LEPTOSPIRAL SEROLOGY IN SCOTTISH COAL-MINERS

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The problem of leptospiral infection in coal-miners became prominent in one area of the Scottish coalfields during the period 1940–52 when altogether 15 cases of Weil's disease were diagnosed or suspected in colliery workers out of a total manpower of some 8,000. Of those 15 cases, 11 were reported from a single colliery and four of these 11 died.

Serological confirmation of the diagnosis was obtained in four of the non-fatal cases, but the swift course of the illness in the fatal cases did not permit the patients to survive long enough to enable typical antibodies to be detected. The clinical findings in most of the cases left little doubt as to the true nature of the disease. All those concerned were underground workers and worked in collieries known to harbour rats.

The incidence of leptospirosis in rats in Scotland has been estimated at 44% of 117 rats in the Aberdeen district by Smith (1938) and 37% of 166 wild rats in East Lothian by Buchanan (1927). Since infected rats are known to shed numerous leptospirae in their urine over a long period, there was a strong possibility of frequent contamination of the pit with *L. icterohaemorrhagiae* and hence extensive contact with infection among the workers.

In view of this, the relative rarity of clinical Weil's disease (an average rate over the 12 years of 0.02% per annum of 8,000 men in the area concerned) led us to investigate the possibility of the occurrence of further unrecognized infection. This possibility was illustrated by one of the Scottish cases which showed little constitutional upset and no jaundice, the diagnosis being established by a mounting titre of antibodies reaching eventually 1 in 10,000 for *L. icterohaemorrhagiae*. As far as subclinical infection is concerned, Smith and Davidson (1936) showed that 51 of 210 fish workers in Aberdeen gave serological evidence of previous infection with *L. icterohaemorrhagiae*. Of these 51 sera, 18 (8.6% of total) came from individuals with

no clinical history. From the data supplied in a paper by Tiffany and Martorana (1942) on the incidence of leptospiral agglutinins in New York sera, the rates for positive findings among sewer workers and fish workers, showing no previous history of Weil's disease, were 11 of 515 (2.1%) and seven of 102 (6.9%) for these respective occupations.

There appears to be no information available in the literature as to the occurrence of leptospiral agglutinins in the sera of normal coal-miners in Scotland.

Sampling Methods

The colliery at which 11 of the cases had been reported was chosen and an attempt made to obtain a random sample of the pit population for serological investigation. Surface as well as underground workers were included in the sample, partly because surface work may itself involve some exposure to risk, and partly because many surface workers have spent appreciable periods in underground employment in the past. The colliery employed a total of about 2,700 men and of this number 400 were employed on the surface. It was decided that a sample including 5 to 10% of the total workers would be sufficient.

Each man in the colliery is normally issued with a number by which he may be identified, and the sample was obtained by selecting every twentieth number and then inviting the man concerned to take part in the investigation. In the event this system produced only about half of the volunteers expected and so it was found necessary to repeat the sampling on a further set of numbers selected on an identical basis to obtain finally 201 samples.

This development tended to destroy the random nature of the sample and in fact it appeared that the younger workers were more willing to come forward than the older men, as Fig. 1, which compares the age distribution in the sample with that of the general pit population, shows.

On the other hand, 65% of the sample population lay between 30 and 59 years while 71% of the pit population lay between these same ages. Again, 81% of the sample

FIG. 1

lay between the ages of 25 and 59 years, this group comprising 80% of the pit population.

Thus, even though the age pattern of the sample is not identical with that of the total colliery population, the working experience of the sample does represent a considerable exposure to risk, the 163 men aged 25 to 59 having put in 2,000 man-years at the colliery concerned and a further 2,800 man-years in mining service, for the most part underground.

Bacteriological Methods

Serological tests were performed on the blood samples at the Bacteriology Department, Edinburgh University.

Serum dilutions in normal saline were mixed with equal volumes of freshly prepared formalized three- to seven-day-old cultures in Korthof's medium (Mackie and McCartney, 1953) of *L. icterohaemorrhagiae* (Wijnberg and Jackson strains) and *L. canicola* (Berlin). The final dilutions ranged from 1 in 10 upwards. The mixtures were kept in the refrigerator overnight and read by dark-ground microscope. This technique is the one used routinely by Broom (1952). When positive results were obtained the tests were repeated with further specimens of serum and also using live cultures. During the period of the investigation the strains of leptospirae used were tested several times with standard preserved rabbit anti-sera and no significant differences in titre were observed for any one strain at different times. Two strains of *L. icterohaemorrhagiae* (AB) were used in case any sudden change in sensitivity occurred in either, although no such change was in fact observed at any time.

Results

Table 1 shows the details of positive serological findings. It will be seen that only miners Nos. 63 and 119 gave results which were confirmed on subsequent repeated tests. In both cases the maximum titre obtained was 1 in 90 when live suspensions were used.

Miners Nos. 63 and 119 were, therefore, considered definitely positive and Nos. 87 and 83

TABLE 1
DETAILS OF POSITIVE SEROLOGICAL FINDINGS

Case	Date of Serum Sample	Titre v. <i>L. icterohaemorrhagiae</i>	
		Formolized Culture Used	Live Culture Used
Miner No. 63	27. 5.53	30*	30
	22. 6.53		30*
	10.11.53	30	90
Miner No. 119	26. 8.53	10	30
	15. 4.54		90†
Miner No. 87	11. 6.53	30	30
	29. 6.53		Negative
Miner No. 83	10.11.53	? 10	10
	10. 6.53	? 10	10
	29. 6.53		Negative
	16.12.53		Negative

Titres are expressed as the reciprocal of the final serum dilution at the end-point.

* Titre against Jackson strain was 1 in 10.

† Titre against Jackson strain was 1 in 30.

as doubtful positive. The only serum giving any reaction with *L. canicola* was the second sample of miner No. 119 which gave agglutination of a live suspension to 1 in 10 only. Titres against Wijnberg and Jackson strains of *L. icterohaemorrhagiae* were the same with the exceptions shown at the foot of Table 1. Miner No. 63 was a coal-face worker, aged 44 years, who had spent some 12 years in mining and had suffered no illness suggestive of Weil's disease. The second man, No. 119, also an underground worker, aged 46 years, had spent all 33 years of his working life at the one colliery. There was a history of undefined illness of an influenzal character 10 years previously when he had been off work for one month. Jaundice had never been observed at this or any other time.

Discussion

Evidence for the specificity of low-titre leptospiral agglutination reactions in the sera of normal people is provided by Smith and Davidson (1936) who found no agglutination at a 1 in 10 dilution by the sera of 403 controls, by Stuart (1946) who never found antibodies at a dilution of 1 in 10 in people not exposed to known or highly probable leptospiral infection, and by Ward and Turner (1942) who, in a survey of workers in different trades, accepted an agglutination titre of 1 in 10 as evidence of previous infection. Broom (1948) showed that out of 875 patients suffering from diseases other than Weil's disease, only 23 gave titres of 1 in 10 or more, and most of these worked at occupations where Weil's disease is a recognized hazard, so that the possibilities of previous contact with leptospirae could not be ruled out.

It therefore seems certain that miners Nos. 63 and 119 had had previous unrecognized infection

with *L. icterohaemorrhagiae* and there is a definite possibility that miners Nos. 87 and 83 had also had subclinical infections. The occasion of the original infection of miner No. 119 may well have been the influenzal illness 10 years before, which must have been a fairly severe one since, (a) he remembered it, and (b) he was off work for a month with it.

Although one cannot rule out completely the possibility that miners giving a negative serological reaction may yet have had previous leptospiral infection, the evidence shows that leptospiral agglutinins persist in the serum for long periods after infection. Thus, Kisker (1935) found positive agglutination from two to 16 years after recovery from Weil's disease, Uhlenhuth and Fromme (1930) after 22 years, and Stuart (1939) after 28 years. Broom (1948) found agglutinins in all cases which he examined following recovery (up to four years in one case). Whether this applies equally in the case of subclinical infection is not definitely known, but miners Nos. 63 and 119 in the present series gave a definite reaction of slightly higher titre than the original level, six months and eight months respectively after the first specimen was examined, indicating that no decline in titre had occurred during that period. It therefore seems probable that the miners giving negative reactions had not had leptospiral infection during their previous mining experience.

The findings of this investigation have provided serological evidence of two cases (1% of sample) of leptospiral infection undiagnosed at the time; one with, and one without, a history of illness which could retrospectively be attributed to leptospiral infection. In view of the weighting of the sample with workers of age group 15 to 34 who had been exposed to the risk of leptospiral infection for a shorter time than those of the relatively less well represented age groups 50 to 69, this figure is probably on the low side. On the other hand none of the 33

sample miners of the older age group showed definitely positive results, the only two confirmed reactions occurring in the age group 40 to 49, a group which was in fact fully represented in the sample. The present figure compares with the 8.6% among Aberdeen fish workers quoted above (Smith and Davidson, 1936), the 6.9% of Tiffany and Martorana (1942) for New York fish workers, and the 2.1% of New York sewer workers also obtained from the last authors' results.

Summary

Sera were examined for leptospiral agglutinins from 201 normal coal-miners working in a Scottish pit in which 11 cases of Weil's disease had occurred during 1940-52.

Sera from two of these miners agglutinated *L. icterohaemorrhagiae* to a titre of 1 in 90 and a further two gave doubtful results.

At least 1% of the sample population had had unrecognized infection with *L. icterohaemorrhagiae*.

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