CHRONIC MERCURY POISONING IN LATENT FINGER-PRINT DEVELOPMENT

BY

GILBERT FORBES, M.D., B.Sc., F.R.F.P.S.
F.R.C.S.Ed.

*Senior Lecturer in Charge of the Department of Forensic
Medicine, University of Sheffield*

AND

JAMES WHITE, D.Sc., Ph.D.

*Senior Lecturer in Refractory Materials, University of
Sheffield*

That mercury is a highly toxic substance, whether in the form of the pure metal or in combination with an acid radical, has been known from the earliest times, certainly from the days of ancient Rome. Mercury poisoning was first noticed in quicksilver miners, then in gilders, and at the present day there are at least 80 industries in which mercury is used and in which it may be a potential danger to the workmen (Dublin and Vane, 1933). The history of industrial mercurialism and a review of the main industries concerned has been provided by Buckell and his colleagues (1946). It is superfluous to cover this ground again. To this list, however, there has recently been added another occupation which seems to carry a hazard of chronic mercury poisoning—namely, that of police finger-print expert.

An outbreak of chronic mercurialism in the Lancashire County Constabulary Finger-print Department was reported by Agate and Buckell (1949). So far as we know, this is the only report of such an incident, and after reading their paper we decided to carry out the present investigation. Agate and Buckell found that of a staff of 32 men 7 exhibited tremor with or without other evidence of mercurialism. The substance responsible for the Lancashire outbreak was "grey powder" (hydrargyrum cum creta, *B.P.*), a preparation which is extensively used for the development of latent finger-prints. As it was known that the City of Sheffield Police Photographic Department had for years used the same powder, it was decided to inquire into the health of the members of that department.

The Sheffield City Police Photographic Department is staffed by four men. In addition, one man who was transferred to another branch of the service five years ago was included in the inquiry.

TABLE I

Case No.	Length of Service in Photographic Department	Estimated Daily Exposure
1	12.0 years	1.0 hour
2	13.5 "	0.5 "
3	3.5 "	0.5 "
4	5.0 "	1.0 "
5	3.5 "	0.5 "

Table I shows the length of service of each individual in the department, and his estimate of the time spent each day exposed to the "grey powder" dust. For various reasons connected with staffing, Cases 1 and 2 have had to do more of this type of work than the other three men, but it would appear that the annual estimated exposures have varied between 175 hours and 350 hours, approximately.

Clinical Histories

Case 1.—Since 1945 this man has had vague dyspepsia, and since 1946 depression. In the spring of 1948 he first noticed attacks of sudden sharp pain in the left ankle with momentary weakness in the joint. These attacks occurred at irregular intervals—sometimes twice daily and at other times not once a month at first—but at the beginning of 1949 they became more frequent. The pain was most often experienced on coming down stairs. Since 1947 he has felt abnormally tired at the end of a day's work and has become very irritable. Early in 1949 he noticed that his legs were becoming weak, the left one more than the right. About this time he had an attack of "influenza," and after this the condition got rapidly worse. He developed dyspnoea on exertion and sudden loss of balance when turning round or getting up from a chair. In May, 1949, he was unable to work because of giddiness, which lasted a week. He was admitted to hospital for investigation, and while there the condition was diagnosed as peripheral neuritis of unknown aetiology. The neurologist now agrees that chronic mercury poisoning adequately accounts for all his symptoms. In addition, this man has noticed excessive perspiration of the face in the absence of exertion, a feeling of tremulousness but no actual tremor for 12 months, a tendency to drop things, and slight weakness in the arms. He has experienced no salivation, gingivitis, or sleeplessness, and no tremor was found clinically.

Case 2.—This man was transferred from the photographic department six years ago, after serving there for 13.5 years. When he had been doing finger-print work for 7.5 years he noticed slight tremor of the hands, which has improved since he left the department. A year later his handwriting became shaky. He could write a few words well and then the writing deteriorated. This condition also has improved, but has not entirely disappeared. He was not affected in any other way in spite of being exposed to the risk over a considerable period—in fact, longer than Case 1. This may be due to the fact that, though he did not appreciate that there was any danger inherent in the use of the powder, he admits he used it sparingly and did not indulge in indiscriminate dusting. The desirability of this was brought home to him by the experience of a householder complaining that her wedding-ring had been damaged by the powder. This economy in the use of the powder is borne out by the fact that while this man served in the department the bulk of powder used was approximately 1 lb. (450 g.) in six months, as against 1 lb. (450 g.) a month in recent years.

Case 3.—This man had no signs or symptoms.

Case 4.—This man has noticed that during the past 18 months he has had slight tremor, that he perspires more readily than previously, and that he is more easily upset by difficult situations than formerly. No abnormality was noticed clinically.

Case 5.—This man had no signs or symptoms.

Comment on Cases.—From a review of these five men it seems that two were quite unaffected, two others had minor deviations from normal health which could have been due to mild chronic mercurialism, and the fifth developed peripheral neuritis which was accompanied by other symptoms commonly found in cases of chronic mercury poisoning. It seems not unreasonable to conclude that the illness in Case 1 was due to mercury, and that the minor illnesses, if they can be called that, in Cases 2 and 4 may have been due to the same cause.

The Powder

The "grey powder" used is obtained in 2-lb. (900-g.) tins from a local pharmacist. He in turn obtains it already prepared from a firm of wholesale manufacturing chemists. The powder is supplied in ordinary tins, and it is impossible to discover the time interval between its preparation and its use by the photographers. Since 1944 the powder has been used at the rate of 27 lb. (12.2 kg.) in 29 months, or approximately 1 lb. (450 g.) each month. Before that date it was

obtained freshly prepared from a local pharmacist 1 lb. (450 g.) at a time, and this quantity lasted six months. When dusting is in progress the powder is in an open container and is applied with a brush to the surface in question. The face of the operator is within about 12 in. (30 cm.) of the surface while the work is going on.

Method of Absorption

Mercury may be absorbed from the alimentary canal, through the lungs, or through the skin. Agate and Buckell (1949) favour the view that the route of absorption in such cases is probably by inhalation of fine dust, with the possibility that mercury vapour might be inhaled from the powder left lying about. They also envisage, as a possibility, direct absorption through the skin or by the mouth. In an effort to try to clarify this point, dust counts were made while dusting was in progress. A room was chosen in which the powder had not previously been used, and the Owens jet dust counter was employed to obtain samples of the airborne dust in the region of the operator's breathing level, before, during, and after the application of the powder to various surfaces in the room. The results are shown in Table II. It was hoped that during the counting it would

TABLE II.—Results of Dust Count (Samples Counted at Magnification of 1,600 Diameters)

No.	Operation	Concentration (Particles per c.cm.)
1	General atmosphere of room before dusting	1,660
2	" " " "	1,820
3	During dusting of table " " "	5,640
4	" " " "	5,140
5	During dusting of mantelpiece " " "	6,970
6	" " " "	6,300
7	During dusting of door " " "	8,600
8	" " " "	8,300
9	During dusting of lamp " " "	7,630
10	" " " "	7,470
11	During dusting of window " " "	8,960
12	" " " "	6,140
13	General atmosphere 10 minutes after dusting	3,320
14	As above after 15 minutes " " "	2,320
15	" " " " 20 " " "	2,980

be possible to make some distinction between mercury and other particles, and so obtain an estimate of the mercury content of the samples. A microscopical examination of a sample of the powder showed the presence of a proportion of mercury globules less than five microns in diameter. However, in the sample from the air it was found impossible to identify, positively, the mercury globules, and in fact no recognizable mercury particles were seen in any of the samples.

The counts do show a marked increase in the dust concentration near the operator, and the apparent absence of mercury particles may be due to shattering as they impinge at high velocity on to the instrument's collecting surface. Alternatively, owing to their high density the particles may rapidly fall below breathing level and out of the range of the instrument's intake. If this is so, then the presumption would be justified that the risk to the operator is not from the particles breathed but must arise from absorption through the skin, or, more likely, from contamination of the hands and accidental ingestion.

To follow this line of investigation further, it was decided to try to detect the mercury chemically by filtering the air breathed by the operator and analysing the deposit on the mask. To this end, arrangements were made for the photographers to wear a Martindale protective mask while searching for finger-prints following a burglary. In the light of the dust content of the air found, it was calculated that, in order to get enough mercury on the filter of the mask to identify chemically, it would be necessary for the operator to wear the mask for a total dusting time of at least 12 hours. This part of the investigation was not practicable. The mask was found to be a nuisance, and it had a disturbing influence on the persons whose homes had been burgled. Even if the householders were reassured that the powder

would do no harm, and were told that the mask was being used for experimental purposes, they remained uneasy about the whole matter. For these reasons this part of the inquiry had to be abandoned.

The problem was then tackled from another angle. An air elutriator was used. This consisted of a vertical glass tube having its sides parallel over the upper part of its length, but tapering to a narrow inlet at the lower end. Samples consisting of 2 g. of the powder were placed in the bottom of the tube and air was blown, at a known linear velocity of flow, through the parallel portion of the tube. In preliminary experiments an attempt was made to filter the exit air, but this method was too insensitive. The method finally adopted was to suspend a horizontal glass plate near the top of the tube. It was found that, during a run, powder was deposited on this plate, which could then be removed and examined microscopically. For the latter purpose it was convenient to use an immersion liquid—nitrobenzene—which rendered the calcium carbonate particles transparent so that they could be easily differentiated from the mercury. The results are shown in Table III. While the maximum sizes detected do not agree exactly with those calculated by Stokes's law, they are of the right order.

TABLE III

Air Velocity (cm./sec.)	Microscopical Findings
72.8	Mercury globules up to 0.002 mm. diameter seen
54.5	" " " " 0.001 " " "
45.5	No mercury detected
33.1	" " " "

The conclusion from this examination would appear to be that detectable metallic mercury will settle out from air rather quickly. This supports the results obtained from the examination of dust samples taken while dusting for finger-prints was in progress, and indicates that the failure to find metallic mercury in the samples of dust was not due to shattering of the mercury globules on the instrument, but to the heavy mercury falling rapidly out of the sphere of operation. This suggests that inhalation of vapour and absorption of mercury through the skin are more likely causes of toxicity in finger-print experts.

Chemical Examination

It was thought desirable to inquire into the question of whether, as a result of keeping, the powder was undergoing some change which would make it more toxic. Three samples of "grey powder" were analysed. The first of these, which had been prepared according to the *British Pharmacopoeia* 1932 formula, was received in a 2-lb. (900 g.) tin which had been in use for some considerable time. Approximately $\frac{1}{2}$ lb. (225 g.) of the powder was left in the tin, the rest having been used. This was called B.P.32(1). Later two freshly prepared samples were received, one made according to the same formula described as B.P.32(2), and the other according to the modified formula of the *British Pharmacopoeia* 1948, which specifies that 1% dextrose be added to the mixture of mercury and chalk—B.P.48. The fresh samples were somewhat lighter in colour than the older sample. The difference in colour persisted even after all three samples had been kept a further nine months in sealed bottles.

A chemical analysis was carried out on B.P.32(1) in the "as-received" condition, the normal procedure of drying at 110° C. before analysis having to be omitted owing to loss of mercury by volatilization at this temperature. Assuming all the lime to be present as CaCO_3 , the result of analysis was as follows:

Calcium carbonate (CaCO_3)		67.13%
Mercury (Hg)		32.60%
Silica (SiO_2)		0.47%

These figures are consistent with the formula laid down in the B.P. 1932, but otherwise they provide little significant

information. The silica reported would possibly be present as an impurity in the chalk. The powder was also tested for the presence of tin, which might have been picked up by amalgamation with the tin coating of the container. No detectable amount was, however, found. Tests also for alumina, iron, magnesia, etc., resulted in none being detected.

An attempt was made to determine the moisture content by drying over concentrated sulphuric acid at room temperature. A loss of weight of 0.09% was recorded after 24 hours. After four days this had increased to 0.39%. It seems likely, therefore, that a slow loss of mercury by volatilization was occurring even under these conditions. (In this connexion it may be noted that the vapour pressure of a liquid in the form of small globules is raised by the curvature of the surface over that of the bulk liquid.) Because of this it is not possible to give an accurate figure for moisture content, but the small amount of loss in 24 hours indicates that it must have been very low.

Since ordinary methods of analysis revealed no abnormal constituents, the indirect method was adopted of trying to detect significant differences of physical or chemical behaviour between the old sample and the freshly prepared ones.

Removal of Metallic Mercury by Distillation

An attempt was made to remove metallic mercury by distillation at low temperature, on the assumption that any mercury compounds which might have been formed would be less volatile than the free metal and might therefore be expected to remain in the residue after distillation was complete. Samples of the powders of the same initial weight were spread out on watch-glasses and placed in a thermostatically controlled oven, which was kept at 120° C. The weights of the samples were determined at intervals and the

Rate of removal of metallic mercury by distillation in air at 120° C.

weight losses plotted against time as shown in the Chart. It will be seen that the rate of loss from B.P.32(1) falls much below that of the other two. Three explanations of this behaviour are possible: (1) that a surface coating of some kind, preventing the free escape of vapour, was present on the globules of mercury in this sample; (2) that the globules of mercury in this sample were coarser than in the other two, or had become coarser on storage; or (3) that some of the mercury had been converted to a non-volatile form. Microscopical examination of the three samples proved inconclusive with regard to the second possibility. After 33 hours of heating, the weights of all three samples had apparently reached constancy. the weight losses then being:

B.P. 32(1)	..	..	..	..	..	32.30%
B.P. 32(2)	..	..	..	..	..	33.97%
B.P. 48	..	..	..	..	..	33.23%

The residues were tested qualitatively for the presence of mercury, B.P.32(1) being found to contain a small amount while none was detected in the other two. This would seem to suggest that a small amount of non-volatile, and presumably combined, mercury was present in this sample. A "blank" test carried out on mercuric oxide gave a loss of

only 0.18% in 45 hours at 120° C., confirming that combined mercury would be comparatively non-volatile at this temperature.

Extraction of "Water-soluble Mercury" from the Powders

When attempts were being made to extract any mercury compounds from the powders by means of weak reagents, the somewhat unexpected discovery was made that B.P.32(1) contained a small amount of mercury, presumably combined as a salt, which could be extracted by cold or hot water, the resulting solution giving a precipitate on passing hydrogen sulphide. No precipitate was obtained with the extracts from the other powders. An attempt was made to identify the acid radicals present in the solution from B.P.32(1), but this proved difficult owing to the small amount of material in the solution. A small quantity of sulphate was, however, detected. When the test for "water-soluble" mercury was repeated on all three samples some nine months later, during which time they had been kept in closed bottles, it was found that the cold-water extracts from both B.P.32(1) and B.P.32(2) now contained mercury. That from B.P.48 still gave no precipitate. The amounts of mercury present in the extracts were determined by weighing the precipitates. The results were as follows:

B.P. 32(1)	..	..	0.08%	of mercury extracted (as Hg)
B.P. 32(2)	..	..	0.05%	" " "
B.P. 48	..	..	Nil	" " "

It would therefore seem that the presence of dextrose was enough to prevent the formation of the soluble compound or compounds.

The method of Miss Roberts (1936) was also used to determine the amount of mercuric oxide in the samples. The results appear in Table IV.

TABLE IV.—Amount of Mercury Present as HgO

B.P. 32(1)	..	..	..	..	..	{ 3.33%
B.P. 32(2)	..	..	..	..	..	{ 3.57%
B.P. 48	..	..	..	..	..	{ 0.056%
						{ 0.056%
						{ 0.08%
						{ 0.04%

These figures show that there is no direct proportionality between the "soluble mercury" and the mercuric oxide content. There is, however, probably some relationship between the two—for example, B.P. 32(1), which contained most mercuric oxide, also had the highest content of "soluble mercury."

Conclusions

"Grey powder" is the favourite substance used to develop latent finger-prints by all the police forces in this country. It has been so used for many years, and yet, till the report of Agate and Buckell, there has been no suggestion, so far as we know, that this process is dangerous. The clinical reports of Agate and Buckell and those detailed above show that, while the risk of toxic symptoms arising is real, it is nevertheless small. There seem to be two alternative possibilities to explain this: first, that of individual susceptibility, and, secondly, the amount of care which is taken in using the powder to avoid contamination of the air, clothes, skin, etc. If powder is scattered indiscriminately over any surface which might possibly bear a finger-print, instead of being applied only to those surfaces where a potential print can be seen, then obviously the risk of poisoning is increased.

This inquiry tends to show that the weight of evidence is against absorption by inhalation, in view of the speed with which the mercury globules fall out of the breathing area. This leaves open the possibilities that mercury vapour from spilled powder lying about in the workrooms may be inhaled, that the mercury may be absorbed through the skin, or that it may be accidentally ingested after contamination of the hands. In view of the fact that in many chemical and physical laboratories metallic mercury is left lying about in cracks in the floor and in other inaccessible regions with impunity, the likelihood that the inhalation of mercury

vapour is the answer seems small. The true answer may lie in a combination of absorption through the skin and accidental ingestion. If this is so, then, because of deterioration in the form of the production of water-soluble mercury compounds in the powder prepared according to the B.P. 1932 formula on keeping, this form of the powder should be much more dangerous than the new form (B.P. 1948), in which oxidation is inhibited by the addition of dextrose. Owing to the small quantity of these substances present, it has not been possible to identify the compounds completely, though traces of sulphate were found in the extracts. The presence of sulphate in the extract suggests that impurities such as mercuric sulphide in the mercury may also play a part in the reaction, possibly by inducing electrolytic couples in the metal.

The men concerned in this inquiry, and those in the cases reported by Agate and Buckell, had all been using "grey powder" to develop latent finger-prints long before 1948, when the addition of 1% dextrose was recommended to prevent oxidation of the finely divided mercury. It is interesting to speculate whether such cases would be likely to occur now or not. In view of the fact that soluble-mercury compounds are so much more dangerous than the pure metal, it seems to be a reasonable presumption that the risk would be slightly reduced.

Now that it is known that there is a risk in the procedure, the use of the powder must be discontinued until the method of absorption has been accurately determined, and means of preventing it have been devised. The alternative of elaborating some non-toxic, equally effective substitute emerges, but, up to date, "grey powder" still holds the field as the preparation of choice for the development of latent finger-prints.

Summary

The staff of a police photographic department has been investigated for signs of chronic mercury poisoning due to the use of "grey powder" in the development of latent finger-prints.

One case of peripheral neuritis, probably due to this cause, has been found in a staff of five men.

Experiments are described which tend to show that inhalation of the mercury dust is not the mode of absorption.

"Grey powder" made without the addition of dextrose tends to undergo oxidation, and water-soluble mercury compounds appear in the powder on storage.

We wish to acknowledge our indebtedness to Mr. W. A. Bloor, Senior Scientific Officer with the British Iron and Steel Research Association, who undertook the dust counts, and to Mr. George E. Scott, Chief Constable of the City of Sheffield, for permission to carry out the clinical side of this investigation among the men under his command.

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A note in *La Presse Médicale* of April 5 remarks on the numbers of Dutchmen who are leaving Holland as emigrants to various parts of the British Commonwealth or to the United States. In five years 56,478 persons left Holland: 11,872 went to Australia, 707 to New Zealand, Canada took 23,158 and South Africa 6,392, while the U.S. admitted 11,896. During the first six months of 1951, 9,000 more left for Canada and another 4,000 were waiting for transatlantic transport. The reason for this emigration lies in the smallness of Holland, which has to accommodate over 10 million people in a land which a hundred years ago only supported 3 million.

PILONIDAL SINUS OF THE AXILLA

BY

IAN AIRD, Ch.M., F.R.C.S.

(From the Department of Surgery, Postgraduate Medical School of London and Hammersmith Hospital)

Pilonidal sinus of the coccygeal region appears to have been first recorded by Anderson (1847), of Boston, who found hair in a sacro-coccygeal ulcer. A more typical case was reported, however, by Warren (1854). In 1880 Hodges gave a very complete description of the suppurative lesion of the nates and applied to it the name of pilonidal sinus. Hodges's paper is particularly interesting in that it made full reference to the occurrence of hair-containing sinuses in regions of the body outside the sacro-coccygeal area. He mentions, for example, that "hair cutters are continually in trouble from the short hairs which penetrate the skin of their fingers and hands," thus anticipating by more than 60 years the description of pilonidal sinus as it occurs in a barber's hand, furnished by Patey and Scarff (1946, 1948) and Ewing (1947). Hodges also mentions the frequent intrusion of hair from a mattress or mat into the sole of a bare foot. T. E. Smith (1948) has recorded the occurrence of pilonidal sinus anteriorly in the perineum. Suppuration related to buried hair may also occur at the umbilicus; at the meeting in Boston in 1854 of the Society for Medical Improvement, where Warren made his historic communication, a Dr. Jackson referred to a specimen of a "lock or pellet of hair taken from near the umbilicus"; and we have observed in this hospital a hirsute young female patient with recurrent umbilical suppuration in whom a pilonidal sinus in this situation was suspected but who was unwilling to submit to the proof of omphalectomy.

To these five sites of pilonidal suppuration—the sacro-coccygeal region, the perineum, the barber's hand, the sole of the foot, and the umbilicus—can now be added a sixth, the axilla.

Case Report

A man aged 34, dark-haired and abundantly but not abnormally hirsute, attended this hospital in October, 1949. He had a small sinus in the right axilla which had discharged intermittently for six months. There was a free discharge of pus from the sinus and some oedema around it. The appearance suggested tuberculosis, though the axillary lymph nodes were not enlarged; *Myc. tuberculosis* could not be demonstrated in the pus. The previous history obtained then from the patient included (1) a pleural effusion investigated elsewhere and considered not to be tuberculous, (2) an episode of supraspinatous tendinitis, and (3) a pilonidal sinus of the sacro-coccygeal region whose relevance was not appreciated at this stage.

In August, 1950, the patient was admitted to hospital for the treatment of continuing axillary suppuration, and an elliptical piece of skin was removed, with its long axis transversely across the axilla to include the openings of two sinuses. The incision was deepened into the subcutaneous tissue of the axilla and a block was removed to include the deeper portions of the sinuses, which extended to about 1 cm. under the skin. The skin wound was closed. Histological examination of the material removed showed very narrow openings lined by squamous epithelium leading to an irregular collapsed cavity with a partial wall of squamous epithelium and an abundance of granulation tissue. The histologist considered that excision had been incomplete on one side. The pus obtained at this operation showed a moderate number of pus cells, very few Gram-positive cocci,