ARTERIO-SCLEROSIS IN COAL MINERS.

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ALTHOUGH it is now generally held that the conditions connected with a miner's occupation, apart from its special risks, are as favourable to health as those of other manual workers, it should be noted that after the age of 55 coal miners in the aggregate die off more rapidly than other occupied males, while between the ages of 25 and 55 the death rate is lower.

TABLE I.—Occupational Mortality at Different Age Groups.
(From the Registrar-General's Returns, 1921-23, p. 8.)

Age Groups:	25-	35-	45-	55-	65 and up.
Occupied males	100	100	100	100	100
Miners	91	88	84	105	130

The Registrar-General's return for 1921-23 says: "Analysis of the causes throws very little light on the reason for the relative increase which occurs in the mortality of miners."

Twenty years ago, while associated in a large practice in Fife, we noted with surprise many cases of arterial thickening among coal miners, even in quite young men. This discovery suggested the systematic examination of a considerable number of miners. In all, 500 men were examined. They were taken consecutively, as they came into our surgeries, but no one was included who complained of any symptoms referable to his circulatory system. As a matter of fact, many of them were literally taken in off the street for the purpose of this inquiry.

Even at this late date it seems desirable to publish the results, as no work on similar lines has been undertaken in the interval, and no light has yet been supplied to the Registrar-General. It is possible that our results contribute one explanation of the anomaly to which he refers.

Scheme of Examinations.

The examinations were carried out, as a rule, in the evening between 6 and 7 o'clock; a few were done in the morning between 9 and 10. All the men had been off work for at least four hours, and no man was examined immediately after a meal. The routine procedure was as follows. While the man was standing his pulse rate was counted and the condition of the wall of the radial artery was noted. He was then directed to lie down, when particulars of his habits as to alcohol and tobacco, and the conditions of his work, were obtained, and his medical history was inquired into. The chest wall was then exposed and the apex beat located, the cardiac dullness mapped out, and the different areas auscultated. The pulse was again counted. The patient was then seated on a chair, the left arm bared to the shoulder, and the blood pressure taken (a mercurial manometer and a 12 cm. armlet were used throughout). In a limited number of cases a blood count was done and a haemoglobin estimation made. The majority of the men examined were of the phlegmatic type, so that little effort was required to secure the psychical repose which is so desirable in taking blood pressure readings.

Results.

It may at once be stated that the outstanding feature of this inquiry has been the discovery of an extraordinary prevalence among miners of arterial thickening, as evidenced in the radial artery, a prevalence hitherto undescribed, and apparently unsuspected. Of the 500 miners examined only 44 (9 per cent.) had arteries which could not be palpated. The remaining 456 (91 per cent.) had definitely palpable arteries.

There is, of course, no difficulty in determining when an artery is thickened. It is as easy to feel a thickened artery as it is to feel a rubber tube; the difficulty arises when one tries to convey an idea of the amount of thickening present. For purposes of tabulation an attempt has been made to classify these arteries under the following definitions.

A. *Not Palpable*.—An artery the wall of which cannot be detected by the pulp of the examining finger.

B. *Thick*.—An artery whose wall can be flattened by the finger, but can then be easily felt in its entire breadth, like a piece of thick tape.

C. *Very Thick*.—An artery whose wall rolls readily under the finger, like a piece of rubber tubing, and can be flattened only with difficulty. It is nearly always tortuous.

D. *Atheromatous*.—This is the "ipecacuanha root" artery of the late Dr. G. A. Gibson, showing marked calcareous degeneration.

No attempt was made to measure the actual size of the arteries, and the description applies solely to thickness, as gauged by palpation.

The total number of arteries classified under each group is as follows: A, 44; B, 318; C, 136; D, 2. These figures convey an idea of the general type of thickening met with. Since the age factor enters so largely into the question of arterial changes, we have arranged the 500 cases according to age, as shown in Table II.

TABLE II.—Arteries Arranged in Age Groups; showing Actual Numbers and Percentages.

Age in Years.	A.		B.		C.		D.		Total No.
	No.	Per cent.	No.	Per cent.	No.	Per cent.	No.	Per cent.	
20 and under	16	13.8	94	80.9	6	5.1	0	—	116
21-30	17	9.4	128	71.0	35	19.4	0	—	180
31-40	11	10.1	61	54.7	39	35.0	0	—	111
41-50	0	—	25	41.3	36	58.6	0	—	61
Over 50	0	—	10	31.2	20	62.4	2	6.2	32
Totals	44		318		136		2		500

The salient feature of these figures is the very great frequency of arterial thickening in youths of 20 years of age and under. While the proportion of normal (A) arteries in that particular group is greater, as would be expected, than in any other, yet to have so preponderating a proportion of thickened radials (100 out of 116) in healthy boys of 14 to 20 years is exceedingly striking. After the age of 40 none of the men had arteries which were not palpable. With increase of age there is a gradual and almost uninterrupted progression in the thickening of the arteries.

Pathology of Arterial Thickening.

Arterial thickening as evidenced in the radial artery may be due to one of three different conditions: arterio-sclerosis, atheroma, or hypertonus. Arterio-sclerosis may be defined in general terms as a diffuse organic thickening of the arterial wall perceptible to the sense of touch, and extending as far as the artery can be traced. Atheroma is a focal or nodular thickening, due largely to calcareous degeneration. Professor William Russell has introduced the term "hypertonus" to describe a vessel "the muscular coat of which is unduly contracted, so that the wall is thicker and the lumen smaller."

We obtained specimens of several radial arteries from men who met with fatal accidents during the course of our inquiry. Dr. L. R. Sutherland, professor of pathology in University College, Dundee, very kindly examined these for us. Excerpts from his reports are as follows.

Section of Radial from a Man aged 27.—"Localized thickenings of the intima are readily observed: in some sections as much as one-third of the lumen is involved. Some of the patches are six times as thick as the normal intima. The thickened tissue is tolerably cellular. There is no evidence of fatty degeneration or

calcareous infiltration. The media underlying the larger thickenings is atrophied."

Sections from the other arteries show similar changes varying only in degree. Photomicrographs of two sections are reproduced; the first (Fig. 1) shows a patch of thickening of medium size at the giving off of a small branch, and the other (Fig. 2) shows the cellular nature of the thickening.

These reports give a clear indication of the pathological conditions of the arteries in the cases we have examined. The thickening is shown to be in the intima, and does not

FIG. 1.

involve, in any of the sections examined, the whole circumference of the vessel, and there is no evidence whatever of thickening of the muscular coat or adventitia.

So far as we can discover, arterial changes similar to those have never before been described.

Blood Pressure.

As blood pressure varies within certain not yet accurately defined limits, not only in different individuals, but to almost as great a degree in each individual under the influence of various conditions, there can be no fixed standard of normal blood pressure. But 90 mm. of mercury with the 12 cm. armlet is accepted by most authorities as the lowest systolic pressure in adult males consistent with health; while 140 mm. may be taken as the greatest systolic pressure which should be regarded as normal, at least up to middle life. Of our cases 449 out of the 500—that is, 90 per cent.—had blood pressure falling within normal limits, and only 51 (10 per cent.) showed blood pressure over 140.

The estimation of the diastolic pressure was discontinued after about two hundred readings were taken, as it was apparently of little significance so far as the inquiry was concerned. It was practically always from 25 to 40 mm. below the systolic pressure, as has been found by other observers. The blood pressures at different age groups are shown in Table III.

TABLE III.

Age Group.	Blood Pressures.					
	100 and under.	100 to 110.	110 to 120.	120 to 130.	130 to 140.	Over 140.
20 years and under	10	23	42	26	8	2
21-30	3	21	64	53	26	17
31-40	1	8	41	33	25	8
41-50	3	4	13	12	18	9
Over 50	0	1	6	4	4	15
Totals	17	57	166	128	81	51

Relation of Arterio-sclerosis to Blood Pressure.

There exists even now a general impression that arterio-sclerosis is necessarily associated with increased blood pressure. Professor William Russell, for example, asserted that "thickened arteries never give normal readings." The result of this inquiry is entirely opposed to that view. Over and over again we met with cases where the arteries were very thick and the blood pressure was well below the normal maximum; while, on the other hand, perfectly soft-

FIG. 2.

walled arteries were found in conjunction with high readings. We annex a number of cases showing great variations in blood pressure from arteries of the same apparent degree of thickening.

TABLE IV.

Case.	Age.	Condition of Radial.	Blood Pressure.
G. McL.	15	A	95
T. W.	36	A	140
J. C.	18	B	95
W. B.	32	B	165
C. S.	25	C	110
J. B.	42	C	140

A table is also given of the actual numbers showing "normal" pressure in each artery group.

TABLE V.

Artery Group.	No. of Cases.	Normal Blood Pressure.	Above 140.
Group A	44	42	2
Group B	318	296	22
Group C	136	110	26
Group D	2	1	1

This seems to show that the recorded blood pressure has little relation to actual thickening of the artery wall, within certain limits. (It should be mentioned that in any case where there was unduly high blood pressure the urine was examined for albumin, but with a negative result in every case.) Russell's assertion that "thick-walled" arteries never give normal readings" is disposed of by such a case as the following.

S. S., aged 42, had very thick and tortuous arteries, which could be traced from his wrist right up to his axilla, and felt between the finger and thumb to be round and hard like a lead pencil; his blood pressure was on several occasions 118 to 120. A tracing of this case is given (Fig. 3), showing the first return of pulsation after obliteration of the vessel, and the abscissa, from which one can measure the absolute height of the blood pressure without the risk of error due to the personal equation. This tracing was kindly made for us by the late Dr. G. A. Gibson, who confirmed our description of the arteries. The blood pressure was 118.

Many of our cases distinctly showed hypertonus; in fact, as the great majority had normal blood pressure, it is safe to conclude that the others were examples of hypertonic contraction. This was evident during the course of the examinations, when occasionally pressures were recorded

from men who had just had teeth extracted, whitlows opened, and the like, and almost without exception these were over 130.

Clifford Allbutt described three varieties of arterio-sclerosis: (1) hypertonic, with increased blood pressure;

(2) toxic, in which there is usually no increase of blood pressure, and not infrequently a decrease; (3) decreascent, or senile. There is no doubt that most of our cases are examples of Clifford Allbutt's toxic group—that is to say, they have thickened arteries, with normal or low blood pressure.

Causes of Arterio-sclerosis.

The subject of the causation of arterio-sclerosis is as darkened by conflicting statements as is the pathology. Kidney disease, old age, high blood pressure, defective alimentation, chronic intoxications of all kinds, acute infections, muscular exertion, have all in turn been brought into the limelight. These seemingly widely divergent views as to the etiology may perhaps be reconciled by considering them all as variations of the one common factor—that is, a toxæmia.

In our cases the following points were investigated: (1) acute infections, including syphilis; (2) meat consumption; (3) amount of tobacco used; (4) alcohol consumption; (5) conditions of work. The first four of these may be dismissed briefly, as they did not suggest any explanation of the prevalence of the thickened arteries. It is perhaps worth recording that only two patients gave a history of syphilis, and these were both ex-soldiers. (This was pre-war.) Syphilis among miners is exceedingly rare.

The results of the inquiry as regards alcohol should also be recorded. The easiest and probably most nearly

TABLE VI.—*Effect of Alcohol; showing Condition of Radials and Blood Pressure.*

Amount Spent on Alcohol Per Week.	No. of Men.	Condition of Radials.				Blood Pressures.			
		A.	B.	C.	D.	Up to 100.	Up to 120.	Up to 140.	Over 140.
Nil ...	183	20	146	17	0	14	95	63	11
1s. ...	103	8	61	34	0	1	38	48	16
Up to 5s. ...	123	7	59	56	1	3	41	62	17
Up to 10s. ...	38	6	21	11	0	0	19	14	5
Up to £1 ...	27	3	16	8	0	0	12	11	4
Over £1 ...	26	0	15	10	1	2	8	7	9
Totals ...	500	44	318	136	2	20	213	205	62

* N.B.—The values, both monetary and alcoholic, are "pre-war."

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accurate method of estimating the amount of alcohol consumed by an individual in this walk of life is to ascertain how much he spends on alcoholic liquors per week. Our figures are as nearly right as any obtainable, for we knew personally practically every man examined, and had a very good idea of his tastes and opportunities.

This table, contrary to expectation, shows that there is no essential relation between the amount of alcohol taken and the degree of thickening of the arteries or the blood pressure. Similar tables could be given in connexion with meat and tobacco, again showing no relation between these conditions. We therefore came to the definite conclusion that alcohol, meat, and tobacco have little or no effect in causing the changes in the circulatory system which we have described.

The fifth point investigated, "conditions of work," presented the only factor common to all the cases, and special attention was naturally directed to these conditions.

When this inquiry was undertaken there was little coal-cutting machinery below ground; most of the hewing was done by hand, and at that time it was agreed by experts that the actual physical work required of coal miners was not in excess of that of any class of ordinary workmen—for example, joiners or bricklayers. Any difference in the mortality rates between miners and other occupied males is certainly not due to any excessive muscular effort required by their work.

In the area under investigation the pits vary in depth from 600 to over 2,000 feet; they are ventilated generally on the vacuum system, by which means a current of air which may amount to 200,000 cubic feet per minute is distributed through the workings. Though this seems a large quantity, it must be remembered that there are over twenty miles of underground roads in a large pit. As the coal is worked out in any area of a pit, the strata left are at first supported by timber pillars, so that these waste workings contain a vast quantity of decomposing wood. The practical importance of this will be noted later.

Since the miner works down the pit for eight hours each day, it is obvious that the composition of the air which he is breathing for such a period is a matter of great importance. We therefore secured analyses of samples of the air from various parts of one of the typical pits in the area. The two abnormal constituents which may be found in mine air are CH_4 and CO . CH_4 (fire-damp as it is called) has no direct action on man, and acts simply as a diluent of the oxygen. CO is only present in exceptional circumstances—for example, when a seam of coal is burning, or after an explosion, either of fire-damp or in the process of coal-getting by explosives. The figures concerning these gases, as well as of the nitrogen present, are therefore left out of the analytical samples given in Table VII.

TABLE VII.—*Analyses of Air in Typical Pit (Percentages).*

Place of Observation.	CO_2 .	O_2 .
1. At surface ...	0.03	20.94
2. Pit bottom ...	0.05	20.85
3. Intake air course 1,000 feet from bottom	0.15	20.59
4. At a working face ...	0.30	19.84
5. ditto ...	1.35	19.29
6. ditto; sample taken on pavement ...	4.56	13.13
7. Total return air of pit taken in the up-cast shaft in a current of 200,000 cubic feet per minute ...	0.22	20.51

We would draw special attention to the amount of CO_2 present in different localities in the pit, and contrast it with the normal and "extraordinarily constant" amount in air above ground—that is, 0.03 per cent.

The figures given do not represent bad ventilation from the mining standpoint. We have it on the authority of several general managers that air containing 0.7 per cent. of CO_2 represents good ventilation, while working places showing 1.35 per cent. and the like are referred to by the miner himself as having "dull air," and it is notorious that men work in such atmospheres for prolonged periods without raising serious objections. In these atmospheres a lamp will burn somewhat dimly, not owing to the actual quantity of CO_2 present, but to the deficiency of oxygen; and a light (a tallow candle) only gradually goes out when the oxygen is reduced to 17.6 per cent. Such atmospheres have little or no appreciable effect on breathing, pulse rate,

or blood pressure. We tested this on ourselves below ground in "dull air," and in one section which had been abandoned on account of bad ventilation. The differences noted were: slight slowing of the respiration (16 as compared with 18 above ground), and slight increase in pulse rate (84 and 72); it was not possible to take a blood pressure reading there as the light was so poor.

The large amount of CO₂ in mine air requires some explanation. There is, of course, no consumption of CO₂ underground; on the contrary, it is being produced constantly. The amount present is only to a very slight degree due to respiration of men and ponies and the burning of oil lamps. It is almost entirely due to the oxidization of wood and of the exposed surfaces of the coal, together with the gas actually liberated from the coal itself.

The other obvious abnormal factor in the conditions of work underground, in addition to the composition of the inspired air, is the absence of daylight. It is evident that in winter, at least, many miners seldom see sunlight or even daylight. The importance of this is only now being fully recognized, but at present we are not prepared to assess its significance in the subject under inquiry. We have, however, been able to trace a progressive thickening of the arteries with the length of time during which the men worked underground; this is shown in Table VIII.

TABLE VIII.

Duration of Work Underground.	No. of Men.	Condition of Arteries.		
		A.	B.	C.
(1) Under 1 year	44	21	23	0
(2) 1-5 years... ..	111	6	96	9
(3) 5-10 years	108	7	79	22
(4) 10-20 years	112	6	69	37
(5) 20-30 years	71	4	38	29
(6) 30-40 years	39	0	10	29
(7) Over 40 years	15	0	3	12
Total	500	44	318	118

It is seen that of 44 men who had worked below ground one year or less, no fewer than 21 had normal arteries—that is, 48 per cent.; and those were not only boys, but included men up to 30 years of age. In no other grouping of the cases is it possible to get such a large percentage of normal arteries. It is also noticeable that there is a distinct increase in the amount of thickening of the arteries with the duration of occupation underground.

From this last table it seems evident that work below ground, under the conditions of ventilation shown to prevail, has a definite relation to the prevalence of arterio-sclerosis in coal miners. We believe that it is this arterio-sclerosis, with its subsequent results on general nutrition, which accounts for the increased mortality of coal miners after the age of 55. For although statistics may not show conclusively that miners suffer from diseases of the circulatory system more than men in other occupations, yet it is only to be expected that such an insidious pathological condition as arterio-sclerosis will in many cases fail to be recognized as the initial cause of death.

It has been our experience to meet with many miners who, while not complaining specially of any circulatory disturbances, have the physical appearance, while still on the right side of 60, of having summed up their threescore years and ten; and in many cases we have seen these men dying at or about the age of 60 with all the symptoms of vascular degeneration.

SUMMARY.

1. There is an unexplained difference in the mortality rate of coal miners as compared with other occupied males.
2. The results of the consecutive examination of the circulatory system of 500 coal miners are analysed.

3. It is shown that among coal miners of all ages there is an extraordinary prevalence of thickened arteries; the thickening is confined to the intima in the specimens examined.

4. There is no associated rise in blood pressure.

5. The only significant constant factors are (a) the inhalation of air of altered composition, especially the CO₂ content; and (b) the absence of daylight.

6. It is suggested that the arterio-sclerosis shown to exist in coal miners is the explanation of the peculiarity in their mortality rate.

DIFFUSE PNEUMOCOCCAL PERITONITIS IN A BOY:

POST-OPERATIVE PARALYTIC ILEUS TREATED BY ANTI-GAS-
GANGRENE SERUM: EMPYEMA: RECOVERY.

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SINCE 1926, when Williams¹ drew attention to the uses of anti-gas-gangrene serum in peritonitis and intestinal obstruction, many encouraging results have been described following the use of the serum in such cases. Molesworth² rightly sounds a note of caution in accepting such enthusiastic clinical reports of a comparatively new form of treatment. I venture to publish the following account of a case of diffuse pneumococcal peritonitis where anti-gas-gangrene serum had a beneficial effect and the patient recovered from a disease in which the mortality is admittedly very high.

A boy, aged 15 years, who had previously been in good health and had never suffered from any serious illness, was admitted to hospital on May 25th, 1929, with acute abdominal symptoms. He had become suddenly ill five days previously with severe abdominal pain and vomiting. There was no rigor. The pain was spasmodic, increased gradually in severity, and was felt most acutely in the lower abdomen, especially in the right side. From the commencement of the attack the bowels were constipated. No frequency of micturition was noted, but the boy at times complained of pain during the act. At no time did the patient have any cough or chest symptoms. (For the above particulars I am indebted to Dr. W. W. Turner, Lochinver, who recommended the case.)

On admission the patient was in a critical condition. He was very thin, the face was pinched, the expression anxious. The lips and finger-tips showed some cyanosis. The temperature was 102° F., the pulse rate 126, irregular and feeble; the respirations were 24 per minute. The tongue was dry and furred, and the breath was foul. There was no herpes labialis. He complained of severe and continuous abdominal pain, most marked in the umbilical and right iliac regions. There was frequent vomiting of offensive brown watery matter, which was very acid in reaction. The abdomen was moderately distended, immobile, and intensely rigid all over. Cutaneous hyperaesthesia and tenderness were most marked in the umbilical region and the right lower quadrant. The percussion note was tympanitic except in the flanks, where some dullness was present. There was no cough, and nothing abnormal could be detected on examination of the chest. The right tonsil was moderately enlarged and appeared to be slightly inflamed.

Operation.—As a preliminary morphine 1/6 grain and atropine 1/100 grain were given. Anaesthesia was induced with gas and oxygen, and followed by open ether. The abdomen was opened by a right paramedian incision. Much thin yellowish pus at once escaped and was seen oozing from all directions. The pus had a peculiar musty odour, and contained small flakes of lymph. There were no signs of adhesions even in an early stage of formation, the infection being diffuse. The peritonitis was, however, distinctly more intense in the right infra-colic compartment. The caecum, appendix, and subperitoneal tissues were oedematous and injected. The small gut was of a dull red colour, had lost its gloss, and appeared lifeless. The glands at the root of the mesentery were enlarged and inflamed. The peritoneal cavity having been cleansed as much as possible, and the appendix removed, a drain was placed in the pouch of Douglas through a separate stab wound in the mid-line. The original wound was closed, with a small drain in the lower angle.

Pathological Report.—The direct preparations showed many pus cells and numerous Gram-positive diplococci. Inoculated media yielded pure growths of a pneumococcus.