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UNITED STATES ENVIRONMENTAL
PROTECTION AGENCY

INTERNATIONAL SYMPOSIUM

**Environmental health aspects of lead**

**Die gesundheitlichen Aspekte der Umweltverschmutzung durch Blei**

**Les problèmes sanitaires posés par le plomb présent dans l'environnement**

# THE USE OF THE CAPILLARY BLOOD LEAD FOR THE SCREENING OF LEAD WORKERS

SAYERS, M.H.P.

Central Reference Laboratory
Medical Services Division
Department of Employment
LONDON, ENGLAND

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## SUMMARY

The presence of lead in blood is the most incontrovertible evidence of absorption but hitherto the need for venepuncture has limited its use in the supervision of industrial workers in this country. Micro-methods using atomic absorption spectrophotometry (AAS) have, however, made possible the development of a sufficiently reliable test using a drop of blood obtainable by ear prick for use in the field for screening purposes.

Steps in the development of this technique are described, and the results of field trials given. The applications of the capillary blood lead in assessing environment and health of lead workers are discussed.


Screening tests for lead can be divided into two groups - those reflecting absorption and those reflecting toxic effects. The only test in the United Kingdom required by law is the quarterly haemoglobin estimation for those working in processes subject to regulations made under the Factories Act, 1961.

The need in industry is for a more sensitive index of the environment in which the man is working. Ideally, we want a test which enables continuous sampling to be done throughout the working day, and which can be applied selectively to processes where the hazard is suspected to be high.

The blood lead, of course, reflects absorption irrespective of toxic effects, but at the same time, it is a sensitive index of environment, more so than the conventional methods of environmental monitoring. For these only indicate the state of affairs at a given time and place, whereas by using the man as your canary, we get more information regarding the long term.

Our thinking, therefore, in recent years has been directed towards the use of this index rather than waiting for the response to lead, as indicated by the raised excretion of metabolites, such as urinary coproporphyrin, or the development of effects such as a fall in haemoglobin.

Using the blood lead as a guide to environment rather than as a biological index of the worker's health is no new idea, but the need for venous specimens, and the difficulties and expense of analysis, have hitherto precluded its use in this country on a wide scale. However, recent developments in atomic absorption spectrophotometry have brought the possibility of using capillary blood within the range of practical politics. There is ample evidence to show that the micro-technique described by Delves (1970), following on the early work of White (1968), can be as accurate, in competent hands, as established analytical procedures. The difficulties of collection of samples, however, seemed at first to preclude this method from application to industrial lead workers. This prompted the exploration of a punched disc technique as a possible alternative on the lines used by Hill and Palmer (1969) for the determination of glucose and a range of other substances, and by Ainsworth, Davies and Rutland (1952) and Ainsworth, Davies and Eveleigh (1953) for the determination of blood cholinesterases.

In brief, specimens of capillary blood are collected into heparinised capillary glass tubes from ear prick after scrupulous cleansing of the site, and spotted on to filter paper and allowed to dry. Discs are punched from the spots and, without further treatment, placed in the nickel crucible of the Delves accessory and passed into the Atomic reservoir of an atomic absorption spectrophotometer (Perkin-Elmer Model 303), and the signal recorded.

It was found, using this technique, that blood lead results for venous samples were comparable with those using the original micro-method of Delves. We then proceeded to apply the method to capillary blood and compare the results with venous findings from the same individuals.

Results of the examination of 100 lead workers in five factories, using both venous and capillary samples in each case, were published in our paper last year (Cernik and Sayers, 1971), and are reproduced in Figure 1. At the lower levels, there is a slight negative bias of about 10 µg against the capillary result. This decreases steadily to the mean at about 80 µg where it is unbiased. Above this, a slight positive bias develops, but the order of the bias is immaterial to the interpretation of the results.

An example of the tracings obtained using this method, including the standards and blanks, is given in Figure 2.

Attention must be paid to the precise details of the technique of collection of samples from factory workers. Firstly, men should be examined if possible before they go on the shift in order to diminish the chance of contamination. Obvious precautions must be taken regarding the use of a medical centre sited well away from the danger of aerial contamination.

The necessary materials include dressings, lead-free soaps (two pieces), stillettes, paper towels, heparinised tubes and rubber teats, forceps, Whatman No. 4 qualitative filter paper, plastic disposable petri dishes, plastic sealable envelopes, bottles containing measured aliquots of Drabkin Solution (for haemoglobin estimation) and grease pencils.

The modern fashion of long hair may necessitate this being swathed in a triangular bandage to keep it out of the way. Towels are placed in position and the lobe of the ear thoroughly cleansed with soap and dried, using a no-touch technique. One stab of the lower margin of the ear should ensure a free flow of blood, the first few drops of which are allowed to run to waste. The unmarked end of the heparinised tube is applied to the drop and the tube is allowed to fill. Holding the tube at an angle of 30°, the marked end is broken off and dropped into the Drabkin for haemoglobin estimation. After applying the teat to the tube, the blood is spotted onto the filter paper in the petri dish in two locations, allowing it to drop from an approximately standardised height of 1 cm, holding the tube at an angle of 30°. The spots are allowed to dry, and then each paper is placed with forceps into a plastic envelope and sealed. After marking, sets of envelopes can be despatched to the laboratory for analysis.

Although it would seem that the dangers of contamination are considerable, in practice this does not seem to be the case, provided simple precautions are taken. In any case, contamination is usually obvious on analysis and indicated by failure of the tracings to replicate.

It is important to use a fresh packet of filter paper for each session. This may entail breaking down the packet into smaller batches into sealed plastic envelopes under lead-free conditions.

Results of the application of the capillary blood lead by this punched disc technique are illustrated in the figures attached. Figure 3 shows the results of the capillary blood lead (together with the venous findings for comparison) in a bad factory. The group blood lead reflects a thoroughly unsatisfactory state of affairs, and calls for the support of the Industrial Hygienists to advise on how best to clear up the environment. Some of these workers would need suspension and perhaps medical attention.

By contrast, the results found in a good factory where little risk was anticipated are also shown.

A summary of the results, using the capillary blood lead in an investigation of eleven factories engaged in wire patenting, are given in Figure 4.

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This is an industry which nowadays has a relatively low hazard, and this is reflected in the results. There are, however, some men who would require following up.

Another way this technique can be simply applied is to the examination of men exposed to a particular hazard. We might want to know, for example, whether a group of men engaged in a particular process is being subjected to an undue lead hazard, and, if so, whether they are coming to any harm.

From the findings given in Figure 5, it is clear that there is a slight lead risk, as shown by the raised group blood lead. But this is of a low order and from the lack of symptoms and the normal haemoglobin findings (not included in the figure for simplicity), the men are not coming to overt harm. Even so, these results warrant the support of the Industrial Hygienists to investigate the process further.

Thus it is seen that the capillary blood lead can be simply applied to factories and processes within a factory as a check on the environment and on the health of the workers at the same time.

The precise figure for the blood lead is of less importance than frequent checks, using capillary blood, which yield results of sufficient accuracy to indicate the degree of exposure, highlighting the bad factories and the hazardous processes. High results in an individual should always be followed up, using a venous specimen and ancillary tests.

In summary, the capillary blood lead in the hands of anyone prepared to pay meticulous attention to detail is a useful way of supervising workers and gaining an insight into environment at the same time.

It will not solve the problem but should highlight the hazardous factories and processes where improvement in conditions is most needed. The ways of effecting them are not a medical but an engineering problem.

Figure 1


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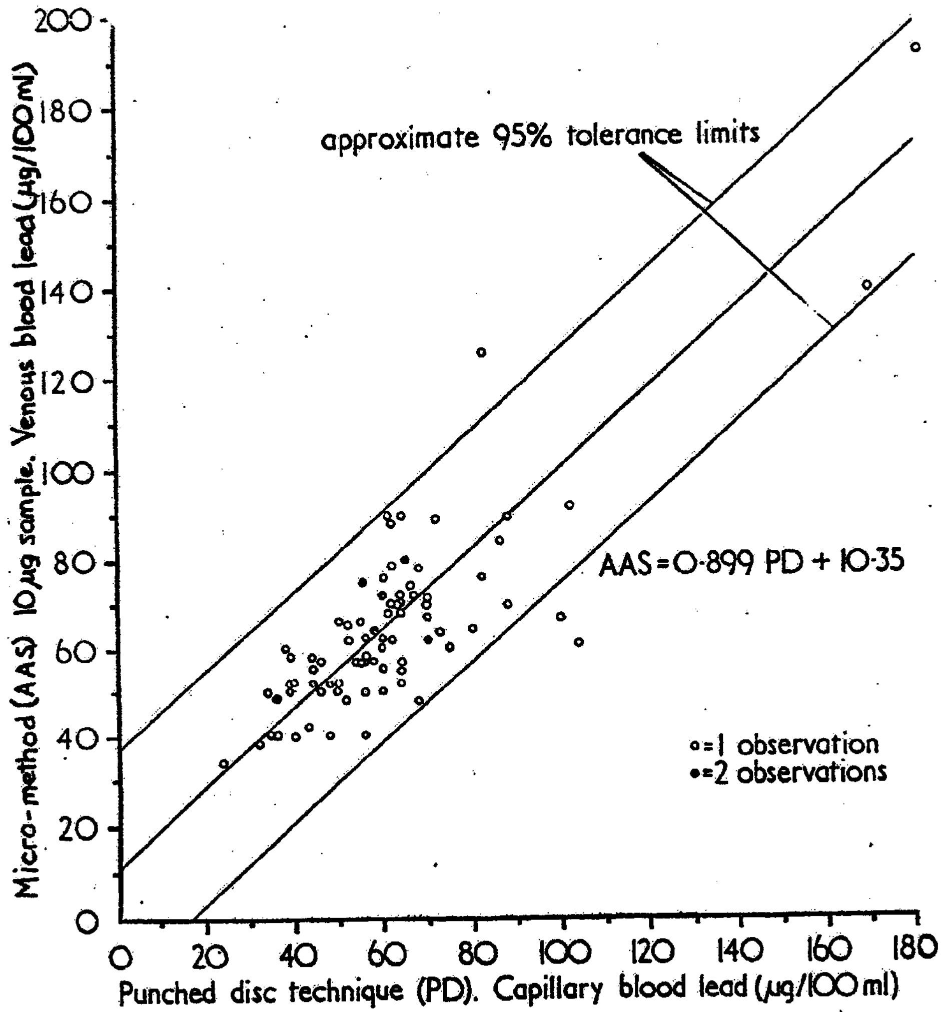


A comparison of results obtained by the 8.9 mm punched disc technique (Cernik & Sayers, 1971) using capillary blood with those done by the micro-method (Delves, 1970) using venous blood. The regression line is shown and the approximate 95% tolerance limits.

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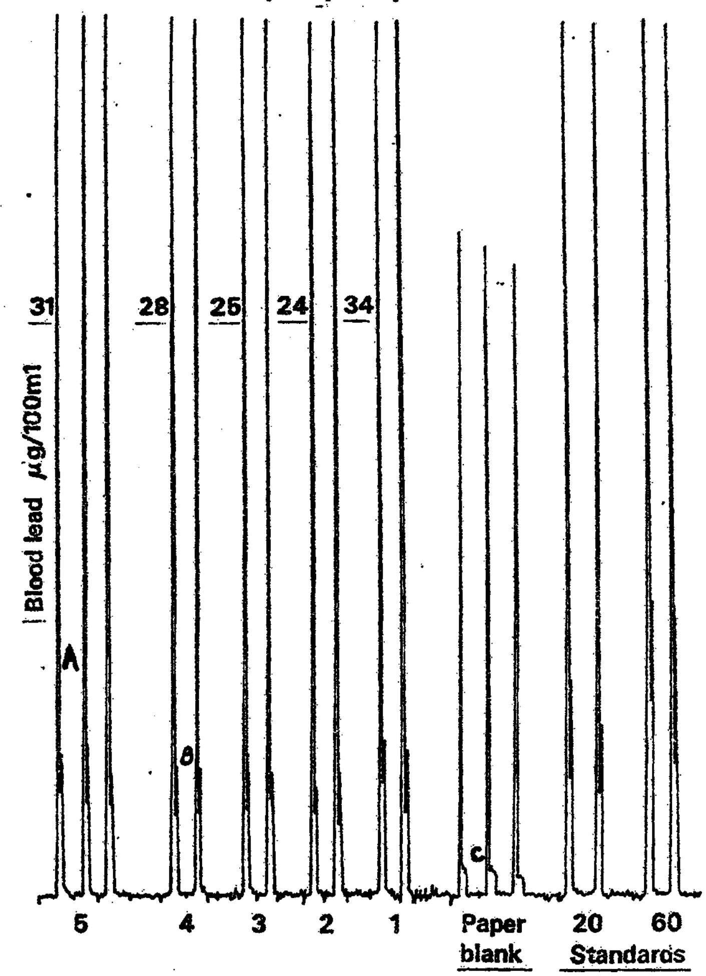
Figure 2

Factory No. 11 Capillary samples




Absorption signals at 283.3 nm obtained from duplicate 6.5 mm diameter punched discs spotted with capillary blood.

A Non-specific absorption signal from combustion products of paper and blood.

B Lead atomic absorption signal.

C Signal given by blank paper and crucible.

Figure 3

CAPILLARY BLOOD LEAD AS INDEX OF ENVIRONMENT
( VENOUS RESULTS INCLUDED FOR COMPARISON )
μg/100

FACTORY: BAD

| No. | CAPILLARY | VENOUS |
|---|---|---|
| 1 | 94 | 114 |
| 2 | 97 | 84 |
| 3 | 108 | 115 |
| 4 | 115 | 105 |
| 5 | 125 | 133 |
| 6 | 139 | 123 |
| 7 | 140 | 162 |
| 8 | 150 | 145 |
| 9 | 154 | 132 |
| 10 | 157 | 115 |
| 11 | 167 | 173 |
| | | |
| GROUP AVERAGE | 131 | 127 |

FACTORY: GOOD

| No. | CAPILLARY | VENOUS |
|---|---|---|
| 1 | 13 | 15 |
| 2 | 13 | 20 |
| 3 | 15 | 23 |
| 4 | 17 | 13 |
| 5 | 17 | 23 |
| 6 | 20 | 21 |
| 7 | 23 | 19 |
| 8 | 23 | 28 |
| 9 | 24 | 22 |
| 10 | 25 | 23 |
| 11 | 27 | 25 |
| 12 | 33 | 25 |
| GROUP AVERAGE | 21 | 21 |

Figure 4

## WIRE PATENTING SURVEY (1971)
## USING CAPILLARY BLOOD

| Serial number of factory | Number of workers examined | Blood lead | | Remarks |
|---|---|---|---|---|
| | | Mean | No > 80 | |
| 1 | 7 | 44 | nil | OK |
| 2 | 9 | 54 | nil | OK |
| 3 | 20 | 75 | 3 | Doubtful(follow up) |
| 4 | 25 | 42 | nil | OK |
| 5 | 15 | 43 | nil | OK |
| 6 | 6 | 53 | nil | OK |
| 7 | 10 | 95 | 6 | Bad(follow up) |
| 8 | 10 | 50 | nil | OK |
| 9 | 27 | 66 | 2 | Doubtful(follow up) |
| 10 | 18 | 54 | 1 | OK(1 follow up) |
| 11 | 30 | 34 | nil | OK |
| TOTALS | 177 | 55 | 12 | |

Figure 3

REF.: 551/68

DATE OF COLLECTION: May/June 1972

| Serial Number | Blood (per 100 ml) Lead (ug) by PD | | Repeats by POL |
|---|---|---|---|
| | Capillary | Venous | |
| 1 | 24 | 25 | – |
| 2 | 33 | 42 | – |
| 3 | 63 | 58 | 50 |
| 4 | 64 | 48 | 56 |
| 5 | 27 | 39 | – |
| 6 | 20 | 36 | – |
| 7 | 63 | 54 | 68 |
| 8 | 61 | 66 | 61 |
| 9 | 74 | 80 | 70 |
| 10 | 47 | 74 | 59 |
| 11 | 66 | 69 | 63 |
| 12 | 52 | 67 | 59 |
| 13 | 70 | 71 | 73 |
| 14 | 110 | 78 | 90 |
| 15 | 52 | 65 | 50 |
| 16 | 77 | 75 | 68 |
| GROUP AVERAGE: | 56 | 59 | |

Application of capillary blood lead to a process.
(Venous blood lead results included for comparison)

PD = Punched Disc
POL = Polarography