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PNEUMONOPLASTY: PERIOSTEO-PLASTIC PNEUMONOLYSIS

BY

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For many years thoracoplasty with extrafascial apicolysis has been the major surgical procedure of choice in applying collapse therapy to the treatment of pulmonary tuberculosis. The results of this operation have been considered to be satisfactory, producing sputum-conversion figures of 70–80% in various hands. The recent advances in chemotherapy and surgical technique have enabled excision therapy to take a gradually increasing place in the surgical treatment, as it must inevitably do, for it is basically a sounder surgical principle. Nevertheless, collapse therapy is likely to remain for a long time one of the main forms of treatment of the disease.

Having undertaken various forms of thoracoplasty on some 500 patients during the last 13 years, consideration and reflection upon the operation and the types of disease on which it has been performed leads me to the opinion that it should be possible to produce a similar permanent collapse of the lung in cases of apical disease without the destructive changes to the thoracic cage that are the features of this operation. These destructive changes tend not only to a deformity of one side of the chest which is aesthetically undesirable, but to difficulties of coughing and raising secretion in the post-operative stages which may lead to an extension of the disease to the lower lobe.

Extrapleural pneumothorax is a kinder operation to the patient, but it is not a permanent form of collapse therapy, and the frequency of complications, among which the most serious are haemorrhage into the space, late tuberculous space infection, and gradual re-expansion of the lung, has led to its falling into disfavour, at least in most centres in Great Britain.

Maintenance of lung collapse by the introduction of various solid or fluid media within the thoracic cage has been tried: fat, muscle, paraffin wax, oil, and more recently lucite balls and polythene, but the fat absorbs, the muscle atrophies, and the history of the use of the foreign bodies has been a sad one, although the newer plastic materials appear to be better tolerated by the tissues.

The following features are considered to be advisable in a collapse operation.

(1) The collapse should be really permanent—i.e., the collapsed lung should be covered by an unexpandable medium of which the only natural one is bone.

(2) The apical space should be ultimately filled with fibrous tissue, and not air, fluid, or a foreign body.

(3) The thoracic cage should remain as intact as possible so that deformity is minimal.

(4) The operation should be done in one stage.

These desirable features can be combined together in an operation, which I have termed "pneumonoplasty" in preference to "periosteoplastic pneumonolysis," which, although a truer description of the procedure, is cumbersome.

In this operation an extensive extrapleural pneumonolysis is performed, the only ribs resected being the fourth and fifth. The second to the sixth or seventh intercostal bundles with the rib periostea are mobilized, detached posteriorly, and re-attached to the side of the vertebral column at a lower level.

The position of the bundles and periostea over the upper part of the lung is adjusted so that when recalcification occurs re-expansion of the lung is prevented (Figs. 1*a*, 1*b*, and 1*c*). Before this recalcification the lung is held down by the liquid which collects in the extrapleural space, and, if absorption of this liquid is too rapid, temporary air refills are established.

Bailey in 1941 described an operation which he called extraperiosteal pneumonolysis which had certain similar features to the pneumonoplasty, but he did not free the lung anteriorly, nor was any attempt made to re-attach the posterior ends of the bundles at a lower level. Furthermore, as the intercostal bundles were not detached from the

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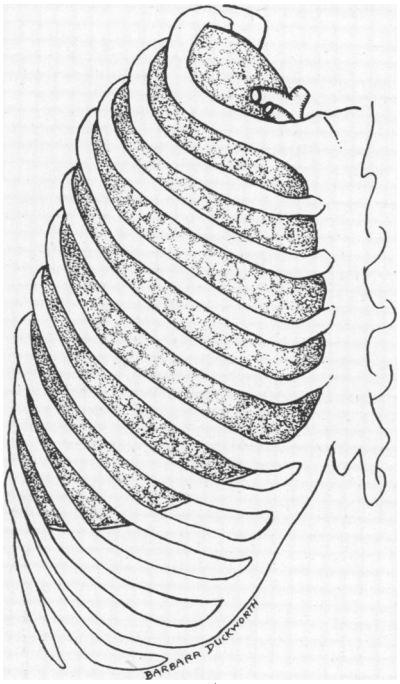

FIG. 1*a*.

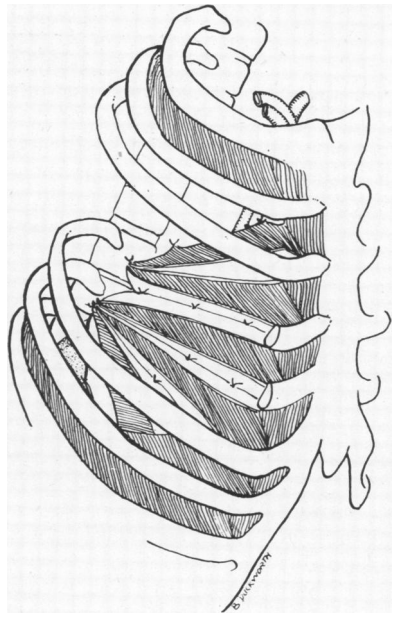

FIG. 1*c*.

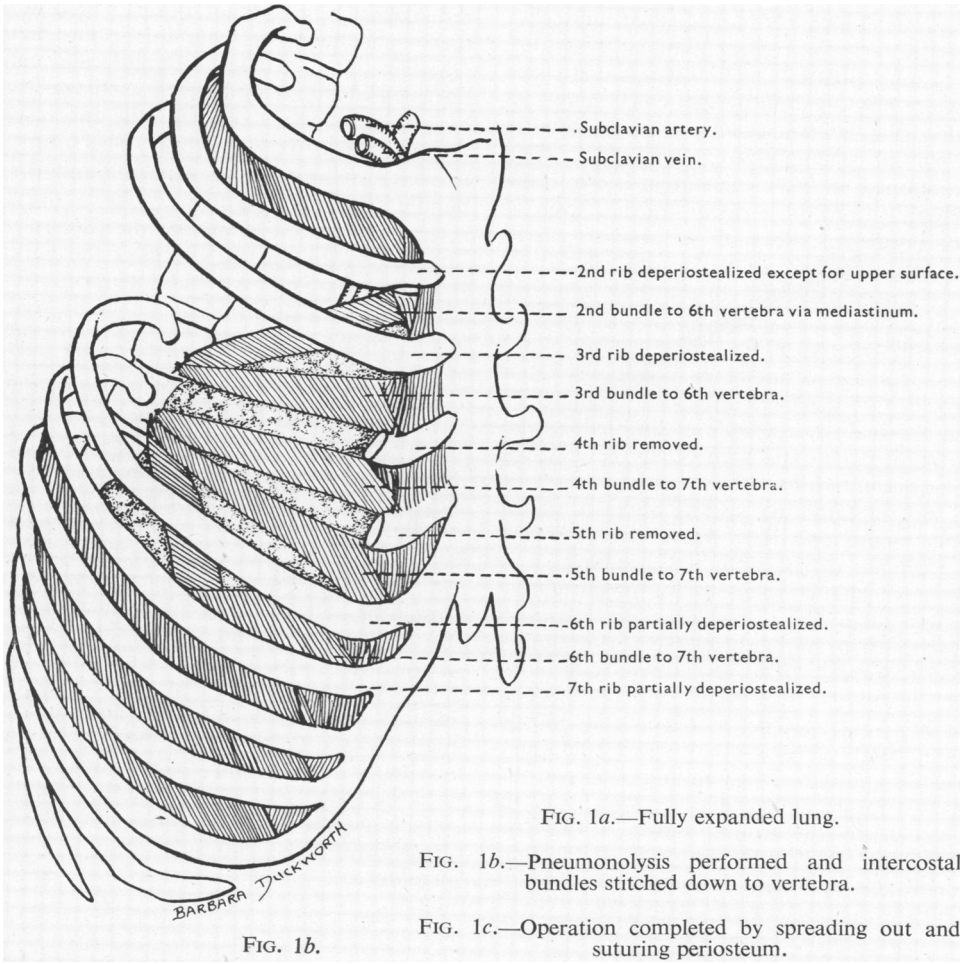

FIG. 1*b*.

FIG. 1*a*.—Fully expanded lung.

FIG. 1*b*.—Pneumonolysis performed and intercostal bundles stitched down to vertebra.

FIG. 1*c*.—Operation completed by spreading out and suturing periosteum.

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lung, and re-applied over the apex, it is likely that apical re-expansion would occur.

An account is given herewith of the results in the first 37 patients on whom pneumonoplasty has been performed, and it is demonstrated that the operation does in fact produce the permanent collapse effect upon the lung for which it was designed.

Cases were selected so that some conception could be gained of the particular type of disease for which this operation might be safely advised.

Operative Technique

All patients are anaesthetized with pentothal, nitrous oxide and oxygen, and with *d*-tubocurarine HCl as a relaxant.

The patient is placed in the usual lateral thoracoplasty position.

A curved periscapular incision is made, not running so high but continued rather more laterally than the standard first-stage thoracoplasty incision. The musculature is divided and the scapula retracted. The fourth rib is delineated and some 20 cm., or more if the patient is of large stature, is removed subperiosteally. The extrapleural space is then entered by dividing the periosteum, and an extrapleural strip is made exactly as in performing an extrapleural pneumothorax operation. The strip is continued on the mediastinum down to the hilum, laterally and posteriorly to the level of the lower border of the sixth or seventh rib as required, and anteriorly to the fourth rib.

Some 20 cm. of the fifth rib are then removed. The periosteum of the inner surface of this rib is raised with great care, and every endeavour is made to keep this as intact as possible as it is the regenerated bone from the periosteum which will form the main framework of the shelf covering and limiting the expansion of the apex of the lung. The preservation of this layer of periosteum intact is not always easy as the support of the underlying pleura and lung has been lost. The outer periosteum of the sixth rib is incised along its lower edge and elevated to the upper border for a length of 20 cm. The inner periosteum is lifted, and the fifth bundle with the periosteum of the sixth rib is freed. The seventh rib is similarly treated if required. The bony elements of these ribs are left intact. The posterior ends of the freed intercostal muscles are divided, the intercostal vessels and nerves ligated and sectioned, the separated periostea detached posteriorly, and the whole flap turned forward and hinged at the front ends. The outer and inner periostea of the third and second ribs are lifted for about 20 cm. forward, and the third and second intercostal bundles divided posteriorly. These structures with the attached periostea provide a further flap which is turned forward anteriorly after the serratus anterior muscle slips have been divided. A linen thread stitch is inserted into the ligamentous structures on the side of the sixth vertebra. The suture must be very firmly inserted as it is the anchor for the upper flaps. The intercostal vessels and the azygos vein should be clearly located at this stage so that these structures are not damaged by the insertion of the needle. The suture is left lying free.

The second intercostal bundle is now fixed over the apex of the lung. The object is to bring this bundle and its periosteum directly backwards in a true antero-posterior direction close to the mediastinum. Unfortunately, the second bundle cannot be safely freed to its anterior limit because the muscle thins out anteriorly and tension may cause it and the periosteum to rupture. This would interfere with the blood supply of the flap and re-ossification might not occur. In order to get the second bundle as near to the mediastinum as possible it is first taken internally and sutured to the back of the second costal cartilage ; then it is brought backwards close to the mediastinum to the side of the sixth vertebra. The suture already *in situ* is rethreaded on a needle and the second bundle stitched with this to the vertebra. The sutures are put through the periosteum which is attached to the muscle as this is the only part of the bundle which will stand tension. The third bundle is treated similarly. The lower bundles are sutured under slight tension to the side of the seventh vertebra in a similar fashion. The lung is now held down but tends to bulge up on respiratory movements between the bundles. If the periosteum has become torn, the loose pieces are spread out and sutured by fine interrupted nylon sutures to the adjacent bundles, and the periosteum on the medial surface of the second bundle is sutured to any available tissues in the mediastinum. At the end of the operation the apex of the lung should be controlled by a firm membrane consisting of periosteum and intercostal bundles. Obviously these flaps would not stay in position for long, but the fluid which collects in the extrapleural space holds the lung down and helps to maintain and fix the grafts in position and relaxes any tension on the flaps. Penicillin solution is put into the space, and the chest wall musculature and skin is closed. A pad is put into the axilla and dressings supplied supported by a firm many-tailed bandage.

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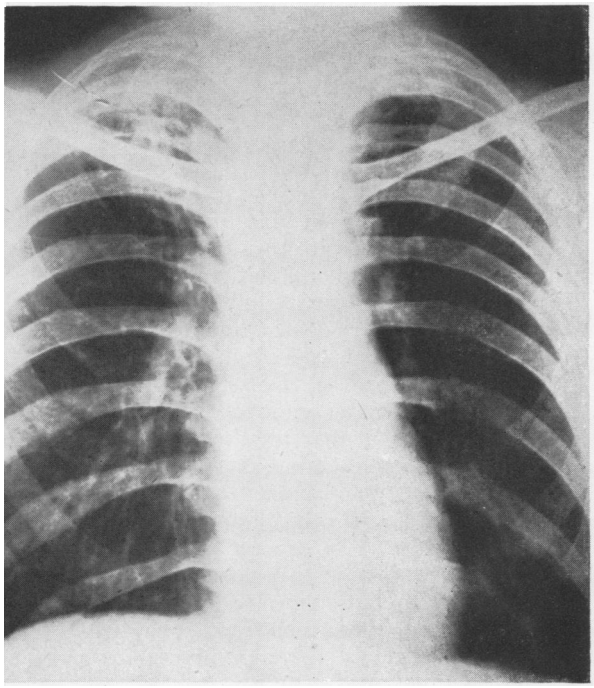

FIG. 2*a*.

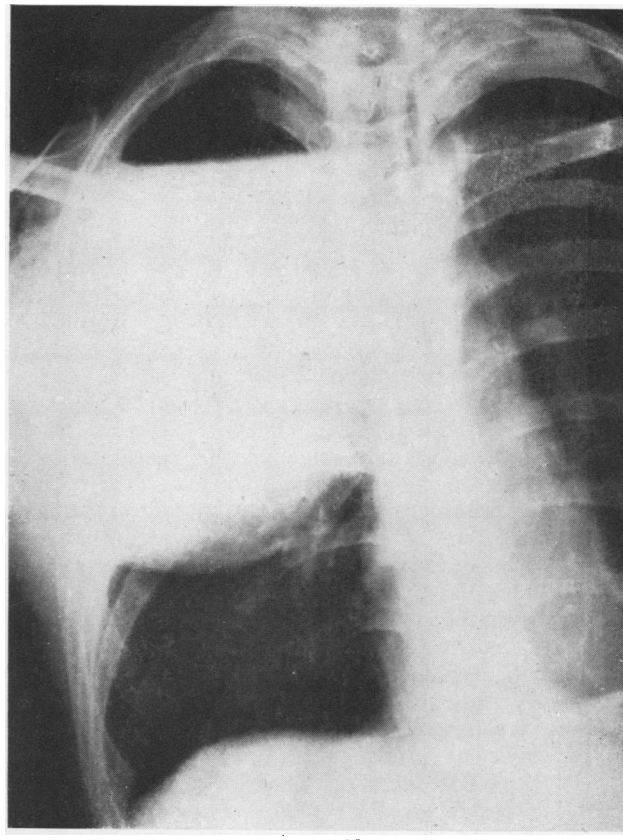

FIG. 2*b*.

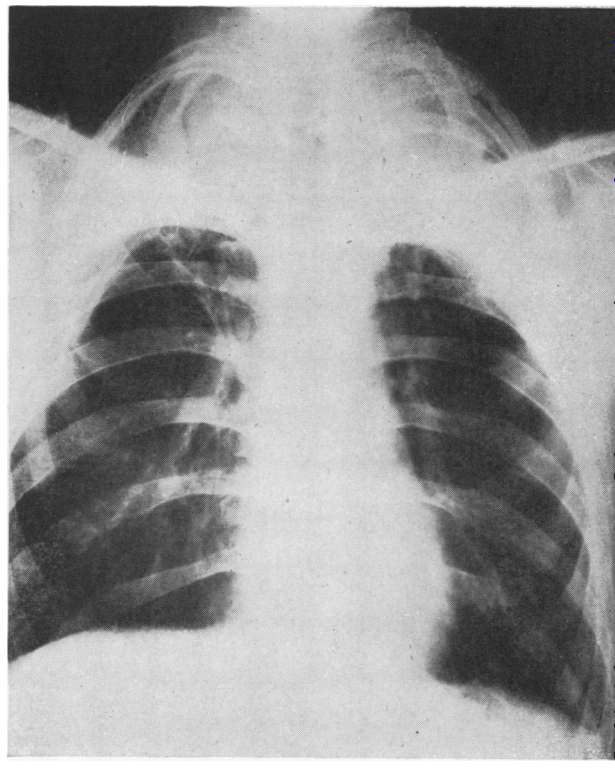

FIG. 2*c*.

FIG. 2*a*.—Man aged 29 years with five years' history. Sputum positive. Bilateral apical disease. Failed artificial pneumothoraces.

FIG. 2*b*.—One week after pneumonoplasty on right side. Lung held down by fluid.

FIG. 2*c*.—Six months after operation on right side and four months after operation on left side. (On left side a variant of the standard operation has been performed in which the fourth and fifth ribs have not been removed, but divided posteriorly only after deperiostealization.) Both lung apices well relaxed and covered with reformed bone. Sputum negative on culture.

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Post-operative Course

Where an extensive lung mobilization has taken place, the rise in pulse rate is usually a little higher than after a first-stage thoracoplasty. Once the wound has been closed, the superior thoracic space rapidly fills with liquid, and this, combined with the residual air, maintains a controlling influence over the lung, enabling satisfactory coughing to be undertaken. A certain amount of air may be forced up into the neck from the space in the first 36 hours due to the collecting liquid, but this causes little or no discomfort. In view of the considerable fluid loss into this space it is well to see that the patient has adequate fluid replacement during the first two days. Radiographs taken at the end of 24 hours show a large collection of liquid in the upper thoracic space. The haemorrhagic fluid should not be aspirated unless there is evidence that an excessive amount is collecting. A slight feeling of tightness in the upper chest is not infrequent and can be disregarded. If, however, tracheal displacement becomes marked or there is some bogginess developing in the supraclavicular fossa, axilla, or parascapular region, then a little liquid can be aspirated until the tension is relieved and the patient is comfortable. Aspiration has been required in three cases (see later).

Normally fluid absorption begins between the seventh and fourteenth day, and air refills will usually be necessary at the end of the second week. They are given by injection through the first intercostal space anteriorly. It will usually have to be bubbled through the fluid to start with, but an air space rapidly develops from which manometric records can be obtained. The pressure should be taken to 15 cm./water, or less if the patient feels tightness at a lower pressure; 150–200 ml. of air can usually be given at this stage. It is not advisable to give air before the seventh day, as the cervical and mediastinal tissue spaces are in direct communication with the extrafascial space, and are not firmly enough sealed off before this time to withstand any considerable air pressure, surgical emphysema resulting. The air injection should be repeated every three days for the first three fills, and subsequently at weekly intervals until the sixth to eighth week, taking the pressure to 20 cm./water. By this time ossification from the periosteum should be visible, and is best seen on a grid film or tomograph. Air refills can at this stage be stopped and the space allowed to fill with the fluid. The lung should then be controlled by the bony layer and the relaxation maintained.

A low grade pyrexia often persists in these patients for some weeks while the haemoglobin from the space is being absorbed, but it is usually not associated with any feeling of toxicity.

Post-operative physiotherapy is given and there should be no visible deformity.

The patients are allowed up after six weeks, and exercise gradually increased. They are usually fit for discharge from the sanatorium in four to five months after the operation. If the other lung requires a similar operation then this is performed three to four months after the first one.

A needle inserted into the space above the reformed bone some months after the operation has encountered fibrous tissue only, and in no case have there been any residual symptoms as a result of this fibrous tissue development.

No case of necrosis of the ribs has occurred following this extensive removal of periosteum, and it would appear that they may develop an accessory blood supply from the muscles of the chest wall and the subscapular tissues. Changes in the rib structure do occur, however, for if the deperiostealized ribs are exposed a second time, as has been necessary in two cases, to perform a secondary thoracoplasty, they are seen to be somewhat whiter than normal, and perhaps not quite so solid in consistency. There has been no case of spontaneous fracture of these ribs.

Results

Details of the first 37 cases operated upon, 20 men and 15 women, are given in Table I, with a follow-up at the end of May, 1949.

Primary sputum conversion was obtained in 28 cases (75% of the total) and a further two patients subsequently obtained a negative sputum following a three-rib apical thoracoplasty which controlled an anterior portion of the lung that was tending to re-expand. It is pointed out that various slight modifications of the technique were tried in the earlier cases, some of which were successful and others not. The importance of the air-refills was not realized until a number of cases had been done. Late re-expansion of the anterior part of the apex was a problem which entailed a subsequent readjustment of the portions of the anterior ends of the second and third intercostal bundles in relation to the lung apex at the time of operation. Furthermore, it was important to study which type of lesion was likely to be controlled by this operation, and consequently pneumonoplasty was undertaken in some cases on a type of disease which in the final assessment would be considered unsuitable.

Analysis of the nine cases which still remained positive (usually only on culture or guinea-pig inoculation) showed that the cause of failure was

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TABLE I

RESULTS OF PNEUMONOPLASTY

	Sex	Age	Length of Disease (Years)	Pre-Operation Sputum	Date of Operation	Sputum	"Follow-up" Notes (May, 1949)
R.C.	M	22	3	−	17.7.47	−	Died August, 1948: cerebral tuberculoma
F.L.	M	30	5	+	20.7.47	−	Culture
N.B.	F	30	1	+	30.7.47	−	Culture
W.W.	M	27	1	+	24.11.47	−	Smear
A.J.	M	20	2	+	2.12.47	+	Guinea-pig: contralateral disease present
A.C.	M	24	1½	+	1.1.48	−	Smear
S.J.	M	31	1	+	3.2.48	−	Culture
I.H.	F	40	3	+	10.2.48	+	Cavity failed to close
J.B.	F	30	1	+	3.2.48	−	Positive laryngeal swab after pneumonoplasty. Apical thoracoplasty converted sputum
M.W.	F	44	1½	+	8.3.48	−	Guinea-pig and culture
E.C.	F	32	4	+	15.3.48	+	Thoracoplasty on other side with patent cavity
M.K.	F	34	1½	+	14.4.48	+	Cavity not controlled
M.G.	F	24	1½	+	19.4.48	−	Gastric lavage
N.W.	F	25	2	+	19.4.48	−	Guinea-pig and culture
K.L.	M	19	1½	+	12.5.48	−	Smear
E.M.	F	54	5	+	31.5.48	−	Culture
W.T.	M	23	1½	+	9.6.48	−	Positive culture after pneumonoplasty. Apical thoracoplasty converted sputum
J.C.	M	37	2½	+	23.6.48	−	Culture
C.M.	F	26	9	+	28.6.48	−	Culture
H.H.	M	32	6	+	22.7.48	−	Gastric lavage
E.K.	F	23	1½	+	13.9.48	−	Smear
O.C.	F	28	4	+	20.9.48	−	Guinea-pig and culture
J.B.	M	31	4	+	18.10.48	+	Recent exacerbation of lesion on opposite side. *Esch. coli* infection of space
J.B.	M	32	2	+	29.10.48	+	Disease uncontrolled in hilar region
N.D.	F	25	4	+	1.11.48	−	Guinea-pig and culture
A.P.	F	42	5	+	13.12.48	−	Culture
G.P.	M	29	5	+	15.12.48 } 28.2.49 }	−	Culture. Bilateral operation
M.A.	F	30	2	+	17.1.49	+	Bilateral re-exacerbation of disease
H.W.	M	36	9	+	24.1.49	−	Culture
J.K.	M	30	8	+	27.1.49	−	Culture
J.F.	M	46	1½	+	7.3.49	−	Smear
T.D.	M	39	3	+	11.3.49	−	Culture
K.W.	M	37	7	+	18.3.49	−	Concentration
A.S.	M	55	5	+	24.3.49	−	Concentration
N.W.	F	21	4	+	11.4.49	−	Smear
A.B.	F	22	4	+	11.4.49	−	Smear
R.B.	M	27	7	+	2.5.49	−	Smear

in two cases re-expansion of the anterior part of the lung apex due to the intercostal bundles not being accurately placed and to the absence of air-refills; in three cases tension cavities which remained patient; in one case extent of the disease being too great for complete control; and in three cases late exacerbation or persistence of uncontrolled disease in the opposite side which was present at the time of operation.

Seven patients had at the time of operation some form of collapse therapy on the opposite side: one had an apical thoracoplasty; one had an extrapleural pneumothorax; and five had an artificial pneumothorax.

A bilateral pneumonoplasty was performed in one patient with a satisfactory result, and this procedure is now being extended to other bilateral cases.

POST-OPERATIVE MORBIDITY

Haemothorax.—This developed in six cases and aspiration was required. A tear was produced in the pleura during the extrapleural strip, and despite pleural suture some leak of liquid occurred in all

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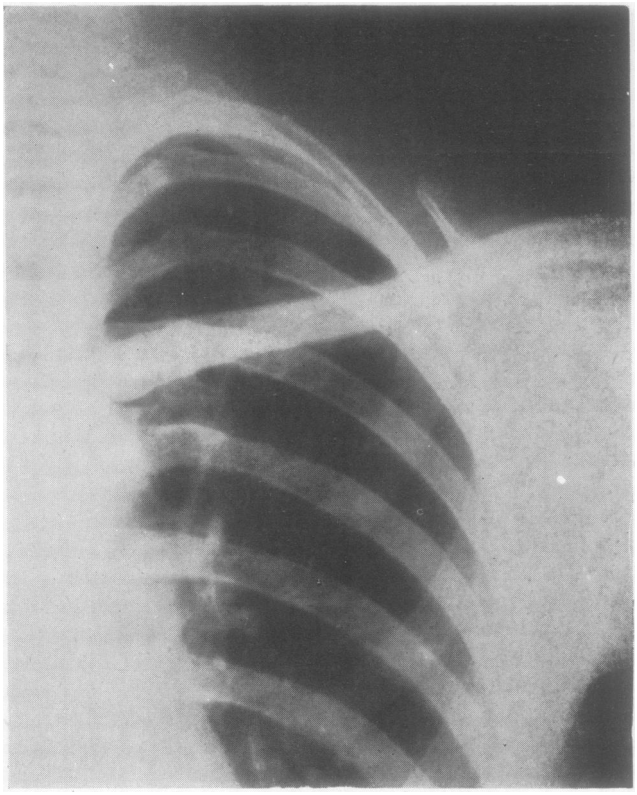

FIG. 3*a*.

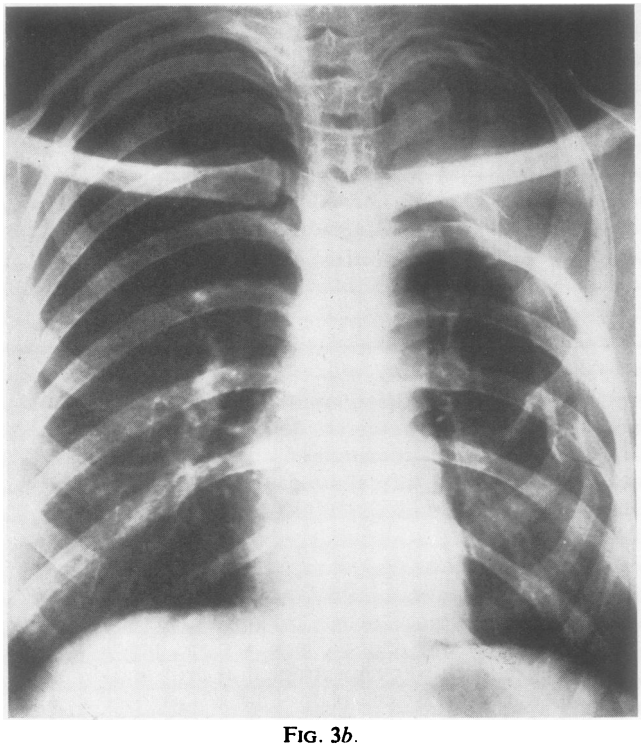

FIG. 3*b*.

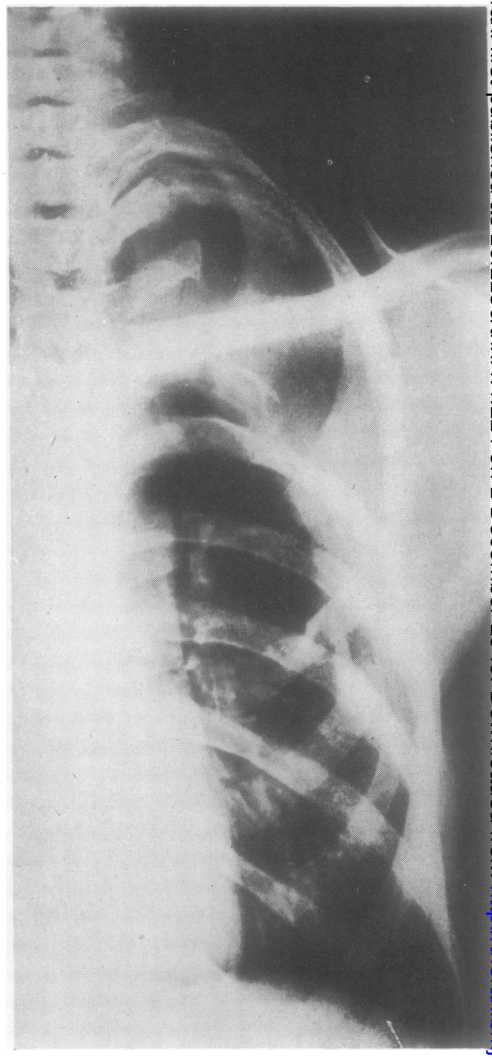

FIG. 3*c*.

FIG. 3*a*.—Woman aged 25 years with two years' history and persistent positive sputum, with uncontrolled lesion behind inner end of left clavicle. Failed artificial pneumothorax.

FIG. 3*b*.—Eight months after pneumonoplasty.

FIG. 3*c*.—Radiograph 15 months after pneumonoplasty demonstrating that the degree of lung collapse is constant and permanent.

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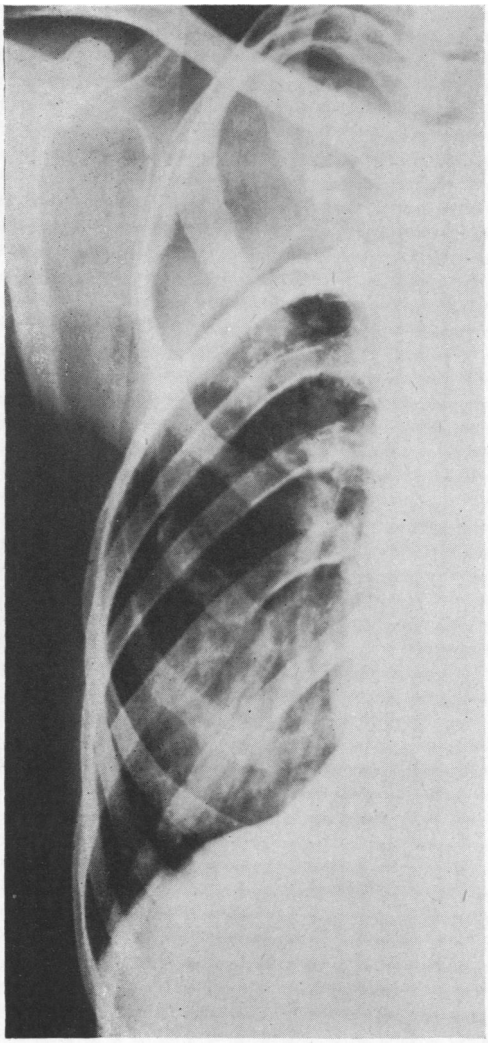

FIG. 4*c*.

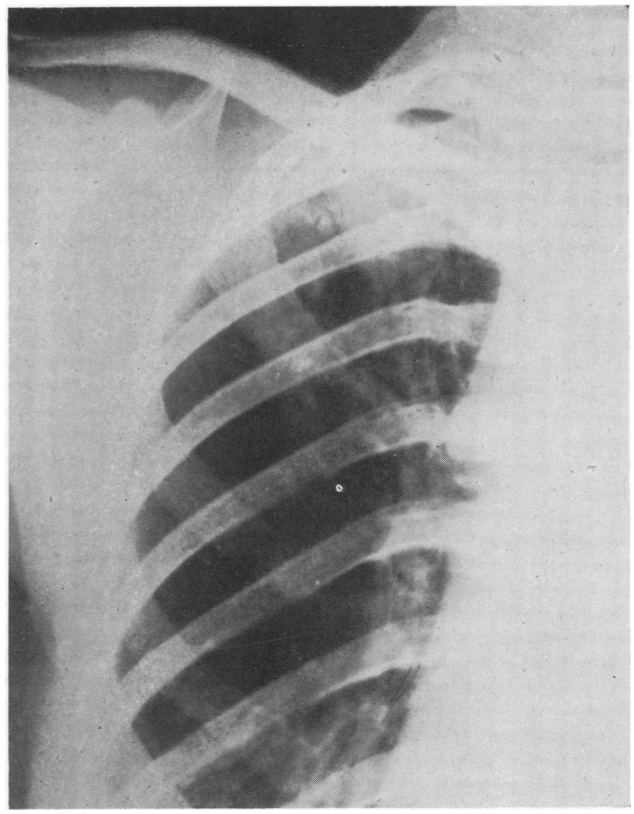

FIG. 4*a*.

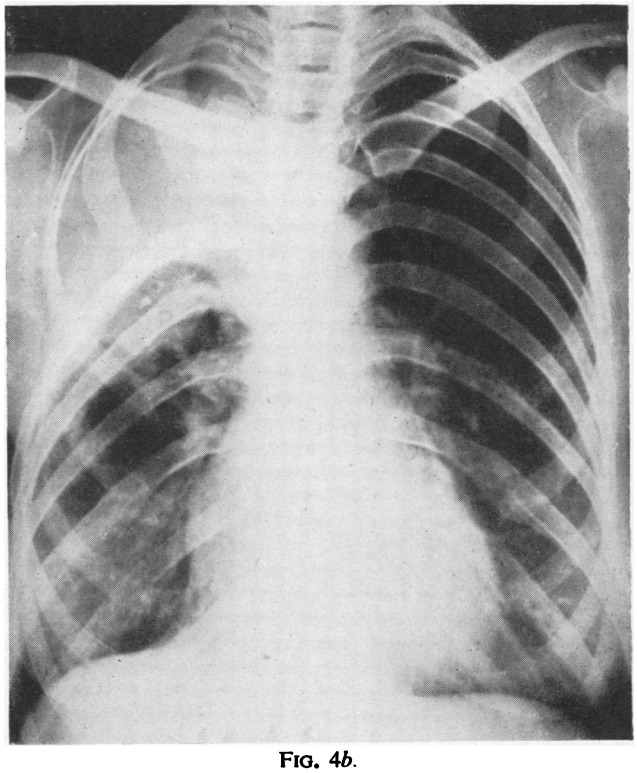

FIG. 4*b*.

FIG. 4*a*.—Woman aged 28 with four years' history and persistent positive sputum. Fibrocavernous disease at right apex. Failed artificial pneumothorax.

FIG. 4*b*.—Three months after pneumonoplasty.

FIG. 4*c*.—Radiograph 10 months after pneumonoplasty showing constant collapse of lung. Sputum negative to culture and guinea-pig inoculation.

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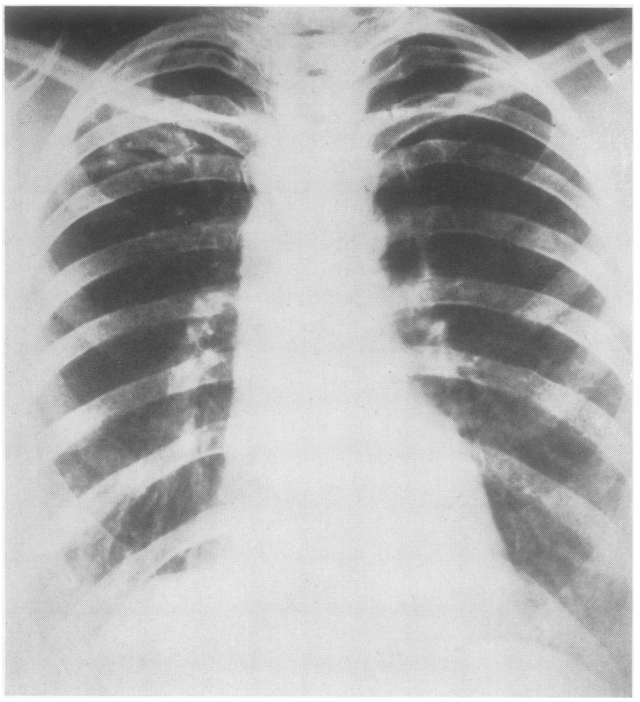

FIG. 5a.

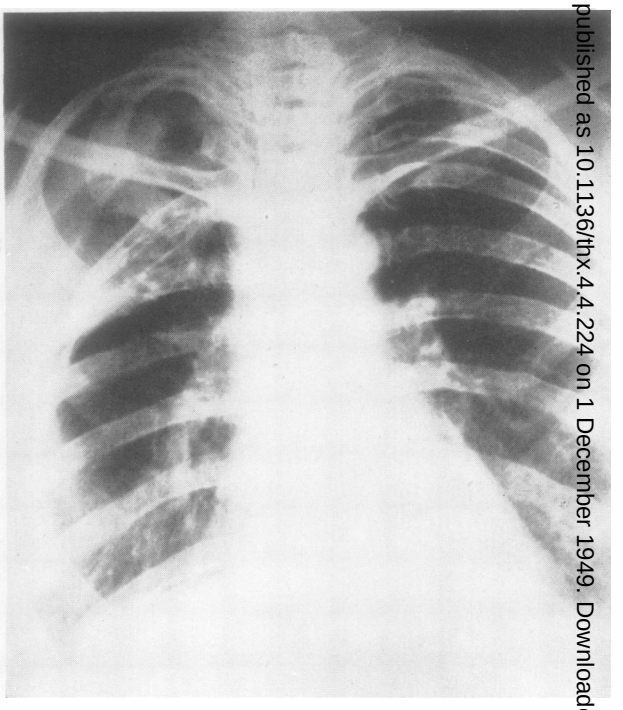

FIG. 5b.

FIG. 5a.—Woman aged 44 with one and a half years' history and failed artificial pneumothorax. Cavity at right apex.

FIG. 5b.—Radiograph 16 months after pneumonoplasty showing new bone formation. There is a tendency to anterior re-expansio of the apex due to the anterior end of the second bundle and periosteum not being carefully adjusted. Nevertheless, th selective control over the posterior part of the lung has produced control of the disease. Sputum negative on culture an guinea-pig inoculation.

cases into the pleural cavity. Although this might apparently diminish the amount of effusion which would collect in the apical space, the small communication between the two spaces very soon became blocked with fibrin and no severe loss of apical effusion occurred except in one case. Air-refills are indicated earlier (about the seventh day) if this complication occurs.

Excessive Apical Effusion.—This occurred in three patients, one on the second day, due to some reactionary haemorrhage, and aspiration was required on two occasions to relieve the tension; the subsequent course was satisfactory. In two other patients a fluctuant swelling was noted under the wound on the seventh day. One patient was treated by complete emptying of the apical space and air replacement, and the other by two aspirations to relieve tension. The final results were good, and no wound dehiscence occurred.

Infection.—No patient developed a tuberculous infection of the space, but one patient eight months after the operation developed a swelling at the lower end of the wound, from which pus containing *Esch. coli* was obtained, and which communicated with the apical space. The space has been drained and a thoracoplasty will have to be performed. No other infections have occurred.

Pulmonary Complications.—These have been notably absent in the post-operative stage. No case of lung collapse or acute embolic spread of the disease has occurred. The follow-up shows that, where there has been any increase of disease on the opposite side, that disease was already present before the operation and the extension was a late phenomenon not apparently associated with the operation.

POST-OPERATIVE MORTALITY

There was no immediate post-operative mortality, although one patient was dead at the follow-up in May, 1949. He died 13 months after the operation from a cerebral tuberculoma.

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PHYSIOTHERAPY

There is no necessity for the specialized groups of exercises which are required following thoracoplasty, and the simple post-thoracotomy regime alone is needed. As only two ribs are removed and the upper three left intact, there is no fear of developing scoliosis. Full scapula movement is obtained at the end of 10 days.

DISCUSSION

Analysing the successful and unsuccessful cases, it is found that pneumonoplasty would be a suitable operation for controlling disease confined to the upper third of the lung. Cavities of up to 3 cm. in diameter could be closed, but if they were of obvious tension type then obliteration was doubtful. If the disease extended right down to the hilum, then the perihilar region might not be controlled. Similarly gross disease involving the antero-lateral segment appeared to be difficult to deal with effectively. Bilateral apical disease, subject to the above limitations, would seem to be an ideal indication for this operation.

This operation has also been found useful in cases of apical disease where an upper lobectomy had been embarked upon but by reason of a densely adherent pleura no separation of the upper lobe could be obtained, and the alternative appeared to be an extrapleural pneumonectomy. To prevent loss of lower lobe function, a switch-over to this type of operation after the exploration has been made is quite simple.

Figs. 2, 3, 4, and 5 demonstrate the results in a selected group of cases.

SUMMARY

Pneumonoplasty is an operation which aims at covering the relaxed upper part of the lung with a bony covering, and at the same time maintaining a relatively intact thoracic cage. It can be utilized in a considerable number of cases for which thoracoplasty has hitherto been employed and has the advantage of being a one-stage permanent collapse operation, with no visible deformity, and utilizing the body tissues only.

I have much pleasure in thanking for their help and suggestions in developing this operation Dr. John Gifford, of Fazakerley Sanatorium, Liverpool; Dr. Clarke Penman, of Cheshire Joint Sanatorium; Mr. John Bickford, Mr. A. M. Mair, and the resident staff of the Liverpool Regional Thoracic Surgical Centre, Broadgreen Hospital, Liverpool.

REFERENCE

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THE POST-OPERATIVE COURSE OF PNEUMONOPLASTY AND ITS MANAGEMENT

BY

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The following notes are based primarily on 20 cases of pneumonoplasty in which I have undertaken the post-operative treatment. In general it may be stated that the post-operative course is smoother than is usual following thoracoplasty and is attended by fewer complications both in variety and incidence, but there is an additional procedure of introducing air into the superior thoracic space for a short period.

GENERAL CONDITION

The general condition is surprisingly good when it is considered that the patient has undergone in one stage a lung mobilization approaching that of a seven-rib apical thoracoplasty. Post-operative shock may be rather more in evidence for two to three hours, but usually recovery is rapid so that after approximately eight hours the general condition is often better than that seen after the first stage of the latter operation.

Temperature and Pulse Rate.—The elevation of temperature is comparable to that following the first stage of a thoracoplasty, but a low grade pyrexia is frequently present for two weeks, and may persist longer. It is occasioned by the absorption of haemoglobin from the haemorrhagic fluid in the large superior thoracic space. There are rarely any symptoms of toxicity associated with it, and the patient is usually unaware of its presence.

The rise of pulse rate tends to be to a rather higher level than is usual after thoracoplasty.

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