few short rods or diplococci were observed. I could find no evidences of organisms in the heart.

Klebs, Waldeyer, and Eppinger[7] have published papers on a micrococcus found in this disease, and Dreschfeld[17] has observed micrococci in one out of the three cases he has investigated. The majority of workers in this field have failed to satisfy themselves of the presence of any microbe in the liver, and I have been unable to find any record of a culture obtained from the liver. Hunter,[15] moreover, has expressed the opinion that "the widespread character of the liver change, and the rapidity with which it usually occurs, suggest the action of a circulating toxin rather than a local invasion by micro-organisms."

I do not know how much importance, if any, attaches to the finding of these bacilli in the liver, spleen, and kidneys; for during the thirty-two and a-half hours between death and the *post-mortem* examination, there was ample opportunity for the organisms to emigrate from the intestine, and to make their way into these organs along the route of the blood vessels. No unequivocal bacilli were seen inside the liver cells, though such were found in the epithelium of the convoluted tubules of the kidney. If these be really colon bacilli, it is not improbable, in the light of Adami's researches,[18] that the micrococci of other observers merely represent different forms of the same colon bacillus. Adami has found typical colon bacilli in the liver not only in cases of cirrhosis, but also in cases in which no cirrhosis could be detected. I could not see in the liver cells the diplococcus-like bodies staining deeply (modified form of the colon bacillus), though such was probably present in the kidney. Neither could I see the remains of dead or degenerate forms of dying bacilli which Adami has observed in the hepatic cell.

I take this opportunity of expressing my indebtedness to Professor Workman for allowing me to make use of this material, and must thank him for much valuable advice, ungrudgingly given, during the progress of my research.

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CHRONIC BRASS POISONING.*

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INTRODUCTION.

IN large metal manufacturing centres like Birmingham a complaint is frequently to be met with which is apt to be not a little puzzling to a stranger. Its most prominent characteristics may be illustrated by the following clinical picture:

The patient is a young workman. As he enters the consulting room you notice that his expression is more or less anxious, his face thin and haggard, his complexion sallow, unhealthy, and consumptive looking. He complains of gradual loss of strength, with dry hacking cough, cold sweats, and possibly hæmoptysis. Pains in the chest, loss of appetite, and progressive emaciation in addition lead one instinctively to the suspicion of phthisis, but a careful examination of the chest fails to reveal any pulmonary lesions beyond, perhaps, those of a slight bronchial catarrh. A tentative diagnosis is arrived at, and the patient is sent away with a tonic or expectorant prescription, and instructions to return in a week. In due course he makes his appearance, with the statement that he is not a bit better, or only slightly so. This time the urine is examined, but no abnormality observed. The complaint is labelled "debility," and there the matter ends, with no advantage to the patient.

In the meantime other similar cases begin to crop up, and one is compelled to admit that there is something in the distinctive character of the symptoms requiring explanation. Inquiry into the occupation of such patients appears at first to afford little assistance, as they describe themselves variously—some as stampers, others as metal finishers, others as polishers, etc.; but further investigation elicits the important fact that the one feature common to the entire class is the metal in which they work—namely, brass. The large proportion of copper in this metal immediately suggests an inspection of the teeth, where we find the almost inevitable green line.

The mystery is now solved, and in course of time we become so familiar with the recital of grave general symptoms unaccompanied by correspondingly serious local signs, that we can almost unhesitatingly prophesy an occupation concerned in the manipulation of raw brass, and a green line at the bases of the teeth.

We now turn for assistance to the literature on this subject, and find it surprisingly scanty and unsatisfying. Practically the first investigation into the effects of brass was made by Dr. Headlam Greenhow nearly forty years ago, although some thirty years previously allusion was made to the subject by Thackrah in his *Essay on the Effects of Arts, Trades, and Professions on Health and Longevity*. Greenhow's conclusions supply the material of a paper on Brassfounders' Ague, published in the *Medico Chirurgical Transactions* (1862), in which he describes a form of ague that attacks the casters or founders, who work the metal in its molten state. His description is graphic and interesting, but, as shown by Dr. Simon and others, by no means accurate. There is no doubt that brassfounders do occasionally suffer from attacks exhibiting symptoms which, as Dr. Simon says, "are just such as would be caused by the ingestion of a quantity of an irritant metal sufficiently large to cause vomiting and its attendant depression;" but this is not the occasion, even if one had the necessary information, on which to discuss what is really a form of acute poisoning. Before leaving the subject, however, I should like to remark that this brassfounders' ague, of which so little is known, is just one of those conditions in which we must look for instruction from the private practitioner. The onset is so sudden, and the symptoms so evanescent, that the patient has no time to arrange for treatment at the hospital or dispensary, and presumably he sends for the nearest medical man. Are such cases common? And, if so, how many are correctly diagnosed?

Not until 1887 was any serious attempt made to describe the complaints affecting brassworkers not engaged in casting. In that year Dr. Hogben, of the Queen's Hospital, published in the *Birmingham Medical Review* an article on Brassworkers' Disease, which contains practically all that is known on the subject. The BRITISH MEDICAL JOURNAL of the following year has a contribution by Dr. Simon, of Birmingham (Remarks on Brassworkers' Diseases) discussing the conclusions of Greenhow and Hogben, with some original observations; while, later still, seven years ago, a summary of these appeared in the work of the late Dr. Arlidge, *On the Diseases of Occupation*.

SYMPTOMS.

A person may be employed for months or years filing, polishing, or otherwise manipulating brass, even under adverse conditions, without suffering any ill-effects, and many appear to enjoy a permanent immunity; but, on the other hand, there are individuals whose health begins to become affected almost from the commencement of their occupation, while others, again, exhibit symptoms only after many years. These symptoms are by no means uniform; and considerable difference exists between those manifested in the early stages of absorption and those of a more advanced period.

Early Symptoms.

I am convinced that in a large proportion of cases the first indication of poisoning is the existence of anæmia. The frequency with which anæmic patients, particularly young women, turn out to be brassworkers, and exhibit a green line at the bases of the teeth, suggests this, while the hypothesis is to some extent supported by the occasional state-

* Delivered before the Midland Medical Society.

ment of undoubted sufferers from brass poisoning that their illness was preceded by a condition of anæmia. This premonitory anæmia seems to be largely confined to young females and boys, being seldom seen in adult males. The usual accompaniments of anæmia—palpitation and dyspnœa on exertion, as well as dyspeptic symptoms, anorexia, and epigastric pains after food—are frequently present in some degree, although not generally very acute. Tachycardia I believe to be of fairly common occurrence, while nausea, vomiting, thirst, and colic are not infrequent. According to Hogben, constipation and diarrhœa are both included among the early symptoms, but the latter, so far as I have seen, is a comparatively rare complication, and probably belongs to the later stages of the disease. In the early stage, slight indefinite pains of a neuralgic character may be complained of, with headache, accompanied by a sense of weakness, *malaise*, and nervousness, greater than is generally to be found in ordinary cases of anæmia.

Even prior to the first symptoms of poisoning one may usually discern a green line upon the teeth. It is a mistake to regard this as diagnostic of brass or copper poisoning. It is merely an indication that the individual is in the habit of coming into intimate contact with the metal, and that the process of absorption has commenced. Not until a considerable quantity has been absorbed does the process of poisoning begin and toxic symptoms appear. The green line is very distinct and not easily mistaken. Instead of being situated on the gums, like the line in plumbism, as is erroneously stated by Arlidge[1] and by Taylor,[2] it forms a band of varying depth in front of the bases of the teeth just where they emerge from the gums, and most marked on the teeth of the upper jaw. The colour varies from a faint greenish in ill-marked cases, through brilliant green, to a very dark olive. In addition it should be noted that not infrequently a thin purplish congested-looking line is also visible on the immediately adjacent edge of gum, but this has no diagnostic importance.

Later Symptoms.

As the disease advances the subcutaneous fat gradually diminishes and a condition of progressive emaciation supervenes, which in course of time becomes one of the most marked features of the complaint. The wasting process may extend also to the muscles, which seem to undergo some amount of atrophy. Loss of strength is invariably evident, and muscular tremors are of very frequent occurrence, sometimes generally, throughout the body, but more often confined to the hands or the tongue. The knee-jerks are normal or exaggerated, except, of course, where an actual peripheral neuritis exists. Headache is almost always complained of, as well as pains, very variable in character and situation, neuralgic and myalgic, occurring most often in the abdomen, then in the legs, then the back, chest, and other parts.

As a rule there is dyspepsia, with loss of appetite and gastralgia, while sickness and even vomiting are occasionally met with. The tongue is generally furred, moist, and tremulous, the bowels normal, loose, or confined. There may be a dry tickling cough, sometimes accompanied by the expectoration of thick tenacious sputum, and occasionally by hæmoptysis. The pallor of confirmed brass poisoning is something different from the waxy whiteness of the early stage, the complexion now presenting the sallow, dirty, "unhealthy" aspect so often seen in phthisis, while sometimes it may have a greenish hue reminiscent of but by no means identical with chlorosis.

Symptoms of laryngeal or pharyngeal catarrh are not uncommon, with aphonia and sensations of dryness, discomfort, or constriction in the throat, and a metallic taste in the mouth. A feeling of oppression or nervousness, sometimes of a very intense character, is general among such patients, who complain also of repeated attacks of faintness or "sinking" sensations in the mornings or at work. Profuse sweatings, described as "frightful" or "cruel," are a prevalent source of annoyance, and there may be sensations of coldness possibly confined to one part, such as the knees, legs, or chest. These phenomena may be referred to vasomotor disturbance. The sweat is observed to be of a greenish colour by its staining the undershirt green, and the same colour may be noticed in the gray hair of old workmen and in the palms of the hands, as well as in the "chlorotic" complexion previously alluded to.

Itching skin eruptions, acneiform or eczematous, are found in various parts of the body, such as the face, neck, shoulders, interscapular region, abdomen, or legs, but itching may be complained of without any visible eruption.

Whether brassworkers are peculiarly liable to certain specific diseases is a question that can be settled only by wide statistical research. Phthisis, for instance, is said to be exceptionally common among this class of operatives, and this is possibly true; but there is no doubt as to the prevalence of pulmonary fibrosis, occurring as the result of the chronic bronchial catarrh from which nearly all the victims of brass poisoning suffer.

Writing in 1887, Hogben says:

> It has been asserted that brassfounders suffer from a definite form of paraplegia. The precise nature of this symptom I have been unable to ascertain, but I believe there is to be seen an unusually large number of nervous disorders among brassworkers.

The real nature of this paraplegia was probably described in the following year by Dr. Suckling in his notes on a couple of cases of ataxic peripheral neuritis.[3] These cases resembled locomotor ataxy without the Argyll-Robertson phenomenon, and were shown by Dr. Suckling to be a variety of multiple neuritis in which paralysis is preceded by inco-ordination. At that time Dr. Suckling had met with only four instances of this condition among brassworkers, and I am not aware if the experience of the last eleven years has enabled him to establish the theory that this is a form of neuritis indigenous to workers in brass.

In Hogben's time paralysis agitans was believed to be common amongst this class, but Hogben himself said he had never seen a case of true paralysis agitans in a brassworker.

DIAGNOSIS.

The main features in the diagnosis of chronic brass poisoning are, in the early stages, anæmia accompanied by excessive debility and nervousness, with neuralgic pains, occurring in persons engaged in brass occupations and showing a green line at the bases of the teeth; in later stages, emaciation, tremors, cold sweatings, cough, extreme weakness, and greenish pallor, with the aforementioned dental line, occurring in similarly occupied individuals.

I understand that not a few cases of lead poisoning are notified from Birmingham as occurring amongst brassworkers; and while it must be conceded that lead is occasionally used as an adulterant of brass, still it is hard to believe that its employment in this capacity is so general as to lead to a noticeable production of plumbism. One process in the "putting together" (of gas fittings, for instance) consists in the application of white lead to the joints to prevent leakage, and in this department it is probable that most of the true cases of plumbism arise; but it is not unlikely that occasionally illnesses are reported as due to lead, which in reality are instances of chronic brass poisoning. Symptoms of anæmia, colic, constipation, dyspepsia, and general emaciation are common to both, but the absence of the blue line upon the gums, and the presence of the distinctive green line on the teeth are sufficient to decide in which category the case must be placed.

CAUSATION.

Brass, as is well known, is an alloy of copper and zinc in the proportion of about 3 to 1. Why, then, should the toxic effects produced by the manipulation of this alloy be referred to as brass poisoning instead of specifying the particular element responsible? Simply because that element has not been conclusively ascertained. Greenhow, in describing the acute manifestation of "ague" occurring amongst founders, attempted to demonstrate the culpability of zinc, and in this he is supported by the French observers Blandet and Bouchut;[4] but a number of cogent reasons were adduced by Hogben, chief among them being that "the malady is not observed in operatives such as galvanised-iron makers, who work with molten zinc and are exposed to its fumes, clearly showing that the zinc is not the prime factor. He held strongly to the opinion that the offending ingredient was the copper, arguing from the close resemblance between the symptoms of poisoning by that metal and the symptoms of poisoning by brass, as pointed out by Thackrah and Claude Bernard. The copper hypothesis is accepted by Dr. Simon, Tardieu, Rayer, Grisolle, and Chevallier. Whilst admitting as a practical certainty that brass poisoning is essentially

copper poisoning, we must not commit the error of altogether ignoring the zinc. According to Stevenson there is a close relation between the effects of copper and zinc on the human economy, while both Bouchut and Schlockow (quoted by Arlidge) describe symptoms not unlike those of brass exhibited among the makers of oxide of zinc. It is quite conceivable, then, that the zinc may to some extent act as an adjuvant to the copper, or modify its action. The green line on the teeth has been ascertained to be due to the presence of copper, and in like manner the green colour of the perspiration may unquestionably be attributed to the presence of the same metal, as well as the peculiar "chlorotic" complexion, and it is probably also present in the urine and saliva.

Absorption seems to take place principally, if not entirely, through two channels: the respiratory and the alimentary. The atmosphere in which the artisan works is laden with finely divided particles of brass, which may be seen scintillating in the sunlight. The finest of these are constantly being inhaled into the bronchi, where, in course of time, probably by purely mechanical irritation, they set up a condition of chronic catarrh which may eventually end in fibrosis of the surrounding lung tissue. The larger particles of triturated brass, being arrested at their entrance into the respiratory passages, are deposited on the naso-pharyngeal and laryngeal mucous membranes, inducing a catarrh of those parts with a metallic taste; and thence, by the process of swallowing, they find their way into the stomach and intestines, become converted into soluble salts, and are absorbed through the lacteals into the general circulation. In addition, a fruitful source of alimentary poisoning is the handling and eating of food with unwashed, brass-contaminated hands.

Arlidge ascribes the eczematous eruptions to the contact of the skin with brass dust and sand, but I think they are just as likely to be caused by the copper salt or salts dissolved and excreted in the sweat. In one case of well-marked brass poisoning that came under my observation, the patient complained of an eruption in the interscapular region; examination of the part revealed a patch of artificial eczema which corresponded exactly in shape and situation to a green perspiration stain upon the undershirt. The irritative action of these salts upon the cutaneous nerve terminations is shown by the itching which is complained of, even when no eruption is visible.

Analysis of the occupations of patients goes to show that brass poisoning as a definite complaint is mainly to be found among persons engaged in processes bringing them into contact with brass dust, and that the degree of their liability is proportional to the amount of dust produced. Thus, we find that the victims are most frequently turners, polishers, and filers, whose occupation visibly permeates the air with fine metallic particles, whereas press-workers, chain-makers, etc., are by no means so liable. Casters are not exempt from the chronic form of the disease; they may contract it through repeated inhalations of the fine powder composing the "smoke" from the melted metal. It is puzzling at first to understand how individuals employed in the warehouse can be attacked, until it is remembered that "warehouse" is the term applied to the place where the unfinished articles fresh from the crude processes, and still more or less dusty, are stored.

Treatment.

As regards the administration of drugs, the first thing that suggests itself is to treat this condition, on the analogy of lead poisoning, with potassium iodide. This I had done for a considerable time without perceiving any appreciable benefit, and I afterwards learnt that Hogben had employed the same remedy on the suggestion of Dr. Suckling. I was further surprised to find in Dr. Simon's paper the following statement in reference to the various manifestations of brass absorption:

> There is nothing distinctive about any of these disorders except the obstinacy with which they resist ordinary methods of treatment, and the readiness with which they yield to the administration of iodide of potassium in combination with the other drugs indicated by the various conditions of ill-health.

Either my efforts were not sufficiently persevering, or my choice of adjuvants was unfortunate; but at any rate I found no salvation in potassium iodide, and cast about for something more effective, trying various agents but finding none satisfactory. At last an empirical idea occurred to me. Remembering that sulphate of copper is recognised as the antidote for phosphorus poisoning, I wondered whether phosphorus might in some way exercise an antagonistic influence on copper. According I began treating my cases of chronic brass poisoning with pills containing $\frac{1}{30}$ gr. of phosphorus three times a day. The results exceeded my expectations; the patients became rapidly well. In most cases it was not even necessary for the sufferer to desist from work; he could go on manipulating brass, and still under phosphorus administration speedily recover.

After a time I tried, for a change, dilute phosphoric acid—15 minims three times a day—and the results were even more encouraging. The only explanation I can offer for this is that phosphorus when ingested becomes converted partly into phosphoric acid, and it may be that only this part is effectual, so that a certain amount of economy is exercised in giving the acid direct. At the same time it must be admitted that cases occur which react better to the pure phosphorus than to the phosphoric acid.

Space does not permit a detailed account of the treatment of individual cases, but I may state generally that the results of this treatment have been remarkable, patients as a rule reporting at the end of a week that they are "much better," at the end of a fortnight "a great deal better," and in three weeks' time either quite well or nearly so. Under phosphorus or phosphoric acid the anæmia with its attendant discomforts gradually disappears, the digestion improves, the tongue becomes clean, and the headache, neuralgic pains, and nervousness pass away. The complexion assumes a healthier aspect, strength returns, and the patient begins to put on flesh. Even the cough and catarrhal symptoms subside; there are no longer troublesome sweatings, the skin eruptions clear up, and the green line on the teeth vanishes without the aid of a toothbrush. How far the treatment might succeed in the case of an ataxic neuritis I am not in a position to say.

When prescribing the pill it is advisable to order also some harmless mixture as a "placebo" to satisfy the well known craving of this class of patient for "a bottle of medicine"; the nature of this mixture is immaterial. When phosphoric acid is given it can be prescribed practically alone, with only a little compound tincture of cardamoms to colour and flavour it.

The only matter of diet that need be referred to is the importance of milk as a beverage, it having acquired a wide reputation as a corrective to the influence of brass.

Considering the difference in susceptibility of different individuals to brass poisoning, it is well to advise anyone who shows symptoms either to change his occupation entirely, or at all events to endeavour to get transferred to some other department of the works.

Prophylaxis.

The prophylaxis of brass poisoning is practically identical with that of plumbism, and to that end I think it would be a step in the right direction if this complaint were included among the diseases notifiable under the Factory Act (1895, Section xxix). Means could then be taken to ensure efficient ventilation, and to see that measures were introduced to enforce personal cleanliness and to prevent the consumption of food in the workrooms. Methods might even be invented to prevent the dissemination of brass particles through the atmosphere, and to provide that all water drunk on the premises should be acidulated with a small proportion of phosphoric acid.

References.

[1] *On the Diseases of Occupation*, p. 443. [2] *Medical Jurisprudence*, 4th edition, p. 320. [3] British Medical Journal, 1888, ii, p. 1334. [4] *Annales d'Hygiene Publique*, xxxiii, xxxiv, and xlvii.

A Roman Professor's Silver Jubilee.—On May 3rd the completion of the twenty-fifth year of teaching by Professor Luciani, Rector of the University of Rome, was celebrated in the Physiological Laboratory of the University. The theatre was crowded with admirers of the well-known physiologist, conspicuous among whom was Professor Baccelli. An address was delivered by Professor Todaro, to which Professor Luciani, who was much moved, replied. Professor Baccelli also spoke, and ended by embracing Luciani, who was the object of enthusiastic congratulations from the assembly.