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TEN YEARS AFTER PNEUMONECTOMY FOR CARCINOMA

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There have been many accounts of the physiological consequences of pneumonectomy (Cournand *et al.*, 1950; Gaensler and Strieder, 1951; Friend, 1954; Björk, 1956; McIlroy and Bates, 1956; Jones *et al.*, 1960), but few attempts have been made to distinguish the early and direct effects of this procedure from such adaptive or degenerative processes as may develop over the succeeding years. The object of the present study is to compare the clinical and physiological findings in a group of patients one year after pneumonectomy for carcinoma with those occurring in another group 10 years after.

Material and Methods

Ten-year Group.—Of 15 patients known to have survived pneumonectomy for carcinoma for more than 10 years, two lived too far away to attend and a third was found to have developed a carcinoma in the other lung. The 12 remaining patients were studied; these had all undergone pneumonectomy for carcinoma between 10 and 13 years prior to the time of the investigation.

One-year Group.—For comparison, the first 10 patients who had been subjected to pneumonectomy after January 1, 1958, and had survived for a period of at least nine months were studied. These 10 patients had all undergone pneumonectomy for carcinoma, by the same technique as the 10-year Group, between 9 and 15 months prior to the investigation.

In both groups the following investigations were carried out: (1) A clinical history and examination. (2) A chest radiograph. (3) A 12-lead electrocardiogram. (4) Measurement of lung volumes, including the residual volume by a closed-circuit helium technique. (5) Tests of ventilatory capacity included maximum voluntary ventilation at 80 respirations a minute (maximum breathing capacity; M.B.C.), maximum inspiratory and expiratory flow rates, and forced expiratory volume in 1 second (F.E.V.₁). (6) Arterial puncture was performed and the arterial oxygen saturation measured by spectrophotometry in the 10-year group of patients. (7) The arterial CO₂ tension was measured by a rebreathing method (Campbell and Howell, 1960) in the one-year group. This method was not available when the 10-year group were examined, the plasma bicarbonate level being measured instead. (8) The pulmonary diffusing capacity (DL) was measured in both

groups by the single-breath carbon monoxide method (Ogilvie *et al.*, 1957).

Information regarding the pre-operative state and immediate post-operative progress of the patient (including history, examination, chest radiograph, physiological tests, and histology) was obtained from the hospital case-records.

Results

Age, Sex, and Size (Table I).—The 10 patients in the one-year group and 10 of the 12 in the 10-year group were men. In the one-year group the average age was 55 years at the time of operation and 56 at the time of study. The corresponding ages in the 10-year group were 51 and 61. The averages of height, weight, and body surface area were approximately the same in the two groups.

TABLE I.—Age, Sex, and Size

	One Year	Ten Years
No. of patients	10	12
Sex { Male	10	10
Female	0	2
Age { At operation	55	51
At time of study	56	61
Height	67 in. (170 cm.)	67 in. (170 cm.)
Weight	146 lb. (66.2 kg.)	143 lb. (64.8 kg.)
Body surface area (sq. m.)	1.76	1.74

Findings Before and at Operation

A history of chronic bronchitis preceding the symptoms of carcinoma had been recorded in the case-notes of two patients in the one-year group and one patient in the 10-year group (Table II).

TABLE II.—Pre-operative Findings

	One Year	Ten Years
Side { Right	3	8
Left	7	4
Radiograph { Collapse	6	9
Peripheral round lesion	3	1
Hilar mass	1	2
Histology { Squamous	4	7
Oat-cell	3	3
Simplex	3	2
Symptoms or signs of bronchitis	2	1
Pre-operative vital capacity (ml.)	2,989	2,905

The routine pre-operative examination had revealed no significant abnormalities apart from those attributable to the carcinoma and the signs of bronchitis

in the three patients giving a history of this condition. In the one-year group the mean blood-pressure was 140/90, the mean vital capacity 2,989 ml., and the mean M.B.C. 79 litres/minute. In the 10-year group the mean blood-pressure was 130/80 and the mean vital capacity 2,905 ml. (the M.B.C. had not been measured in this group).

The carcinoma was situated in the left lung in seven patients in the one-year group and in four in the 10-year group. It was in the upper-lobe bronchus in five patients in each group, the remainder being in the lower lobe except for one in the one-year group where it probably arose in the left main bronchus.

The chest radiograph revealed lobar or segmental collapse in six patients in the one-year group and nine in the 10-year group. Three patients in the one-year group had a peripheral round lesion and one a hilar mass. One patient in the 10-year group had a peripheral round lesion and two a hilar mass.

In three patients from each group the carcinoma was oat-cell in type. In four patients from the one-year group and seven from the 10-year group a squamous carcinoma was found. The remaining cases were reported as carcinoma simplex.

Post-operative Progress

The immediate post-operative course was uneventful except for three patients in the 10-year group (transient atrial fibrillation in one, and persistent discharging sinus in two) and one patient in the one-year group (pulmonary infarct). With one exception in the 10-year group, all patients returned home within one month of admission to hospital. A thoracoplasty to deal with infective complications was necessary in two patients from the 10-year group.

The patients in the 10-year group volunteered that improvement in their breathing had continued for an average period of two years after the operation. This was reflected in the time taken to return to work. Of six patients who returned to full employment, only two had started work within one year of the operation. In the one-year group only four of the eight patients not retired had returned to work within one year of the operation. Eight of the 12 patients reported one or more attacks of bronchitis during the 10 years since the operation. All but two of the 22 patients had been regular smokers of more than 10 cigarettes a day for most of their adult life. Three patients in the one-year group and five in the 10-year group claimed to have stopped smoking since the operation.

Present Condition

The average grade of dyspnoea was the same in the two groups (Table III). Two patients from each group had only mild dyspnoea (grade 1), while in one from the one-year group and two from the 10-year group disability was severe (grade 3). In the remaining patients dyspnoea was of moderate degree (grade 2)—that is, they

TABLE III.—*Post-operative Findings*

	One Year	Ten Years
Dyspnoea { Grade 1	2	2
" 2	7	8
" 3	1	2
Symptoms or signs of bronchitis	1	5
Increased J.V.P.	1	6
E.C.G. { P. pulmonale	4	8
R.V. hypertrophy	1	3
Radiograph: gross mediastinal shift	2	7

were able to walk any distance on the level at their own pace but were breathless walking quickly or climbing stairs.

Physical signs of bronchitis (rhonchi, coarse crepitations, wheezing expiration) were found in one patient in the one-year group and five patients in the 10-year group. The jugular venous pressure was raised in one patient in the one-year group and six patients in the 10-year group, three of the latter showing slight pretibial oedema also but no liver enlargement. (The 10-year patients with a raised jugular venous pressure included four out of the five patients with a P wave greater than 4 mm. in the E.C.G.). The average blood-pressure was 140/95 in the one-year group (pre-operative: 140/90) and 165/100 in the 10-year group (pre-operative: 130/80).

The electrocardiograph revealed direct evidence of right ventricular hypertrophy in one patient in the one-year group and in three patients in the 10-year group (R wave of greater amplitude than the S wave and/or greater than 7 mm. in V1 or V2; T-wave inversion in V1 and V2). There was indirect evidence in a further three patients in the one-year group and four in the 10-year group. The P wave in lead II was taller than 3 mm. in four patients in the one-year group and eight in the 10-year group. (Average height 2.6 mm. in the one-year group and 3.4 mm. in the 10-year group.)

The chest radiographs in the one-year group showed mediastinal displacement of marked degree in two patients, of moderate degree in three, and of slight degree in five; in the 10-year group they showed marked displacement in seven patients, moderate in four, and slight in one.

Physiological Findings

Lung Volumes (Table IV).—The total lung capacity and its two main subdivisions, the vital capacity and the residual volume, were rather larger in the one-year group than in the 10-year group. When the results are expressed as percentage of expected normal for one lung (assuming 55% for right lung and 45% for left lung) there is no significant difference in the residual volume, which is about twice the predicted normal in both groups. The vital capacity, however, is still greater in the one-year group than in the 10-year group (the pre-operative vital capacity values were the same) and more than the predicted normal for one lung. The ratio of residual volume to total lung capacity is approximately the same in the two groups (see Table VII).

Ventilatory Capacity (Table V).—The M.B.C. was measured before and after operation in the one-year group and showed only a very slight fall after

TABLE IV.—*Lung Volumes*

	One Year	Ten Years
Vital capacity (ml.)	2,154	1,720
% normal for one lung	114	104
Residual volume (ml.)	1,656	1,465
% normal for one lung	198	197
Total lung capacity (ml.)	3,810	3,193
% normal for one lung	140	133

TABLE V.—*Ventilatory Capacity*

	One Year	Ten Years
Maximum breathing capacity (l. min.)	74	40
F.E.V. ₁ (ml.)	1,475	1,053
Maximum insp. flow-rate (l. min.)	177	122
.. exp. flow-rate (l. min.)	125	96

pneumonectomy, from 79 to 74 l./min. In the 10-year group the M.B.C. was not measured pre-operatively, but 10 years after pneumonectomy it was little more than half the value obtained in the one-year group (see Chart). Expressed as a percentage of predicted normal for one lung (assuming 55% for right lung and 45% for left lung) the M.B.C. was 140% of normal in the one-year patients and 89% of normal in the 10-year group. This greater impairment of ventilatory capacity in the 10-year group is also reflected in the maximum inspiratory and expiratory flow rates (which were reduced equally) and in the F.E.V.₁. On the other hand, there is only a slight difference in the two groups between F.E.V.₁ expressed as a percentage of vital capacity (Table VII).

TABLE VI.—Gas Exchange

	One Year	Ten Years
Respiratory rate	17/min.	18/min.
Tidal volume	800 ml.	515 ml.
Minute ventilation	11,800 ml./min.	9,335 ml./min.
Oxygen uptake	226 ml./min.	234 ml./min.
Ventilation equivalent for oxygen	5.2 l./100 ml. O ₂	3.9 l./100 ml. O ₂
Blood CO ₂	Pco ₂ 39 mm. Hg	Plasma bicarb. 25 mEq/l.
Oxygen saturation	—	95%
Diffusing capacity	14.7 ml./mm. Hg/min.	17.0 ml./mm. Hg/min.
"% normal for one lung" ..	107%	137%

Alveolar Gas Exchange (Table VI).—Resting oxygen uptake was the same in the two groups, but the resting minute ventilation was increased in the one-year group owing to a larger tidal ventilation, the respiratory rate in the two groups being similar. The ventilatory equivalent for oxygen was therefore greater at one year than at 10 years. There was no evidence of CO₂ retention in either group. Values for Pco₂ in the one-year group (mean 39 mm. Hg) and for plasma bicarbonate in the 10-year group (mean 25 mEq/l.) were normal in every case. Arterial oxygen saturation was measured only in the 10-year group and was within normal limits in each case. The mean diffusing capacity of the lung was 14.7 ml./mm. Hg/min. in the one-year group and 17.0 ml./mm. Hg/min. in the 10-year group. Expressed as percentage of predicted normal for one lung (assuming 55% for right lung and 45% for left lung), the mean diffusing capacity was 107% in the one-year group and 137% in the 10-year group.

Discussion

It will be seen that certain features are common to both groups of patients. Except for three with severe disability, all patients complained of only a moderate degree of dyspnoea. In both groups the residual volume of the remaining lung was twice the expected normal and its total capacity increased by about one-third. The three ratios commonly used as indices of airway obstruction were only slightly abnormal and were essentially the same in the two groups (see Table VII). Arterial

TABLE VII.—Airway Obstruction Ratios

	One Year	Ten Years	Normal
R.V./T.L.C.	43%	46%	40%
F.E.V. ₁ /V.C.	69%	62%	70%
M.I.F.R./M.E.F.R. ..	1.41	1.27	1.0

levels of oxygen (10-year group only) and of CO₂ were normal in every case. The mean diffusing capacity in each group was rather greater than would be expected for one lung in a normal subject, and in only four cases was it less than this (see Chart).

The main differences between the two groups were as follows. There was a higher incidence in the 10-year group of bronchitis, raised jugular venous pressure, gross mediastinal deviation, and P pulmonale in the electrocardiogram. Each of these signs was noted in about half the patients at 10 years, as compared with only one or two patients at one year. The ventilatory capacity was considerably worse in the 10-year group (see Chart), all but three of the patients having an M.B.C. of less than 50 l./min. (average 40 l./min.). In the one-year group the M.B.C. was 50 l./min. or more in every case (average 74 l./min.).

The cause of the much greater impairment of ventilatory capacity in the 10-year group poses a challenging problem. Judging from our findings in the one-year group, pneumonectomy itself has remarkably little effect upon the M.B.C. even where there is a reduction in the vital capacity. In some patients—for example, Case 5—the M.B.C. actually improved, probably as a result of the relief of airway obstruction and the abolition of infection and toxæmia, all of which may influence the patient's performance in this exacting test. Cournand *et al.* (1950) made a similar observation among patients studied within a few years of pneumonectomy. They found that, whereas the vital capacity was reduced to about half predicted normal, the M.B.C. remained within 70% of predicted normal. The actual values which they reported for these two parameters were indeed remarkably similar to our own one-year group: vital capacity 2,450 ml. (present series 2,154 ml.); M.B.C. 75 l./min. (present series 74 l./min.). In contrast to this, Jones *et al.* (1960), studying a group of patients 10 years after pneumonectomy, reported a considerable reduction in M.B.C. relative to vital capacity. Again, the figures which they reported are comparable with those obtained in our 10-year group (see Table VIII).

TABLE VIII.—Lung Volumes and Ventilatory Capacity 10 Years After Pneumonectomy. Comparison with Series Reported by Jones *et al.* (1960)

	Jones <i>et al.</i> (1960)	Present Study
Vital capacity (ml.)	1,853	1,720
Residual volume (ml.)	1,330	1,465
Total lung capacity (ml.) ..	3,183	3,185
R.V./T.L.C. ratio	41%	46%
Maximum breathing capacity (ml.)	42	40

It is unlikely that a poor ventilatory capacity acts as a selective factor, favourable to long-term survival, so that this finding in our 10-year group almost certainly represents a true deterioration between the first and the tenth year after pneumonectomy. This deterioration cannot be attributed to increasing airway obstruction or over-inflation of the lung, because the evidence of these changes in the 10-year group is no greater than in the one-year group. Jones *et al.* (1960) attributed the impairment of M.B.C. in their 10-year patients to pulmonary fibrosis. If this were the explanation of the difference in the ventilatory capacity of our two groups, one would have expected at least as great a fall in lung volumes and diffusing capacity at 10 years because these are more sensitive than the M.B.C. to fibrotic changes in the lung. Cook and Bucci (1961) studied a group of children 5 to 14 years after lung resection and also reported a reduction in M.B.C. (without evidence of airway obstruction) out of proportion to the amount of lung removed. They attributed this to decrease in effective respiratory muscle strength, as judged by maximum inspiratory and expiratory mouth pressures. Some interference with the efficiency of the respiratory

musculature or the mobility of the thoracic cage does seem the most likely explanation. This could result from distortion of the mediastinum (which we noted to be greater in the 10-year group), scoliosis, or arthritic changes in the costo-vertebral joints.

It has been noted that in the 10-year group there was not only a much poorer ventilatory capacity than at one year but also a greater incidence of bronchitis, jugular venous engorgement, and P pulmonale in the E.C.G. It is therefore remarkable that the patients in this group should not have been more disabled than their fellows at one year and that the diffusing capacity and ventilatory equivalent for oxygen should have been at least as good. Cook and Bucci (1961) made a similar observation in their lobectomized children 5 to 14 years after operation. They found that, whereas the M.B.C. was less, the diffusing capacity was more than would have been expected for the amount of lung removed. Jones *et al.* (1960), using the Filley method for measuring diffusion, found that even the maximum diffusing capacity on exercise was normal in a third of the patients studied more than 10 years after pneumonectomy; the average M.B.C. among these patients was similar to what we have reported (see Table VIII). Cournand *et al.* (1947), using the oxygen method for measuring diffusion, reported a high normal diffusing capacity in two young men nine years after pneumonectomy, but in another two young patients a reduced diffusing capacity was found within six months of pneumonectomy. McIlroy and Bates (1956), using a steady-state method, reported that the diffusing capacity after pneumonectomy for carcinoma was about half predicted normal. It should be noted that all but two of his 10 patients were studied within a year of pneumonectomy and are therefore comparable with our one-year group and with Cournand's two cases studied at three and six months post-operatively.

Dietiker *et al.* (1960) noted that, after pneumonectomy, the diffusing capacity by the single-breath method was reduced in proportion to the reduction in lung volume. This is certainly true of our 10-year group (lung volume 133% normal for one lung; diffusing capacity 137% normal) but not of our one-year group (lung volume 140%; diffusing capacity 107%). However, Dietiker *et al.* drew attention to the fact that the diffusion/lung-volume ratio might be temporarily reduced during the early post-thoracotomy period, although this did not seem to apply to their pneumonectomy cases.

The evidence from the literature is thus compatible with the observation in the present study that the diffusing capacity after pneumonectomy can be well sustained even after 10 years (see Chart) and may then be at least as good as during the first post-operative year despite increasing mechanical and circulatory difficulties. The possible reasons for this are discussed in the succeeding paragraphs.

1. *Successful adaptation* to pneumonectomy depends upon adequate expansion of the pulmonary vascular bed to accommodate the increased blood flow. This increased vascularity would lead to an increased diffusing capacity, but also an impaired ventilatory capacity because of reduced compliance of the lung. "Successful" adaptation would thus contribute to the difference between our two groups if this process of vascularization of the lung were to continue beyond the first post-operative year.

2. *Failure of Adaptation.*—If the vascular bed fails to expand enough the pressure within it must rise. Increased intracapillary pressure will lead to pulmonary oedema and increased arterial pressure to right ventricular failure. In these circumstances the diffusing capacity will remain low. Such patients might be encountered during the first post-operative year but would not survive to 10 years.

MAXIMUM BREATHING CAPACITY AS % NORMAL
Maximum breathing capacity (as % normal) plotted against diffusing capacity (as % normal) for patients in the two pneumonectomy groups. The interrupted lines indicate the values expected for one lung in a healthy subject.

3. *Partial Delayed Adaptation.*—A third group of patients may pass through a phase of pulmonary congestion and oedema which is relieved when pulmonary hypertension due to "protective" arteriolar constriction develops. (A similar situation is sometimes seen in mitral stenosis.) During the early phase one would expect to find a relatively poor diffusing capacity and exercise tolerance and a high ventilatory equivalent for oxygen. In the later stage of pulmonary hypertension, provided that the resistance to flow remains at the arteriolar level and is not due to degenerative changes in the capillary bed, the diffusing capacity and exercise tolerance could be well sustained even where signs of cor pulmonale have developed. In this connexion it may be relevant that the mean diffusing capacity of the eight patients in our 10-year group with electrocardiographic signs of cor pulmonale (63% predicted normal) is similar to those without these signs (61% normal). At one year, on the other hand, the four patients with E.C.G. signs of cor pulmonale have a lower DL (47% normal) than those without these signs (62% normal) and include the three lowest values in the group. It is probable that these patients would not survive to 10 years.

From what has been said it is apparent that measurement of diffusing capacity, in so far as it reflects the state of the pulmonary capillary bed, may be of more value than ventilatory tests in assessing the suitability of patients for pneumonectomy and their post-operative prognosis. Catterall (1961) has reported a high mortality for pneumonectomy among patients with a low diffusing capacity even though their ventilatory capacity was only moderately impaired. We have recently studied a patient who was in serious trouble 10 years after pneumonectomy for bronchiectasis. He was more breathless

(grade 4) than any of the patients reported in the present series, and his electrocardiogram showed more advanced changes of right ventricular strain. Whereas his diffusing capacity was also lower than in any of our other patients, his lung volumes and tests of ventilatory capacity were essentially the same as in our 10-year group (see Table IX).

TABLE IX

	V.C. (ml.)	M.B.C. (l./min.)	F.E.V. ₁ (ml.)	Dyspnoea Grade	Diffusion (ml. mm. Hg min.)	E.C.G.
Case 23	1,650	48	1,110	4	6.6	R.V. strain
10-year group	1,720	40	1,053	2	17.0	P. pul- monale, no strain

Summary

A clinical and physiological investigation has been carried out in 22 patients subjected to pneumonectomy for bronchial carcinoma. Twelve patients were studied 10 years after the operation and 10 one year after.

The degree of disability, airway obstruction, and over-inflation of the remaining lung was similar in the two groups, and none of the patients showed evidence of oxygen lack or carbon-dioxide retention at rest.

The patients in the 10-year group were found to have a poorer ventilatory capacity and a higher incidence of cor pulmonale, although their diffusing capacity was at least as good as in the one-year group.

It is suggested that the reduction in ventilatory capacity 10 years after pneumonectomy is due more to impaired mechanical efficiency of the thoracic cage than to progressive emphysematous or fibrotic changes within the lung itself.

The reasons for the diffusing capacity being relatively well sustained among patients surviving to 10 years are discussed and the possible value of this measurement in predicting the functional outcome of pneumonectomy is noted.

We are indebted to our surgical colleagues and to Dr. W. S. Sutton for allowing us to study patients under their care and for their constant encouragement, and also to Dr. Frank Whitwell for kindly providing the histological reports. We are specially grateful to Mr. Ronald Edwards, who originally proposed this investigation and was also responsible for most of the earlier operations.

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Appendix

Lung Volumes and Ventilatory Capacity

Case No.	V.C. (ml.)		R.V. (ml.)	T.L.C. (ml.)	R.V./T.L.C. Ratio	M.B.C. (M.V.V. ₈₀) (l./min.)		M.I.F.R. (l./min.)	M.E.F.R. (l./min.)	F.E.V. ₁ (ml.)	F.E.V. ₁ as % V.C.
	Pre-op.	Post-op.				Pre-op.	Post-op.				
One Year After Pneumonectomy											
1	2,750	1,880	1,800	3,680	49%	63	50	120	40	990	53
2	2,300	2,310	1,253	3,563	35%	78	67	133	120	1,530	61
3	2,550	1,770	1,650	3,420	48%	66	72	171	133	1,560	88
4	3,750	2,550	2,980	5,530	54%	68	74	240	109	1,500	39
5	3,450	2,130	1,830	3,960	46%	70	96	120	200	1,530	72
6	2,550	2,130	1,740	3,870	45%	65	65	171	100	1,170	55
7	3,152	2,050	1,468	3,518	42%	106	72	100	130	1,470	62
8	2,300	1,890	1,090	2,980	37%	72	65	240	67	1,285	68
9	3,275	1,890	1,430	3,320	43%	92	67	240	109	1,380	73
10	3,850	2,940	1,320	4,260	31%	113	115	240	240	2,340	80
Mean	2,989	2,154	1,656	3,810	43%	79	74	177	125	1,475	69

10 Years After Pneumonectomy											
1	3,000	1,725	1,280	3,005	43%	45	120	150	1,200	70	
2	2,400	1,170	1,024	2,194	47%	22	50	50	750	64	
3	—	1,950	1,720	3,670	47%	49	171	37	990	51	
4	2,900	1,830	1,897	3,727	51%	55	150	150	1,150	63	
5	2,900	2,100	1,610	3,710	43%	41	100	100	1,350	64	
6	2,900	1,500	1,238	2,738	45%	40	100	75	900	60	
7	3,200	2,910	1,910	4,820	40%	70	171	200	1,860	64	
8	—	1,050	2,185	3,235	68%	18	38	35	660	63	
9	2,900	1,800	1,024	2,824	36%	58	200	150	1,200	67	
10	2,650	1,200	1,400	2,600	54%	36	200	120	960	80	
11	3,100	1,900	927	2,827	33%	22	100	66	900	47	
12	3,100	1,600	1,360	2,960	46%	28	70	20	720	45	
Mean	2,905	1,720	1,465	3,193	46%	40	122	96	1,053	62	

Alveolar Gas Exchange

Case No.	Respiratory Rate	Total Volume (ml.)	Minute Ventilation (ml./min.)	Oxygen Uptake (ml./min.)	Plasma Bicarbonate (mEq l.)	Pco ₂ (mm. Hg)	Diffusing Capacity (ml. mm. Hg min.)	Arterial Oxygen Saturation (%)
1 Year After Pneumonectomy								
1	12	880	10,560	180	—	40.0	13.4	—
2	12	750	9,000	240	—	33.8	14.5	—
3	36	550	19,800	158	—	39.5	18.1	—
4	6	1,410	8,460	—	—	41.2	17.7	—
5	18	690	12,420	278	—	41.8	13.0	—
6	12	960	11,520	220	—	—	11.7	—
7	22	360	7,920	270	—	37.2	13.7	—
8	20	600	12,000	—	—	—	7.6	—
9	9	1,020	9,180	220	—	37.7	16.3	—
10	22	780	17,160	240	—	38.8	21.3	—
Mean	17	800	11,800	226	—	39	14.7	—

10 Years After Pneumonectomy								
1	20	450	9,000	240	28	—	14.8	99
2	15	320	4,800	150	26	—	12.9	96
3	13	470	6,100	237	25	—	—	—
4	13	650	8,450	390	22	—	30.2	93
5	19	460	8,740	300	24	—	23.4	95
6	17	690	11,740	330	22	—	21.8	93
7	18	400	7,200	250	25	—	19.2	99
8	36	360	12,960	120	31	—	—	94
9	25	1,050	26,200	380	23	—	16.9	95
10	13	460	5,980	114	25	—	12.5	95
11	13	420	5,400	180	26	—	7.6	93
12	12	450	5,400	120	—	—	10.6	—
Mean	18	515	9,335	234	25	—	17.0	95

The Association for Special Education (formerly the Special Schools Association) has published a report of its twenty-sixth biennial conference, "Growing Points in Special Education," held in Birmingham last year at the end of August. Copies may be obtained from Mr. G. M. Williams, A.S.E., 46 Balliol Avenue, London E.C.4.