

THE DANGER OF MERCURY-EVAPORATION AND THE AMALGAMS.

by

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Since Stock, the director of the Government Institute for Chemistry in Berlin-Dahlem, proved in 1926 that mercury-evaporation—as well as metallic mercury itself—is very dangerous for the working people in factories using mercury, many new researches have been started and improvements made with success.

How was this found out? Stock in 1926 delivered a very interesting and conclusive lecture before the Berlin Medical Association, and during this lecture he said that the danger from metallic mercury was not a new discovery; already in the days of antiquity, when amalgam was used for gilding, this danger was very well known. About 1000 A. D. we find in alchemistic writings the knowledge of the effect of the “dangerous metallic mercury” on the nerves and on the mind. Nevertheless it must be mentioned here that on the other hand mercury has been used for a long time in the arts and in medicine. Paracelsus (1494-1541) advocated its use for the treatment of syphilis, and Mead (1673-1754) recommended the swallowing of the metal “to a pound weight at least” in cases of “iliac passion” in order that by its ponderosity it might restore the natural motion of the intestines.

The origin of this paper is due to the facts which I found in the Litcho Gold-Mines (originally Société des Mines d'Or de Litcho, since February 1941 taken over by the Thai Government under the name of the Thai Gold-Mines, Tomoh); and furthermore it is due to the symptoms which I found during the examination of 14 patients suffering from various troubles: general weakness, undefined headaches, insomnia, loss of memory, the feeling of having got a cold, nervousity, sometimes the feeling of vomiting and the feeling of an obstructed nose. Of the people concerned, six had teeth troubles and especially one (a European) was suffering in a large way from nearly all the above-mentioned troubles.

Mercury, from occupational exposure or from its therapeutical use, causes a condition known as ptyalism or mercurial salivation. The mechanism of salivation is not definitely known. Since it may be diminished by Atropine, it is probably due partly to a reflex response to the stomatitis; but this does not appear adequate. Histologic degenerative changes have been described in the parotid glands, but this cannot be attributed to the concentration of the mercury by the saliva, for it is of the same order as in the blood (Lomholt found 0.05-0.06 mg per 100 cc. in the saliva). The increased flow of saliva is not an immediate effect of mercury, for it is not produced acutely, for instance, by intravenous injection. Toxic doses prevent the response to pilocarpine or stimulation of the secretory nerve. According to Bradbury's experiences mercury causes first a metallic taste with soreness of the teeth upon chewing. Continued absorption results in increased secretion of saliva, swollen, tender, spongy gums which bleed easily; swelling and soreness of the salivary glands, especially of those under the tongue; and a foul breath. In extreme cases ulcers appear upon the gums, cheeks, tongue and palate; the teeth loosen and may fall out, and the jaw may undergo necrosis. When even moderately intoxicated, the patient is quite wretched; he suffers considerable pains which are made worse on his attempts at eating; he may lose weight, appear cachectic, and eventually die.

MacConnell, medical director of the Industrial Health Section in New York (U.S.A.), says that the subacute poisoning is ordinarily caused by the excessive therapeutic use of mercury. The common symptoms—salivation, gingivitis and diarrhea—subside upon the withdrawal of the drug.

The most important point, however, is the question of industrial poisoning. Industrial mercury poisoning is almost invariably a chronic intoxication resulting from the volatilized mercury for a long period. The most hazardous trades are the production of mercury and its derivatives, the manufacture of scientific apparatus (thermometers and barometers), the preparation of hatter's fur and felt-hat making; furthermore the extraction of gold or silver from the amalgams by distillation, and the preparation and handling of the fulminate of mercury used as a detonator of explosives. The daily absorption of approximately 1 mg for several months may produce symptoms of poisoning, although most intoxications become apparent only after many months or several years of exposure.

Regarding the symptoms, it must be mentioned that chronic mercuria-

lism has various manifestations, far from those that may be observed in any particular cases. The most typical symptoms are included in the following groups :

1) Stomatitis, salivation, a metallic taste, reddish-brown discoloration of the buccal mucosa, gingivitis, loosening of the teeth, and occasionally a marking of the gums similar to the lead-line.

2) *Erythismus mercurialis*, a peculiar psychic disturbance characterized by ready excitability and a strange shyness in the presence of strangers, a symptom of great interest and importance ; insomnia, headache, vertigo, mental depression, and dullness ; and, rarely, hallucinations.

3) Tremors of the orbit, lips, tongue, fingers, and limbs. These are usually moderately fine at first, but at intervals become a coarse jerking. They may become very severe and in rare instances involve contractions of the limbs of such violence as to require restraint. The tremor is intentional and subsides during rest. Under observation it may increase and diminish, rhythmically recurring. When it is marked, the patient may require assistance in eating and in other activities. Weakness of both the flexor and extensor muscles of the hand and fore-arm has been reported, but marked paresis is rarely, if indeed ever, caused by mercury.

Lewin differentiates the stomatitis into three groups :

1) *Stomatitis simplex* (Gingivitis) : metallic taste, bluntness of the teeth, dark edge, livid discoloration, swelling and loosening of the easily bleeding gums, *foetor ex ore*, and salivation.

2) *Stomatitis ulcerosa* : formation of flat, sharp-edged, grey covered substance-losses.

3) *Stomatitis gangraenosa* : in the whole cavity of the mouth, also at the cheeks, large ulcerations which may lead finally to a *necrosis osseae*.

It must be mentioned furthermore that there is still another symptom of the *stomatitis mercurialis* : the denudation of the *colli dentes*. In consequence of this symptom we find often disturbances of the teeth-nutrition, the teeth start loosening and may fall off later on.

The authors, quoted above, state that the stomatitis is usually the first and earliest symptom of chronic mercurial poisoning. It begins with *foetor ex ore*, then metallic taste, soreness of the gums and some salivation

(ptyalism). Then the teeth loosen, the edges of the gums blacken, and they, and later the tongue, become swollen and ulcerated. The infection and irritation causes severe salivation and progressive exhaustion, and sometimes fatal ulcerative stomatitis. With a more chronic course of severe poisoning there may be a loss of the teeth and necrosis of the jaw. The susceptibility to stomatitis varies greatly and is markedly influenced by the hygienic condition of the mouth and teeth and by other individual factors, as well as by the quantity of mercury.

In connection with the stomatitis we have to mention also the colitis, caused by mercurial poisoning. The mechanism of the stomatitis and colitis is probably connected with the local precipitation of mercury sulfide which occurs in the capillary endothelium in these situations, being formed by the interaction of putrefying material with the circulating ionic mercury. This sulfide is toxic to the cells with which it is in contact. The injured and necrotic tissue furnishes a starting point for ulcerative micro-organisms, such as the *Bacillus fusiformis* and the *Treponema dentium* in the mouth and the *Bacillus coli* in the large intestines, the latter giving rise to different lesions. Analogous conditions arise also in necrotic tonsils. The ulceration is, therefore, an indirect effect, resulting from invasion of special micro-organisms through a nidus prepared by the precipitation of mercuric sulfide. The stomatitis always starts as gingivitis, in "gingival pockets," which invite putrefaction.

Kussmaul divides the chronic mercurialism into erethism, tremor, and *kachexia terminalis*. During the stage of erethism (only when the patient tries to work!) we find the intentional tremor, which may become so strong, that it has been called *tremor mercurialis* by several authors. At this stage the patients cannot leave the bed and the whole impression is that of a polynetrinitis; during sleep the tremor ceases always nearly completely.

Fine tremors are observed also in other chronic intoxications, but the tremor of mercurial poisoning, a very rare complaint as Drinker says, is only at first fine but later coarse and even choreiform. It is met amongst workers in furs, hat-makers, thermometer- and barometer-makers, and especially amongst people working in the gold-distillation from the amalgam. It begins in the face, hands, and arms, and may spread to all parts of the body. At first it is brought out only by excitement, or on attempted movement. Later it may persist even during sleep, and speech may be interfered with from involvement of the muscles of the tongue.

pharynx, and larynx. Other prominent symptoms of mercurialism that should not be absent are anaemia, and cerebral symptoms of various kinds. Mercurial tremors may have to be differentiated from those of *paralysis agitans* or disseminated sclerosis,

Struempell pointed out that workmen who are exposed to the mercury evaporation very often get the *tremor mercurialis* (intentional tremor), which appears especially when the patients like to make arbitrary movements with their hands. The finer the handwork they like to do, the greater the tremor. As already mentioned above we find sometimes weakness in the muscles, but there are reports, which state that not only muscular weakness may occur but also atrophy and bone-changes (decalcification), more rarely neuritis and pareses. It is interesting to learn that abortion is frequent.

Stock, in his lecture in 1926, pointed out furthermore that chronic mercury poisoning occurred also in consequence of amalgam-fillings in dentistry. The copper-amalgam seems to be especially dangerous, whereas the silver-amalgam does not provoke such symptoms of poisoning. He, however, was of the opinion that silver-amalgam dental-fillings also may often be the origin of several troubles and of a general weak feeling. Besides the concentrated mercury-vapors we have more diluted vapors in the mercury-mines, and although we find more or less the same symptoms there, we can say, that these more diluted mercury-vapors may be fatal to small animals, but usually not to man.

Joachim, the famous clinical professor of medicine in New York, has observed a special sensitiveness of the gums in biting, a sweet taste in the mouth, and swelling and tenderness of the salivary glands. Furthermore he saw not only ulcerations, but also membrane formations in the mouth. He also noted ulcerative colitis in some cases and he found albumine in the urine; sometimes even bloody diarrhea with tenesmus.

It would, therefore, not be complete if we should not mention at least the mercurial nephritis, because the kidneys are especially susceptible to irritation and injury by mercury. The long continued exposure to relatively small doses to a slow and insidious development of chronic poisoning, usually with renal irritation. So we find sometimes albuminuria and even high blood-pressure. While the severe nephritis associated with acute mercurial poisoning is not associated with the chronic type, these symptoms appear with such frequency as to warrant the belief that the kidneys are usually involved in chronic poisoning. Loss of appetite, in-

digestion, and diarrhea (*cf.* the above-mentioned colitis) are occasionally observed. There is loss of weight in severe cases and at times a secondary anemia is found.

Dermatitis characterized by erythema and desquamation is not uncommonly produced by contact with mercuric chloride or even by ingestion of mercury. In susceptible individuals, fulminate of mercury produces severe dermatitis. Punched-out and penetrating ulcers may develop about the finger-nails and knuckles. The conjunctivae and the mucous membranes of the mouth, nose, and larynx are often affected. Andrews found that fulminate of mercury produces erythematous and papular eruptions, conjunctivitis, and swelling of the eyelids, in operatives who especially have to do with gold-distillation. Gifford states in his textbook of ophthalmology that the conjunctiva of the lower eyelid and fold usually suffers most severely, though the upper eyelid may be severely damaged and damage to the cornea more or less commonly accompanies such injuries. If only the epithelium is destroyed, it is repaired with no permanent damage to the conjunctiva. More severe burns are followed by marked shortening of the folds or the formation of adhesions between the eyelids and the globe (*symblepharon*). When the cornea is involved, conjunctival tissue grows in to cover the defect, resulting in *pseudo-ptyergium*. Such adhesions and cicatricial bands are important, as they often interfere with movements of the eye and cause diplopia.

Regarding the prognosis we can say that there is apparently no acquired immunity to mercury. The severity of symptoms is usually determined by the length and degree of exposure to the poison. While most severe symptoms tend to decrease when the subject is removed from contact with mercury, such manifestations as erethysm and tremor may persist for a long time. Tremor, particularly, has been observed many years after the last exposure. Chronic mercury poisoning is only indirectly a cause of death.

Having gone through all the relevant literature, we may say that it is absolutely necessary to protect the workmen who have to handle mercury, as for instance in the gold-mines. We must acknowledge that we have to thank Stock for his enlightening lecture which he made in 1926. He himself suffered from several of the above-mentioned symptoms together with some of his collaborators, and it was only after a large number of analyses that he found out all these facts. Stock, therefore, merits not only the greatest thanks of all working with mercury, but

also the thanks of all physicians, who learnt from him how to find out the origin of many complaints, unknown up to that time. From the literature, we can see that after Stock's lecture, a great spate of research started anew.

Now before I go into the details of what I found in Litcho, I must first state that all the sufferers said that they did not get their symptoms regularly. They often had not only several hours, but even many days, of good health and then, suddenly, they had a strong deterioration. The symptoms did not come always with the same strength, and furthermore they came in changing intervals. I saw gingitis, loosening of the gums, ulcerations, dermatitis, loosening of the teeth, and in two cases I found albumen in the urine. Three workmen had conjunctivitis and three others had teeth troubles, so that I had to pull out some teeth. All the patients suffered from insomnia and from headaches; some of the them had diarrhea too. The first step was that the patients were given other work in the fresh air and those who had eye-trouble, dermatitis, gingivitis, ulcerations, loosening of the gums and albumen in the urine got rest, corresponding medical treatment and special food.

Although the distillation of the gold and also the amalgamation took place in the open-air stamp mill, the people concerned stood very near to the evaporation and so they were obliged to inhale the mercury-steam: the consequences have been spoken of already fully and completely. There cannot be any doubt about what Stock and all the other authors have found out, but the immediate danger—as I found out in Litcho—is not so great. The climate there is a good, cool (during the night), and healthy one. Nevertheless all the people who were working at the amalgamation and distillation had to be as careful as possible. Another point is that the local inhabitants are better able to stand the climatic conditions and therefore have a greater resistance than Europeans, who are weakened after a certain time by the tropical climate.

This paper has been written after thinking over all the symptoms presented by the above-mentioned patients. The literature shows the whole complex of all relevant chemical and medical questions and necessities, and we have to consider the measures to be taken for the protection of the workmen to prevent danger as far as possible. The conditions in South Thailand are very much more favourable than, for instance, in Europe, but one should by no means be allowed to be careless.

Since the gold-mines were taken over by the Thai Government, special advices have been given :

- 1) Thorough hygienic treatment of the mouth and cleanness of hands and eyes.
- 2) The most strict control to see that all working places are kept as clean as possible.
- 3) During the gold-distillation, a specially strong ventilation has to be provided to supply continually cold and fresh air, so as to expel the mercury-steam.
- 4) Gymnastic exercises in the fresh air, are compulsory for all workers especially in the early morning and in the evening.

As the result of these measures, properly taken and controlled, success has been achieved : people, suffering before from the various symptoms, soon felt better. Their appetite had come back, they were feeling happier, and memory and brain-work were better and more exact. Headaches, nervousity and relaxation had disappeared nearly completely. The patients who had been taken under special medical treatment also got better very soon and there was not one patient who was absent from his work more than three weeks.

These facts not only prove that Stock merits the greatest thanks of physicians and patients, but also that in South Thailand with a good, healthy, and sometimes cool climate, we have nearly all the essentials we need for avoiding the very heavy and severe symptoms and troubles.

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