

Lung cancer in miners

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The clinical, histological, and biological features of 157 lung cancers in coal miners and ex-miners are presented. In most respects—age, bronchoscopic appearances, histological type, and symptoms—the two groups are similar. A high incidence of dyspnoea in the miners was attributed to the concurrence of chronic bronchopulmonary disease. A striking feature was the lower frequency with which lung cancer in miners was found to be operable. It was suggested that the lower frequency of lung cancer in miners is related to an enhancement of the state of immunological preparedness in the lung related to the immune component in the pathogenesis of pneumoconiosis. The differences in lung cancer between miners and non-miners may be partially explained in this way.

The frequency of death from carcinoma of the lung is lower in workers in the coal mining industry than in other groups of men of comparable age (Kennaway and Kennaway, 1953). This relative advantage enjoyed by the miner is to some extent correlated with the presence in the lungs of men in this industry of the chronic fibrotic disease pneumoconiosis (Kennaway and Kennaway, 1953; James, 1955), although the mechanism of protection remains uncertain. Previous investigations (Ashley and Davies, 1966; Ashley, 1967) have shown that this protection is also enjoyed by workers in the dusty textile industries of Lancashire and Yorkshire, and it has been suggested that the pneumoconiotic process confers some measure of immunity to carcinogenesis in the bronchial tree. Smith (1959), writing from the Midlands coalfield, reported a markedly better survival in miners treated surgically for lung cancer, and Goldman (1965), from Sully at the eastern end of the South Wales coalfield, reported an increase in survival rate *pari passu* with the degree of pneumoconiotic change in the lungs.

The present investigation is directed to a study of the clinical and biological features of lung cancer in a group of 157 miners and ex-miners who have been treated for this neoplasm at Morriston Hospital, Swansea, during the past 12 years. The cases are compared with 1,196 pulmonary neoplasms seen in men who were not employed in the mining industry. Some histological features of the cases in this series have been reported elsewhere (Ashley and Davies, 1967).

AGE INCIDENCE

The ages at diagnosis in the 156 cases in which the information was available are given in Table I. The mean age at diagnosis was 59.7 years.

TABLE I
AGE INCIDENCE OF LUNG CANCER IN MINERS

Age Group	No.
Not stated	1
31-	1
41-	15
51-	56
61-	77
71-80	7
Mean age 59.7 years	

Previous investigations had shown that the mean age at diagnosis in patients presenting with cough was 58.3 years whereas in 69 patients in whom the diagnosis was made on routine radiographic examination the age at diagnosis was 60.7 years.

SYMPTOMS

The major presenting symptoms of this type of tumour were cough, dyspnoea, chest pain, and haemoptysis. The frequencies of these symptoms, of diagnosis as a result of routine radiographic examination, and of secondary deposits present at the time of diagnosis are given in Table II. These frequencies are compared with those in the remaining 1,196 instances of lung cancer in men who did not work in the mining industry. The second column shows the numbers of cases

TABLE II
SYMPTOMS AT DIAGNOSIS OF LUNG CANCER

	Miners		Non-miners
	Observed	Expected	
Cough . . .	94	95	728
Dyspnoea . . .	82	72	551
Chest pain . . .	77	71	542
Haemoptysis . . .	54	63	481
Routine radiograph . . .	5	8.4	64
Secondary deposits . . .	21	17.5	133
Total . . .	157		1,196

expected if the frequencies seen in the non-miners had applied to the 157 miners and ex-miners.

There was an excess of patients with dyspnoea among the miners; this may be related to the high frequency of chronic bronchopulmonary disease in them. The miners also showed a lower than expected incidence of haemoptysis and of cases initially diagnosed on routine radiological examination. Among the miners there was an excess of patients in whom extrathoracic secondary deposits of tumour were clinically apparent at the time of diagnosis.

BRONCHOSCOPY

Endoscopic examination of the bronchial tree is a routine part of the investigation of suspected bronchopulmonary neoplasm. Bronchoscopy was carried out on 139 of the 157 patients in this series (Table III) and an endobronchial tumour was seen in 77 (56%). Bronchoscopy was carried out on 1,001 non-miners, 540 of whom had endoscopically visible neoplasms (54%).

TABLE III
BRONCHOSCOPIC EVALUATION AND OPERABILITY

	Bronchoscopy			Total
	Positive	Negative	Not Done	
Operable . . .	6	11	1	18
Inoperable . . .	71	50	18	139
Total . . .	77	61	19	157

OPERABILITY

The only present prospect of cure in patients with bronchial carcinoma is surgical extirpation of the lesion. In the series of miners, 16 were regarded as having operable lesions, and either pneumonectomy or lobectomy was carried out. The percentage of operable cases, 11.8%, was low.

Twenty-one per cent of the tumours in non-miners were regarded as operable. The difference is highly significant.

The majority of the miners lived in the westerly extremity of the South Wales coalfield between the Neath valley in the east and the mines of south Carmarthenshire in the west. It was considered probable that almost all the miners in this area who had signs and symptoms suggestive of lung cancer were referred to Morriston Hospital for evaluation and that the total number of cases in non-miners might include many from further afield who were sent only because they were considered by the local clinicians to have potentially operable lesions. In such an event the frequency of operability in local patients might be less than in those from more distant areas. A total of 398 men from the County Borough of Swansea were included in the series; 98 (24.6%) of these had operable lesions. Two hundred and twenty-four men from the adjacent parts of Glamorgan were included; 44 of these (19.7%) had operable lesions. Both these groups of men, each with a higher chance of operability than had the miners, had homes close to the hospital in the area of the Glantawe Hospital Management Committee, and it is reasonable to expect that admission to Morriston for the investigation was made on the same basis as for the miners.

The anatomical situation of the tumour in the lung, whether it is visible at bronchoscopy or not, is of cardinal importance in determining whether surgical resection will be feasible or not (Ashley and Davies, 1967). There was no difference in the proportion of tumours visible at bronchoscopy in the two groups of miners and non-miners, and in each group severally the chance of a lesion being resectable was greater if it was not visible at bronchoscopy than if it was seen through the endoscope.

HISTOLOGICAL FEATURES

Material was available for histological study in 83 instances of lung cancer in miners. The histological types were determined on the basis of a classification into five groups: squamous cell carcinoma, well and poorly differentiated; adenocarcinoma, well and poorly differentiated; and undifferentiated carcinoma, which has been described in more detail elsewhere (Ashley and Davies, 1967). The observed types in these 83 cases are set out in Table IV and are compared with the findings in 694 lung cancers from non-miners analysed in a similar way. There is a

TABLE IV
HISTOLOGICAL TYPES OF LUNG CANCER

Type (best differentiated part)	Miners		Non-miners
	Observed	Expected	
Squamous-cell carcinoma ..	12	41	162
Poorly differentiated squamous carcinoma ..	29		237
Adenocarcinoma ..	6	16	44
Poorly differentiated adeno- carcinoma ..	10		29
Undifferentiated carcinoma ..	25	23	194
Mixed squamous/adeno- carcinoma ..	1	3	28
Total ..	83		694
Degree of differentiation (least well differentiated part)			
Well differentiated ..	17	16	127
Poorly differentiated ..	36	38	304
Undifferentiated ..	30	29	235
Total ..	83		666

slight deficiency of cases of carcinoma showing squamous differentiation and of cases showing mixed glandular and squamous differentiation, and a slight excess of cases showing the glandular mode of differentiation. The second part of the table shows that there is no difference in the degree of differentiation in the miners compared with the non-miners.

SMOKING HISTORY

The association between cigarette smoking and lung cancer is well known. The smoking history of 112 of the miners in this series was available in the hospital case records and has been compared with the numbers in each group expected had the experience of 666 patients with histologically demonstrated tumours applied to them (Ashley and Davies, 1967). There was a slightly higher proportion of pipe smokers among the miners, and among those who were cigarette

TABLE V
SMOKING HISTORY IN MINERS WITH LUNG CANCER

	Observed	Expected
Non-smokers ..	2	2.4
Pipe smokers ..	10	8
Cigarette smokers		
< 10/day ..	25	18
11-20 ..	44	35
21-30 ..	14	15.5
31-40 ..	4	10.5
> 40 ..	2	6
'Heavy' ..	7	
Not stated ..	4	
Total ..	112	

smokers a higher proportion were smokers of less than 20 cigarettes per day than was the case in the group of non-miners (Table V).

FOLLOW-UP

Analysis of the follow-up data of cases of lung cancer is not encouraging. Because of the low survival in this condition it was decided to use follow-up at one and two years, by which time over 90% of inoperable cases had died, as the numbers of patients surviving longer than this were so small. The data for miners and for non-miners, subdivided into operable and inoperable cases, are shown in Table VI. In the patients who

TABLE VI
FOLLOW-UP OF PATIENTS WITH LUNG CANCER

	Died < 12 mths	Died 12-24 mths	Alive at 24 mths	Total
Miners				
Inoperable ..	55 (76%)	12 (17%)	3 (4.3%)	70
Operable ..	1 (11%)	1 (11%)	7 (78%)	9
Total ..	56	13	10	79
Non-miners				
Inoperable ..	578 (84%)	64 (9%)	47 (7%)	689
Operable ..	60 (38.5%)	34 (22%)	62 (40%)	156

had operable lesions, deaths within one month of operation were regarded as being related to the major operative procedure and have been excluded.

Miners with inoperable lesions showed a slightly better survival at one year after diagnosis but had lost this meagre advantage by the end of the second year. In the few miners who had operable lesions, the chance of survival to the end of two years was greater than for non-miners. This difference did not reach statistical significance.

DISCUSSION

It is established (Kennaway and Kennaway, 1953) that there is a reduced incidence of lung cancer in coal miners and that this is seen to the greatest extent in the mines of the South-western Division of the National Coal Board, which also has the highest prevalence of pneumoconiosis. A previous investigation (Ashley, 1967) showed a relative decrease of lung cancer and an excess of deaths from bronchitis in the coal and textile areas of England and Wales and that this differential mortality is independent of the factors of population

density and of air pollution. The possibility that areas in which there was a heavy mortality from bronchitis had a low mortality from lung cancer because of early death from the former disease was discussed at some length in that paper and it was concluded that this explanation was not tenable.

A similar suggestion was made in respect of pneumoconiosis (James, 1955)—that miners with dust disease of the lungs were likely to die before they could develop cancer of the lung. Death from pneumoconiosis, however, does not occur at an earlier age than death from lung cancer. In Table VII I have set out the age-specific death rates for lung cancer and for pneumoconiosis for the year 1964 (Registrar General, 1966); it is

TABLE VII

AGE-SPECIFIC DEATH RATES PER MILLION FOR LUNG CANCER AND PNEUMOCONIOSIS, ENGLAND AND WALES 1964

Age Group	Lung Cancer	Pneumoconiosis
35–	113	0
45–	651	16
55–	2,079	79
65–	3,522	175
75–	3,058	219
85–	1,497	144

shown that deaths from pneumoconiosis occur with increasing frequency up to the decade 75–84, whereas deaths from lung cancer reach a maximum some 10 years earlier. A personal series of 106 cases of pneumoconiosis seen at necropsy during the last three years showed a mean age at death of 67·3 years (Table VIII), which was almost 10 years greater than the mean age at diagnosis in cases of lung cancer. Furthermore,

TABLE VIII

AGE AT DEATH IN 106 CASES OF PNEUMOCONIOSIS IN MINERS

Age Group	No.
30–	1
40–	5
50–	20
60–	41
70–	22
80–	16
90–	1

Mean age at death 67·3 years.

Kennaway and Kennaway (1953) showed that there was a greater proportion of miners aged 50 to 69 years, two decades of high lung cancer incidence, in the South Wales coalfield, which has the highest frequency of pneumoconiosis. It is

considered that a simple age effect of this type cannot be accepted as the reason for the deficit of lung cancer in miners.

Gough (1962) suggested that in the pneumoconiotic lung, because of the extensive destruction of parenchymal tissue by the fibrosis of the lesion, there might be fewer available epithelial cells which could undergo neoplastic change. If this were the case the number of lesions in these parts of the bronchial tree which are accessible to bronchoscopy would be expected to be normal, as usually little of this epithelium is lost and the more peripheral lesions, in the parts of the lung subject to fibrosis, would be expected to be reduced. The present series, however, shows that the proportion of cancers accessible to bronchoscopic examination was the same in miners and non-miners, and this suggested explanation must be discarded.

Smith (1959) and Goldman (1965) published evidence that the prognosis in operable lung cancer was better in miners than in non-miners, and Goldman, who found the better prognosis to be correlated with the degree of pneumoconiosis, suggested that this might be because of impairment of the spread of tumour through fibrosed lymphatic channels. In the present series there was a slightly better prognosis in the few operable patients, but this explanation does not solve the problem why fewer miners than non-miners develop lung cancer.

An alternative suggestion which has been put forward (Ashley and Davies, 1966; Ashley, 1967) is that in pneumoconiosis, because of the immunological component of this disease, the lung is in a state of immunological enhancement and that its defence mechanisms are better able to recognize as 'not self' the first few cells which have undergone neoplastic transformation and to react and destroy them. If the degree of immunological enhancement may be correlated with the extent of the pneumoconiotic process, the observation that the reduction in death rate from this disease is greatest in those areas which have the highest prevalence of pneumoconiosis (Kennaway and Kennaway, 1953) and the reduced frequency of lung cancer in the men with greater degrees of pneumoconiosis in the Cardiff necropsy series (James, 1955) would be explicable.

The cases in the present series, both miners and non-miners, are regarded as representative of men who have symptoms suggestive of pulmonary neoplasm. The proportion of cases regarded as operable is lower than in the Sully series (Goldman, 1965); this is probably because the patients seen at this hospital are a more random sample

of men with lung cancer than obtains at Sully, where patients seen in other hospitals and regarded as inoperable *ab initio* may not find their way to the thoracic surgical centre. The proportion of miners with operable lesions was lower in this series than the proportion of non-miners regarded as suitable for operation. This difference, which was apparent when men from more distant areas, who might have been sent in only because the physician seeing them first thought that they might be curable, were excluded, is regarded as a real one. Part of the difference, but not all, may be due to the lower ventilatory capacity in miners (Goldman, 1965) which would make resection of a large part of the lung an unacceptable surgical procedure. On the other hand, part of this difference may be explained by the suggestion that the inoperable tumours represent those which, by their antigenic constitution or their rate of growth, have overcome the immunological defences of the lung and have begun a period of uncontrollable spread. The operable cases, on the other hand, are held in check by a balance between neoplastic growth and immunological control and therefore have a better chance of surgical extirpation. A major part of the deficiency of lung cancer in miners lies in the operable cases.

An absolute bar to surgical intervention in lung cancer is the presence of extrathoracic metastases at the time of diagnosis. In this series the frequency of such metastases was 13.5%, whereas in non-miners the frequency was 10.9%. This difference approached statistical significance. On the other hand, only 3.2% of the miners presented as a consequence of routine chest radiography (although regular radiographic examination of the chest is an important part of the medical care of mining workers), whereas 5.4% of the non-miners did so. These two opposing observations confirm the relatively greater clinical 'malignancy' of lung cancer in miners when it occurs. The slightly better survival at one year after diagnosis in the miners with inoperable lesions, however, does not support this suggestion.

In other respects, lung cancer in miners is biologically similar to lung cancer in non-miners. The age at onset in the two groups is much the same and the frequency with which the lesion was visible at bronchoscopy is the same in the two groups. A rather higher proportion of miners showed the symptom of dyspnoea; this may be

related to the high prevalence of chronic bronchopulmonary disease in these workers with a lower reserve of respiratory function readily used up by the additional load of a carcinoma. The slightly lower proportion of patients complaining of haemoptysis may be related to the lower proportion of cases of tumour showing squamous differentiation. In the series of all cases of lung cancer, haemoptysis was more frequent in this group (Ashley and Davies, 1967).

The histological types of lesion seen in this series did not differ markedly from those seen in the previously reported series of 666 miners and non-miners. There was a small deficiency of tumours showing squamous differentiation and an excess of tumours showing glandular differentiation. James (1955) also found the proportions of the different histological types to be similar in his groups of miners and non-miners, whereas Goldman (1965) found a higher proportion of the tumours in miners to be of the squamous-cell or oat-cell types.

The extent of cigarette smoking was less in the miners than in the non-miners studied in these series. This difference could account for some of the difference in incidence of lung cancer but would not explain the differences seen in the frequency with which the lesions were amenable to surgical intervention.

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