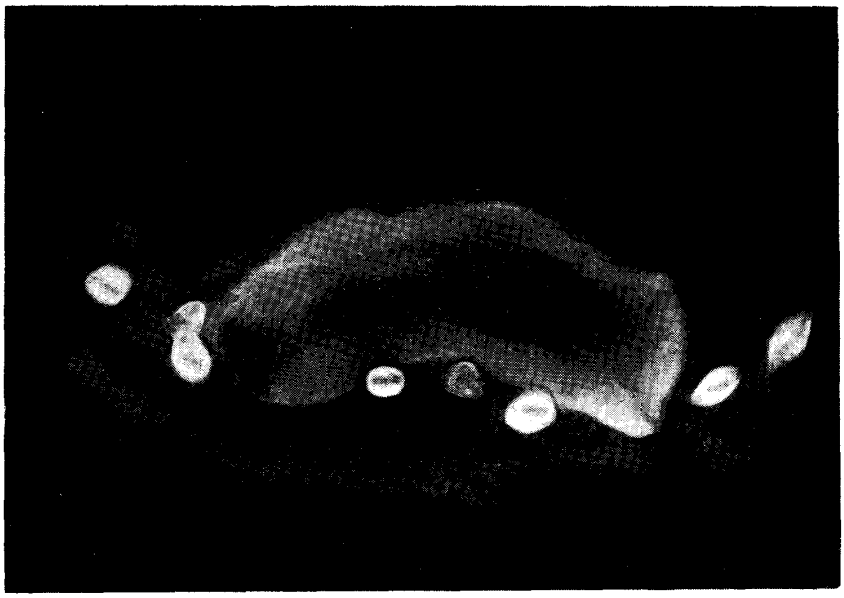


Fig. 11 Regeneration of bone tissues (6 monthes after plumbage)

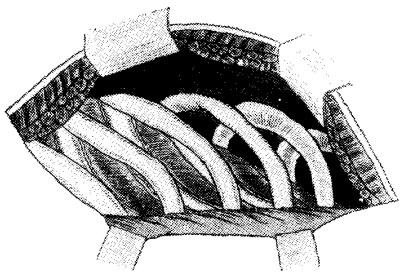


Fig. 12 Fundamental operative technique
(left side, after detachment of periosteum)

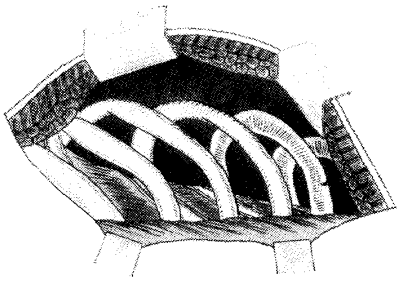


Fig. 13 Fundamental operative technique
(left side, after cutting of intercostal muscles, periosteum and nerves)

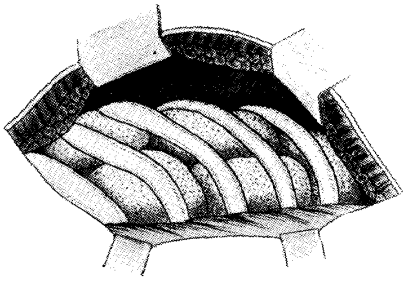


Fig 14 Fundamental operative technique
(left side, after filling of polyvinylformalsponge)

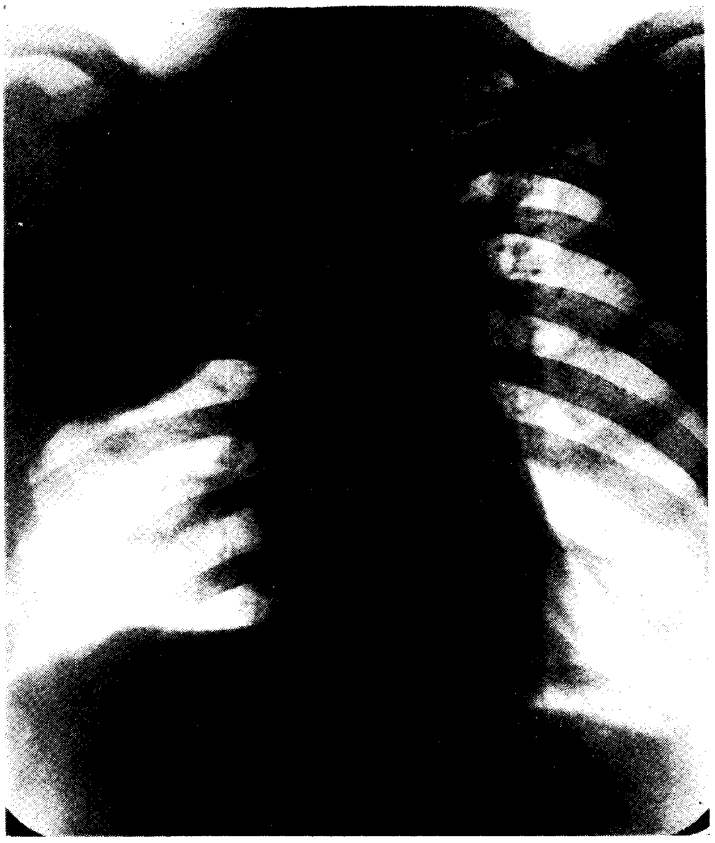


Fig. 15 Roentgenogram after plumbage

Fig. 16 Angiocardiogram after plumbage

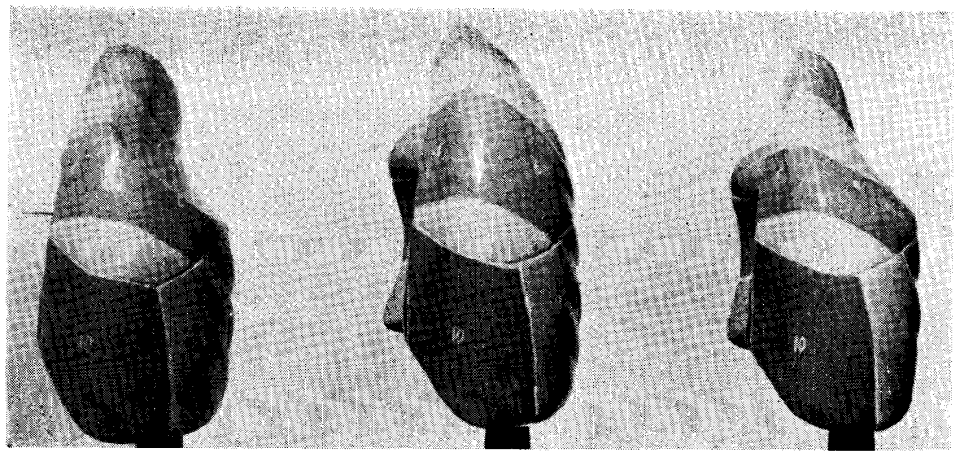


Fig. 17 Models of normal lung and collapsed lung

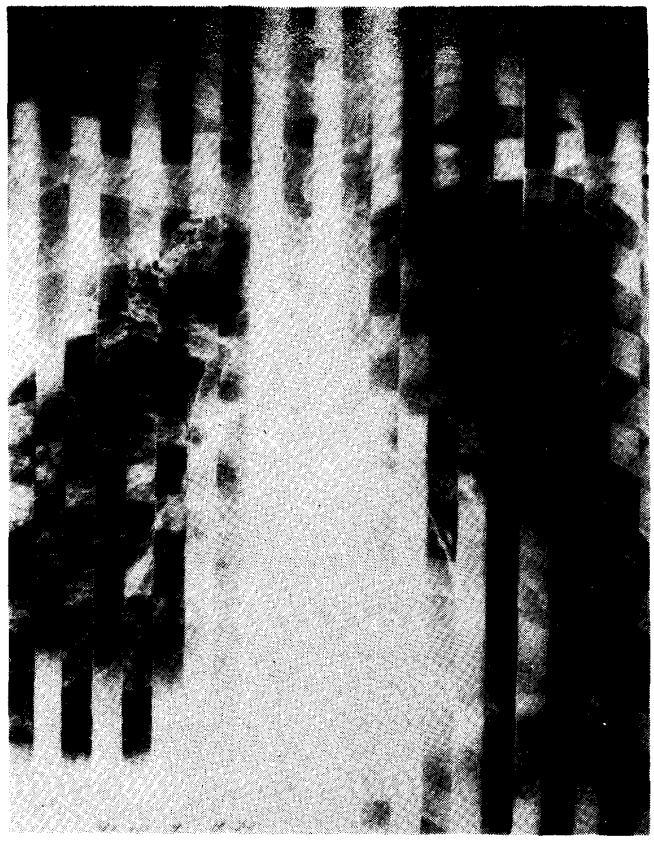


Fig. 18 Broncho-distatogram after plumbage