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RELATIONSHIP OF CORONARY HEART DISEASE TO RESPIRATORY DISABILITY

INVESTIGATION OF A RANDOM SAMPLE OF COAL-WORKERS AGED 55-64 FROM A MINING VALLEY IN SOUTH WALES

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Increasing breathlessness on exertion is a common feature of coal-workers' pneumoconiosis (Fletcher, 1948). The number of men presenting for consultation with this symptom increases with age, both because the prevalence of pneumoconiosis in the mining community is related to years of exposure to coal dust (Cochrane *et al.*, 1952; Fletcher, 1955a), and because the presence of pneumoconiosis accentuates the normal impairment with age of the physiological indices of lung function (Gilson and Hugh-Jones, 1955). The prevalence of disabling pneumoconiosis is consequently higher in the older age groups, so that the assessment of breathlessness may be complicated by the coexistence of coronary heart disease or of generalized atherosclerosis (Lavenne and Belayew, 1955). It is therefore necessary to determine whether there is any causal relationship between them.

The prevalence of coronary heart disease has recently been studied in a random sample of coal-workers aged 55-64 (Cotes *et al.*, 1955; Thomas *et al.*, 1956), and the opportunity was taken to investigate pulmonary function, with a view to determining if coronary heart disease was associated with pulmonary disability. At the time it was uncertain whether or not there would be sufficient cases of coronary disease in the sample to justify the comparison; however, 18 cases, giving a 38% prevalence of clinically active and silent coronary heart disease, were found, together with a relatively high prevalence of respiratory disability, as had been anticipated from other surveys of this type (Higgins, 1956). It is believed that the tentative conclusions which have been drawn from the observed relationship between the two syndromes in this randomly selected group may be of value, if only in provoking further studies of this kind.

Method

The sample of 55 men was drawn from the 1,160 miners and ex-miners aged 55-64 known to be living in the Rhondda Fach at the time of a survey carried out in 1953 (Cochrane,

1954). Two of these men had died, two had left the district, and four declined to co-operate; the remaining 47 (1 in 25 of the original population and 93% of the men in the sample who were living in the valley) were investigated.

The prevalence of coronary heart disease was established by clinical examination and electrocardiography, using criteria which are described in detail elsewhere (Thomas *et al.*, 1956). Breathlessness was not taken into account.

Breathlessness was assessed, using the questions recommended by Fletcher (1952), and recorded on a five-point scale. A man in grade 1 has no undue breathlessness when compared with other people of the same age; in grades 2 and 3 he is unable to keep up with normal people of the same age walking uphill and on the flat respectively. In grade 4, walking on the level is limited by breathlessness to 200 yards, and in grade 5 breathlessness occurs on the least exertion.

"Bronchitis" was diagnosed in those men who fulfilled the arbitrary criteria that during the last three years they had had one or more chest illnesses associated with increased cough and/or sputum and wheeze or tightness in the chest. Pulmonary heart disease was diagnosed, using previously described criteria (Thomas, 1951). The radiological category of pneumoconiosis was determined on the International Classification (1950) by duplicate readings (Cochrane *et al.*, 1951; Fletcher, 1955b).

The maximum voluntary ventilation was estimated as a measure of ventilatory capacity from the mean of three or four readings of the three-quarters of a second timed vital capacity (Kennedy, 1953), using a spirometer fitted with an electronic timer (Gaensler, 1951). The results obtained with this indirect method correlate well with those obtained when the maximum voluntary ventilation is measured directly (Bernstein and Kazantzis, 1954; Kennedy, 1953). The ventilatory response to exercise at 300 kilogram-metres a minute, breathing oxygen, was obtained, using a standardized exercise step test (Hugh-Jones and Lambert, 1952).

The rise in blood lactic acid attributable to the exercise was determined as a measure of the adequacy of the blood supply to the active muscles, using a method previously described (Cotes, 1955).

Results

Bronchitis.—"Bronchitis" was diagnosed in 16 men (34% of the whole group). Of these, four reported one chest illness only; 12 more than one. Of the 16 men, 13 said that their sputum was yellow during their illnesses; three of them had not noticed the colour. All had a productive cough apart from their acute attacks, and at least those who had more than one such episode would probably be generally regarded as having some degree of chronic bronchitis. Two subjects with typical established chronic bronchitis had pulmonary heart disease.

Pneumoconiosis.—Twenty-eight subjects had pneumoconiosis with x-ray category 1 or above: 17 (36% of the sample studied) had some degree of simple pneumoconiosis, and 11 (23%) had progressive massive fibrosis. One of the latter had pulmonary heart disease.

Relationship between coronary heart disease, bronchitis, and pneumoconiosis.—The number of subjects with coronary heart disease, bronchitis, or progressive massive fibrosis who also had either of the other two conditions is given in Table I, together with the number of cases which would have been anticipated from their overall incidence on a proportional basis. The numbers are small, but they do not suggest any relationship between the three conditions.

Maximum voluntary ventilation in relation to clinical grade of breathlessness, coronary heart disease, bronchitis, and progressive massive fibrosis.—A significant relationship was found between the maximum voluntary ventilation and the clinical grade of breathlessness in the present series (Regression line, M.V.V. (indirect) = $108.5 - (17.07 \pm 2.247) \times \text{clinical grade}$). This relationship is comparable with that observed in a previous series, when the maximum voluntary

TABLE I.—*Distribution of Cases with Respect to Coronary Heart Disease, Bronchitis, and Progressive Massive Fibrosis*

	Coronary Heart Disease			No Coronary Heart Disease			Total		
	Bronchitis	No Bronchitis	Total	Bronchitis	No Bronchitis	Total	Bronchitis	No Bronchitis	Total
P.M.F. . .	0 (1.43)	3 (2.78)	3 (4.21)	4 (2.31)	4 (4.48)	8 (6.79)	4 (3.74)	7 (7.26)	11
No P.M.F. .	5 (4.69)	10 (9.10)	15 (13.79)	7 (7.56)	14 (14.65)	21 (22.21)	12 (12.25)	24 (23.75)	36
Total . .	5 (6.12)	13 (11.88)	18	11 (9.87)	18 (19.13)	29	16	31	47

The upper figure in each square refers to the actual distribution; the lower one (in parentheses) to that predicted on a proportional basis.

ventilation was found to be the best available physiological index of ventilatory disability in pneumoconiosis (Gilson and Hugh-Jones, 1955). The mean maximum voluntary ventilation for the subjects with bronchitis or progressive massive fibrosis was 62.8 l./min., for those with coronary heart disease 84.5 l./min., and for the remainder 76.6 l./min. No significant interrelationship between the effects of coronary heart disease, bronchitis, and progressive massive fibrosis on the maximum voluntary ventilation was found (Table II), and the difference between the three groups of subjects is significant at, at least, the 1% level of probability. The relationship between the four factors in the individual subjects is illustrated in the Diagram. This

Relationship of maximum voluntary ventilation to bronchitis, coronary heart disease, and x-ray category of pneumoconiosis.

TABLE II.—*Average Values for the Maximum Voluntary Ventilation (Indirect) in Subjects With and Without Coronary Heart Disease and/or Bronchitis and Progressive Massive Fibrosis*

	Coronary Heart Disease	No Coronary Heart Disease	Average
Bronchitis and/or P.M.F. . .	76.1 (8)	55.7 (15)	62.8 (23)
No bronchitis and no P.M.F. . .	91.2 (10)	76.6 (14)	82.7 (24)
Average . .	84.5 (18)	65.8 (29)	73.0 (47)

The number of subjects in each group is shown in parentheses.

shows that of the 11 subjects in the sample with a maximum voluntary ventilation of less than 60 l./min., 10 had either had an attack of bronchitis within the past three years or had progressive massive fibrosis. The eleventh subject was admitted to our ward in June, 1953, with emphysema and acute bronchospasm. Of the 11 subjects with a maximum voluntary ventilation of over 90 l./min., 9 had coronary heart disease and one had severe atherosclerosis. Thus the lowest values are found in subjects who have had

attacks of bronchitis during the past three years, or who have progressive massive fibrosis, and the highest values in those who have coronary artery disease. The differentiation is most pronounced in the subjects who have no radiological evidence of pneumoconiosis (category O), and suggests that "bronchitis" is the cause of the low maximum voluntary ventilation in this group.

Exercise Tolerance

Thirty-six subjects completed five minutes' exercise, breathing oxygen. One gave up after four minutes, five after less than two minutes; five subjects who had severe coronary disease were not asked to undertake the test. The mean ventilation during the fourth and fifth minutes of exercise, breathing oxygen, was 26.5 l./min. for the 37 subjects completing at least four minutes of exercise. This included 12 subjects with coronary heart disease, 12 who had had bronchitis, and 8 with progressive massive fibrosis. The ventilation values for these subgroups did not differ appreciably from the value for the group as a whole.

The mean resting blood lactic acid was 11.6 mg. per 100 ml., and this did not differ appreciably between the subgroups. The mean increase due to exercise was 7.8 mg. per 100 ml. That for the subjects with coronary disease was 6.9 mg. per 100 ml. (range -1.2 to 14.8 mg. per 100 ml.); these subjects were, with one exception, in clinical grades 1 and 2, and the mean increase was not dissimilar to that of the 17 other subjects in the same grades (mean 5.1, range -0.7 to 13.1 mg. per 100 ml.). There were seven subjects in clinical grades 3 and 4, of whom six had marked pulmonary disability. The biggest individual increases in blood lactic acid occurred in this group (mean increase 15.5, range 0.8 to 35.1 mg. per 100 ml.) with values exceeding 20 mg. per 100 ml. in three cases.

Discussion

The 34% prevalence of "bronchitis" found among this randomly selected group is very similar to the combined figure of 37% found for two other groups selected at random from amongst the miners and ex-miners of the same age without pneumoconiosis and with pneumoconiosis x-ray category 3 living in the Rhondda Fach (Higgins, 1956). The prevalence of pneumoconiosis corresponds with that of the age group from which the sample was drawn (Cochrane *et al.*, 1955), and it is believed that the sample can be accepted as representative. The surprisingly high prevalence of coronary heart disease among this population is discussed elsewhere (Thomas *et al.*, 1956).

The present findings do not suggest any relationship between these three conditions. The subjective assessment of breathlessness, and the objective measurement of maximum voluntary ventilation, both suggest that those men who have coronary heart disease, whether or not they have bronchitis or progressive massive fibrosis, have less ventilatory disability than those who have not. This difference, which is not due to age, is probably attributable to differences in temperament and body type (Dunbar, 1943; Gertler and White, 1954). In the subjects with progressive massive fibrosis and/or bronchitis the maximum voluntary ventilation was significantly reduced, which is consistent with other evidence on the nature of disability in these conditions (Gilson and Hugh-Jones, 1955; Higgins, 1956).

The response of blood lactic acid to exercise, breathing oxygen, was normal in those subjects with coronary heart disease who were considered fit enough to undertake the exercise; this is compatible with the observation that in such cases the cardiac output increases normally during moderate exercise (Chapman and Fraser, 1954).

Taken together, the results suggest that subjects who develop coronary heart disease have normal ventilatory function, and that in the absence of clinical manifestations of this condition they are, if anything, less rather than more likely to develop symptoms of breathlessness on this account.

Summary

The prevalence of coronary heart disease and of respiratory disability has been investigated amongst a sample of 47 men drawn at random from coal-workers in the Rhondda Fach in the 55-64 age group.

It was found that 38% of the subjects had coronary heart disease, of whom half presented with positive clinical findings; 34% had "bronchitis"; and 23% had progressive massive fibrosis of pneumoconiosis. The evidence does not suggest any relationship between these three conditions.

The maximum voluntary ventilation (indirect) was on average 73 l./min., and decreased by 17.07 ± 2.247 l./min. for unit drop in clinical grade of breathlessness. Coronary heart disease was associated with a significant elevation, and bronchitis or progressive pulmonary fibrosis with a significant reduction, of the maximum voluntary ventilation. The response of blood lactic acid to standard exercise was normal in those subjects with coronary heart disease who were judged fit enough to undertake the test.

It is concluded that coronary heart disease does not commonly contribute to impaired ventilatory function.

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The *American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine* celebrates its golden jubilee this year. It was begun in 1906 as the organ of the American Roentgen Ray Society with the title *American Quarterly of Roentgenology*. By 1913 increasing calls upon its space made necessary monthly publication, with a change of title to *American Journal of Roentgenology*. The American Radium Society, founded in 1916, used the journal as a vehicle for the publication of its papers, and in 1920 this arrangement became officially recognized, with a consequent addition to the title of the journal. A further addition in 1951 reflects the increasing importance of radioisotopes in diagnosis and treatment. The January issue of the journal includes a review of technical developments in radiology during the past 50 years by Otto Glasser and several papers on historical aspects of that subject.

PEPTIC ULCER, PARTIAL GASTRECTOMY, AND PULMONARY TUBERCULOSIS

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During the past few years suspicion among clinicians has grown that partial gastrectomy predisposes to pulmonary tuberculosis in the years that follow operation. Physicians have been impressed with the high proportion of their patients with pulmonary tuberculosis who have previously had a partial gastrectomy (Forsgren, 1947, 1948; Isorni *et al.*, 1948; Allison, 1955). Forsgren (1948) calculated that, in a Swedish community, the risk of developing pulmonary tuberculosis was ten times greater after partial gastrectomy than in the general population. Pulmonary tuberculosis is mentioned as a cause of death after partial gastrectomy in most reported surgical series (Pulvertaft, 1952; Swynnerton and Tanner, 1953; Pearson, 1954).

Johnsson (1951) was the first to describe a search for pulmonary tuberculosis after partial gastrectomy, but his results were not conclusive. Tanner (1954) reported a follow-up of 611 patients after partial gastrectomy; he found that 12 had since developed active pulmonary tuberculosis, and stated, "We do not think that we shall find a very remarkable increased proneness to tuberculosis, particularly as some have been treated for this disease prior to operation." Anderson *et al.* (1955) found that 3.3% of those surviving partial gastrectomy had active pulmonary tuberculosis, and concluded that there was definitely an increased liability to pulmonary tuberculosis in patients who had undergone partial gastrectomy. Eight years ago it was decided to radiograph the chests of all patients entering the surgical professorial wards of the Queen Elizabeth Hospital to find the incidence of unsuspected pulmonary tuberculosis in surgical patients; this gave an opportunity to study its incidence after partial gastrectomy, and we describe here the follow-up of 955 patients to find out more about the relationship of this operation to subsequent pulmonary tuberculosis.

Method and Materials

We studied all patients who had had a partial gastrectomy for peptic ulcer performed by the surgeons of the surgical professorial unit at the Queen Elizabeth Hospital between January 1, 1948, and June 30, 1953. Of these 955 patients, 772 were men and 183 were women (Tables I and II).

These patients were operated on before this particular investigation was planned; routine chest x-ray examination before operation should have been done on all of them, but some were omitted for a variety of reasons (emergency operation, economy of film, omission) (Table III). Interview