We may now come to the prognosis and treatment of dilatation of the heart at a period when it has not given rise to the serious consequences just described, and an enormous degree of dilatation may be arrived at before such effects are developed.

As regards physical signs, the most important evidence will not be as to the actual size of the heart, but as to the strength remaining in its walls. A greatly dilated heart which is capable of giving a recognisable apex beat and fair impulse of right or left ventricle is more to be trusted than one which has apparently undergone less change in its dimensions, but the movements of which can scarcely be felt at all. There is always a possibility that degeneration may enter into the causation of the symptoms. It is better, again, that the sounds should be strong than weak, spaced than approximated, and it is important that the second sound of both ventricles should be well marked. Irregularity of action is, according to my experience, of less consequence than frequency, and I have learnt not to attach serious importance to the regular alternation of a strong and weak beat, so long as there is no great frequency with it.

The pulse is of importance chiefly as an indication of the vigour with which the blood is propelled into the arterial system. Dilatation of the heart presupposes high arterial tension at the time of its production, and it is a favourable sign that a certain degree of this tension persists. When we find a short, small, low tension pulse, unless this is the result of treatment, it means that the heart has not sufficient strength to maintain the pressure in the arteries.

The probability of improvement or of prolonged immunity from ulterior consequences will next depend on the general condition of the patient, on the soundness and nutritional vigour of his tissues and organs, and especially of his blood-vessels; if he is weak and anæmic, on the cause and character of the impairment of health—whether it is inherent or accidental, whether, in effect, it is remediable or not. When the state of the heart and of the general health is attributable to alcoholic or other excesses, including the abuse of tobacco, to habits or mode of life or external conditions adverse to health—whether or not the patient is willing and able to renounce his self-indulgence, and relinquish his vices, or alter his ways and surroundings. Considerations of this kind are of the utmost importance, but there is not time to enlarge upon them here.

When we come to consider the treatment of cardiac dilatation in this stage, the first question to be asked is, What object may we venture to set before ourselves? What assurance can we give our patients? Can we ever reduce existing dilatation? Can we even arrest the tendency to increase, and avert or postpone the evil consequences? To no question can we return a more confident answer. Every day we see dilatation reduced in some degree in favourable cases, and, at the worst, much can be done to prevent the development of its ill effects. It has already been stated that in the acute aggravation of dilatation which gives rise to symptoms, the apex and extreme limit of dulness may be seen to return towards the normal position day by day, and the well named "curable mitral regurgitation" of Dr. George Balfour is a form of dilatation incident to anæmia.

The means to be taken are in the first place the removal of any recognised cause in the habits, mode of life, and surroundings so far as this is practicable. Next, to improve the general health by favourable hygienic influences and by suitable remedies. The amount of exercise to be taken will be a most important question, but no rule can be laid down applicable to all cases. Speaking generally, exercise is good, and whatever amount of walking can be done without breathlessness or exhaustion, and especially with enjoyment, that will be safe and beneficial, and, provided due prudence is exercised, walking up hill need not be forbidden. It is injurious as well as cruel to insist on an amount of exercise which distresses the patient. The exercise should be regular and daily, not spasmodic with intervals of inaction. A walk may be taken day by day with advantage which, taken only once a week, would be injurious. The exercise, again, should not come immediately after food, and it is better taken early in the day than in the afternoon or evening. A walk into the City, for instance, might do good, when a walk back after the day's work would do harm.

In some cases the treatment may have to be begun by actual rest in bed for two or three weeks, perhaps with massage, and the patient may have to resume exercise with just the same caution as food is resumed after hæmatemesis from gastric ulcer.

The question will now come before us whether we should recommend the systematic graduated walking up hill at high altitudes known as the "Oertel" treatment for heart disease. In my judgment the idea is good, inasmuch as many people will submit to and carry out strict regulations, to which a certain amount of mysterious virtue is attached, who will not obey common sense instructions. I doubt very much whether any good will be done in fatty degeneration of the heart. Fatty overloading of the heart in connection with obesity, and some cases of early dilatation will be benefited, and an enormous number of imaginary cases of heart disease will be cured; the class of patients who come to us saying they have heart disease will be attracted by the treatment. A few patients will be killed.

But it is not always possible either to modify the patient's life in such a way as to put an end to the conditions which tend to produce and aggravate dilatation of the heart, or to secure for him all the desirable hygienic influences. It would be useless, for example, to recommend a city clerk to relinquish the sedentary occupation which is his only possible livelihood, and little less vain to order a lady who has never walked in her life to take regular exercise. We can, however, do much to keep down the arterio-capillary resistance or high arterial tension, which plays such a fatal part in the production of dilatation of the heart; we can regulate the diet and warn against habits and occasions which are injurious, and, by securing efficient and continuous elimination from the liver and bowels, we can often make just that difference which is required for the safety and comfort of the patient. This can usually be effected by an aperient pill, containing a small dose of one or other of the appropriate mercurial preparations, taken twice a week, and we must not be afraid to order patients, whose hearts have given way under protracted arterial tension, to go on with such a pill for years. Tonics of various kinds may be given with advantage from time to time with acids or alkalis. It is not often that digitalis or remedies of the same class will be required continuously, though they may render service occasionally.

GOULSTONIAN LECTURES

ON

LEAD POISONING IN ITS ACUTE AND CHRONIC MANIFESTATIONS.

Delivered at the Royal College of Physicians of London.

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LECTURE III.

Channels by which Lead is Introduced into System.—Respiratory and Digestive Organs.—Digestive Experiments.—Saliva, Gastric Juice, Bile, Pancreatic Juice.—Experimental Production of Lead Poisoning: Pathology.—Relationship of Gout and Lead Poisoning.—Treatment.

LEAD gains entrance into the human body by the skin, by the lungs, or by the digestive organs. The mere handling of lead in its metallic state develops a peculiar odour, indicating the escape of metallic particles in a state of fine division. It is thus that we seek to explain the wrist-drop met with in leather cutters and type setters. Tancquerel does not admit that any absorption of lead occurs through the skin. I regard the skin, however, as a very suitable surface for the absorption of lead. I have seen lead amaurosis in an actress from the use of cosmetics, and the reason why actors and actresses do not suffer more frequently is, in all probability, owing to the action of the fat in the paste blocking up the pores in the skin. In my own experiments I found that the application

of lead oleate mixed with lanolin to the skin of rabbits more quickly produced symptoms than when lead salts were ingested by the mouth. In two of my patients lead was found by Professor Bedson in the perspiration. If lead is capable of being eliminated by the skin, it must be capable of entering the system by the same channel.

As regards the entrance of lead by the respiratory organs there is no doubt. People who have slept a few nights in newly-painted rooms have suffered from colic. Colic has been experienced by naval officers whose sleeping cabins have been but recently painted. To this circumstance—namely, lead dissolved in a volatile agent such as turpentine—we attributed part of the *colique sèche* noticed on board the French men-of-war. Lead dust disseminated through the atmosphere, whilst entering by the digestive organs, may also pass into the system by the respiratory mucous membrane. The insoluble lead carbonate is carried into the trachea and bronchi, and probably into the air cells of the lungs, but in whatever part of the respiratory passages it is deposited it comes under the influence of heat and moisture; it is moistened by alkaline fluids rich in carbonic acid coming from the lungs, and the lead carbonate is converted into bicarbonate, which is fairly soluble. A similar chemical change in all probability occurs with the fumes of the molten metal. Alderson says that statistical observations have shown that absorption by respiration is more productive of deleterious consequence than any other method of receiving the metal into the system. On this point I offer no opinion.

The chief channel by which lead is passed into the system is the digestive canal. As lead is never present in the blood or tissues to any great extent, we must admit that very little of the poison is absorbed, and that when absorbed it is eliminated immediately by the kidneys and skin, and that the insoluble lead is thrown out in the faeces. That it is eliminated freely by the kidneys is shown by its presence in the urine of lead workers and those who are suffering from colic. Most of it, however, is unabsorbed, as is shown by the infrequency of symptoms in those who are exposed to the metal or its compound.

With the object of determining the chemical conditions under which lead enters the system through the digestive canal, I had a series of experiments carried out for me by Mr. Best—under the direction of my colleague, Professor Bedson, of the College of Science, Newcastle—with basic lead carbonate or “lead white,” as lead poisoning is more frequently due to this compound than to any other. Throughout all the experiments the same quantities of lead carbonate and animal juices were as nearly as possible employed.

Saliva.—During the digestion of starch by saliva in the presence of lead carbonate, we found that less of the metal was dissolved than where saliva operated upon lead alone. The minced tonsils of a dog and carbonate of lead were digested together, but no lead was dissolved, either when these two substances were alone or during the additional digestion of starch.

Gastric Juice. Two double sets of experiments were performed with gastric juice—artificial and natural. The natural juice was obtained through the gastric fistula of a dog, the experiments being performed in test tubes and also in parchment tubes. When lead carbonate was simply digested by the gastric juice for three hours at blood heat, we always found that more or less of the lead was dissolved. These experiments were repeated in parchment membrane with varying amounts of pepsine, but with the same percentage of hydrochloric acid. The greatest proportion of lead carbonate was dissolved when hydrochloric acid was alone. When pepsine was alone present with lead carbonate none of the metal was dissolved. The active agent, therefore, is the acid, and the influence of pepsine is rather to diminish than increase the amount of lead dissolved. The presence of proteid in gastric digestion was found to reduce considerably the amount of lead dissolved—a circumstance to be explained by either the acid of the gastric juice acting upon the lead carbonate, converting some of it into lead chloride—which, as a fairly soluble compound of lead, would unite with the albumens to form an insoluble albuminate—or the acid is first used up in the conversion of peptone, leaving, therefore, the lead carbonate unacted upon, and which, being insoluble, would pass out of the stomach with the chyme.

In all probability it is in the form of lead chloride, which is a soluble and diffusible salt, that lead chiefly passes into the system from the stomach, and the reason why herbivorous animals, such as the rabbit, are not so quickly poisoned by lead as the carnivorous animals, is due to the deficiency of hydrochloric acid in their gastric juice. Chloride or basic acetate of lead, when mixed with albumen, forms at once a dense coagulum, just as mercuric chloride does. Albuminate of lead is a very insoluble and indiffusible compound. Peptone also is precipitated by lead. It cannot be, therefore, either as lead albuminate or peptonate that lead is absorbed from the stomach. When lead is taken into the system by means of drinking water, it is probably in the form of the bicarbonate. This is a soluble salt, and it might pass at once into the system as such from the stomach or be converted first into chloride by the gastric juice. In whatever form lead reaches the stomach, what these experiments have shown is that, during proteid digestion less lead is dissolved than when the stomach is empty. Employers have frequently noticed that it is the ill-fed who suffer, and that if the workers have breakfasted before beginning their toil they practically run no risk whatever. The giving of a free breakfast or the allowance of a reasonable quantity of milk to the workers is likely to postpone or prevent lead poisoning. A few hours' work at a time in a lead factory and frequent meals are the corollaries to be drawn from these experiments, and that no worker should be allowed to enter the lead factory without having first had a substantial meal.

Pancreatic Digestion.—The action of the various juices that normally assist in duodenal digestion, namely, the bile and pancreatic juice, were next examined. When lead carbonate was alone digested with bile a relatively large quantity of lead was dissolved compared with the gastric juice. Bedson and Best found three times the amount of lead dissolved. When bile was allowed to act upon fat at the same time as upon lead less of the metal passed into solution. In order to illustrate what would occur in normal digestion when the acid chyme passes from the stomach into the duodenum and is brought into contact with the bile and pancreatic juice, we first of all digested lead carbonate with albumen in gastric juice for three hours, then bile and pancreatic juice were added and digested for another hour, the result being that the amount of dissolved lead was greater than in ordinary gastric digestion, but was less than in biliary digestion alone.

During pancreatic digestion, either when artificial or natural pancreatic juice was employed, no lead carbonate was found to be dissolved, and this applies to the action of this juice upon lead alone, or when, in the process of digestion, there were also present peptone, fat, or starch. When combined with bile it was noticed that there was an amount of lead dissolved which practically agrees with the effects of bile alone; the experiment also confirming what has already been shown, namely, that during the digestion of food products the amount of lead dissolved is always lessened.

In some respects lead poisoning in animals differs from that in men. Heubel¹ says that it has been found impossible to produce fully-developed lead paralysis in an animal. It is extremely difficult, but an animal, after exhibiting symptoms of paresis, may become paralysed in all its limbs, if only time is given. This occurred in a rabbit which had first paresis, then inco-ordination—so that if the animal was laid on its side it could not rise again—and ultimately paralysis of all its limbs, particularly of its extensor muscles, developed. The ordinary phenomena of lead poisoning are readily induced, but in some animals more quickly than others. The rat is not easily poisoned by lead. Whether this immunity has been acquired—rats having for long been known to gnaw through leaden pipes with impunity—I cannot say. The plan adopted was to give rabbits and rats small quantities of lead with their food—rectal injections of a solution of acetate of lead or of the chloride; hypodermic injections of a 1 per cent. solution of acetate of lead, and the inunction of lead oleate into the skin of the back of the neck, where the chances of the animal rubbing off the ointment by its paws and eating it were reduced to a minimum. In nearly every instance the first effect that was noticed was emaciation and anaemia, both of which were progressive. If, however, the lead was withheld from the food for a day or two the animals soon be-

¹ *Pathogenie und Sympt. der chron. Bleivergiftung*, p. 28.

gan to put on flesh. One or two of the rabbits exhibited a distaste for food. The food consisted of bran mash, and green vegetables principally. Other animals retained their appetite almost to the end. They all drank water greedily. Some remained lively for a length of time; others early lost this natural characteristic, and became dull and apathetic. One or two of the rabbits became extremely nervous and seemed to be afraid of being handled, but did not resent it, whilst another would not allow herself to be caught. The length of time required to develop symptoms of lead poisoning ending in death varied. The shortest period was nineteen days, and this was in a rabbit which had a limited patch of its skin anointed with lead oleate.

In the rabbit that lived the longest blindness occurred, depending upon neuro-retinitis, paralysis of the extensor muscles of all the limbs, and albumen was found in large quantity in the urine. Some of the animals suffered from lead colic—a symptom which was noticed by Heubel to be present in a very severe form in dogs fed upon lead. Rabbits and guinea-pigs alike miscarried when pregnant, and so violent must have been the uterine contractions that in one case the uterus ruptured, causing death of the rabbit. The others died evidently in convulsions. Anæmia, with deficiency of hæmoglobin, early appeared: the blood exhibited a very rapid tendency to coagulate. Popp found in the blood of a man, aged 27, suffering from lead cachexia, that the quantity of fibrin was considerably increased, whilst the blood corpuscles had undergone a diminution. Heubel also noticed this rapid tendency for the blood to coagulate. The decrease of red blood corpuscles generally amounted to 20 to 40 per 1,000 only, so that briefly what occurred in Heubel's case was a decrease of solid constituents of the blood by 24 to 50 per 1,000, a corresponding increase of water, a decrease of red blood cells in the ratio just stated, a decrease of albumen by 4.5 to 7.5 per 1,000, and finally, an increase of the extractive substances and soluble salts.

In the later stages of lead poisoning in animals, just as occurs in man, and particularly where optic neuritis is developed, the pupils are dilated. Constipation was present in most of the animals, but in a few there was diarrhoea. The fæces were generally dark, due to the unabsorbed lead passing out in the form of sulphide. The temperature was, as a rule, normal throughout. In some it rose a few degrees a day or two before death.

On *post-mortem* examination, generally made immediately, I was always struck by the peculiar odour of decomposition which escaped, and also by the physical signs of rapid decomposition. The blood was greatly diminished in each instance, scarcely more than a few drops being detected. Beyond the extreme emaciation, which affected mostly the muscles and the subcutaneous fat, nothing, as a rule, was observed by the naked eye. The small intestines were pale, generally contracted and empty; the large were discoloured, bluish-black, and contained liquid or solid dark fæces. In every instance the left ventricle was firmly contracted as in systole, and completely empty, but the auricles and the right side of the heart were full of dark clot. The lungs were all healthy, with the exception of those of the rabbit that died from rupture of the uterus. In her lungs were several discrete hæmorrhages. Beyond the softness of the walls of the stomach and the presence of a thick layer of tough mucus around the food which lay in that viscus, there was nothing discovered. Beyond pallor there was nothing noticed in the other organs by the naked eye. Microscopic examination of the stomach and intestines, the lungs and the heart, the spleen, brain, and spinal cord failed to reveal anything abnormal. In the liver of animals and in the liver of lead workers there will be found an atrophied, cloudy, or granular condition of hepatic cells, amounting at times to a true fatty degeneration. The columns of cells become irregular and slender, and thus become separated from each other by spaces of considerable size. In nearly all the specimens, both of human beings and ruminants, these spaces between the individual cells and rows of cells were occupied by small round cells. There was an increase of connective tissue elements, derived in all probability from the capillaries or the sheath which surrounded them. In other words, there was an intercellular cirrhosis, not unlike that met with in congenital syphilis.

The kidneys presented alterations not less interesting. In

the early stages of lead poisoning the renal epithelia of the convoluted tubules become enlarged, their protoplasm exhibits cloudy swelling and becomes fatty granular, and they soon break down, their *débris* being found lying in the interior of the tubules. There is, however, not the rapid shedding of cells seen in ordinary cases of desquamative nephritis. It is noteworthy that, whilst the renal epithelia of the convoluted tubules thus exhibit alteration, those of the straight tubules of the medulla exhibit almost no change from first to last. I have observed this early stage of parenchymatous nephritis in girls who have died from lead encephalopathy; it was also observed in rabbits. In addition, there is generally to be detected an increased leucocyte exudation underneath the capsule of the kidney, and the same is noticed around the afferent vessels of the Malpighian glomeruli. This accumulation of small round cells around the entering vessel of the glomerulus is very interesting, as I found it in nearly every instance, and with the alteration next to be described, seemed to me to be uniformly present in lead poisoning. Bowman's capsule becomes thickened and laminated, and the cells composing its internal lining are seen to have multiplied greatly, and to lie in irregular heaps at places within the capsule. The capillaries in the glomerulus are noticed to be at places distended with blood cells, and at others constricted, whilst in not a few the thickened capsule has pressed so completely against the coil of capillaries that they appear attenuated and shrunken.

In addition to the increase in the number of cells lying within the capsule of Bowman, the cells which lie between the coils of capillaries are seen to have undergone extensive proliferation. Where accumulation of leucocytes has occurred around the afferent arteriole of the glomerulus, the cells on the outside of Bowman's capsule are also noticed to have increased in number, and from this as a focus they seem to have penetrated between the neighbouring convoluted tubules, causing a distinct increase in the connective tissue framework of this portion of the kidney. Lying in some of the tubules may be observed homogeneous and granular tube casts. From the first, therefore, I would say that lead poisoning produces an acute parenchymatous nephritis as observed in the cloudy and fatty granular degeneration of the renal cells of the convoluted tube, and concurrently with this, a proliferation of cells around the afferent vessels of the glomerulus, also inside Bowman's capsule, and in the inter-capillary spaces within the glomeruli. After this has existed for a time, a true interstitial nephritis is developed, in which not only is the interstitial tissue increased, but the walls of the small blood vessels are thickened, the walls of Bowman's capsule thickened and laminated, and the glomeruli compressed. As these are, apparently, the primary conditions occurring in the early stages of acute lead poisoning, alike in man and animals, I regard them as characteristic of plumbism.

Lead acts directly upon hepatic cells. Some lead is eliminated, but very little, by the bile, part is deposited in the liver tissue, generally a good deal. Circulating in the blood lead is being constantly eliminated by the kidneys. Thus, owing to the peculiar function which is thrown upon the protoplasm of the renal cells, the cells soon degenerate, and owing to the irritating action of the lead as it circulates in the blood vessels and through the glomerulus there is hyperplasia of the surrounding connective tissue. The strain upon the kidney from the first is great owing to the increased diuresis which is present for a period, but as the disease advances and involves all the elements of the renal tissue, urinary secretion diminishes. So long as the kidneys are eliminating lead the patient runs little risk from poisoning, but when the kidneys become defective the individual is no longer free from all the risks of plumbism.

It is difficult to say exactly how lead acts upon the normal structure of secreting cells. Potter and I found, when amœbæ were brought into contact with a weak solution of plumbic acetate, say from 1 to 10 per cent. solution, that almost immediately the active movements previously exhibited by the organism ceased. The amœbæ at once became suddenly elongated and seemed stiffened, and if carefully watched no further movement would occur. We were able, however, to poison amœbæ only for a period, for if we quickly removed, by washing away, the lead solution with

which the amœbæ had become surrounded, movements would return and the organism would be found active next day. If, however, even a weak solution of lead remained in contact with amœbæ for several minutes, no amount of washing was capable of restoring lost vitality.

How plumbism is brought about in man and animals it is difficult to say. It seems to me that it primarily affects the organs of elimination, such as the liver and the kidneys, and that whatever consequences follow, they are due to the presence in the blood of secondary poisons, arising out of the imperfection of liver and kidney function.

The Influence of Lead upon Metabolism.—Anæmia is an early symptom, and progressive up to a certain stage. It depends rather upon a fault in the formation of the blood than in the disintegration thereof. Most writers have observed a deficiency of urea and uric acid in the urine of those suffering from lead poisoning. In the London hospitals, the administration of a few grains of acetate of lead to those who have been previously exposed to the influence of the metal has been followed by pains of a distinctly gouty nature. I have noticed the association in the North, but it has generally been in subjects with an hereditary taint of lead poisoning. Workmen from the South develop it in the North of England. The natives of the North, though equally exposed, seldom become gouty, even when the kidneys are affected. Gout, as a disease, is not met with in the North with anything like the frequency that it occurs in London. When uric acid is deficient in the urine in lead poisoning, it is not meant to be inferred that it is in excess in the blood. It may ultimately be present in excess in the blood, but this is due to the fact that, under the employment of alkalis, the uric acid, which was retained in the tissues owing to the action of lead, has passed in solution into the blood, and, when present there in excess, passes in excess into the urine. In other words, the measure of uric acid in the blood is the amount of uric acid in the urine; if in the blood it will be thrown out by the urine, and the one circumstance in particular which determines the amount of uric acid thrown out is the alkalinity of the blood. Lead, by diminishing the alkalinity of the blood, as Ralfe has shown, lessens the solubility of uric acid, and must, therefore, diminish its excretion in the urine.

The absence of gout amongst the lead workers in the North of England is a point of great interest, physiologically as well as pathologically. Sir William Roberts has coined the word "uratosis" to designate the precipitation of crystalline urates in the tissues or fluids of the body, and has raised a most important question. "It is not easy," he says, "to believe that lead poisoning produces really and truly the same constitutional diathesis as that which exists in true gout.....the gouty diathesis and lead poisoning, while differing in all other respects, have one tendency or vice in common, namely, the tendency to uratosis." He regards uratosis, therefore, as a gouty tendency, which may be reinforced by lead poisoning, and saturnine uratosis as one in which saturnine poisoning is reinforced by a previously existing gouty tendency. My observations go strongly to support this conclusion. Here I may state the elimination of urea in lead poisoning is diminished, and that this circumstance stands related to the violent headaches complained of by lead workers.

From the analysis of the urine in lead poisoning, we cannot state that any absolute relationship exists between the elimination of urea, uric acid, and lead. Occasionally it would seem, however, as if uric acid and lead stood inversely related to each other. What analyses show is that metabolism is much deranged, and, as nearly all cases of lead poisoning, both in the stages of colic and encephalopathy, exhibit extremely deficient renal function, I cannot but regard many of the symptoms of plumbism as due to the retention in the system of animal poisons, depending upon imperfection of liver and renal function caused by lead.

It is a well-known fact that intemperance and the use of alcohol determine attacks of plumbism. Combemale and François³ found that when they had fed animals up to the point at which nerve symptoms were about to show themselves the admixture of alcohol was always followed, a few hours afterwards, either by indications of great fear or by epileptiform attacks, which would be repeated for two or three

days and then disappear, even though alcoholic intoxication was not suspended. Alcohol was not the only determining cause of these events—fear, a prospect of chastisement, and a simple catheterisation induced them. These observers lay considerable stress upon the influence of drunkenness in causing convulsions in plumbism. In one of my guinea-pigs the administration of small quantities of alcohol with lead in the food undoubtedly precipitated death.

Lead has been found in the brain by many chemists. Its presence in the brain is supposed by many writers to be the explanation of the convulsive seizures and death in saturnine poisoning. Lead-saturated cells would be incapable of high function; in fact, so far as their capability of conduction, inhibition, and volition are concerned, such cells would be practically dead. In not one of my cases was a whole grain of metallic lead found in the brain; I do not think that lead encephalopathy is to be attributed to the presence of lead in the brain, intimately combined as it may be with the protoplasm of nerve cells. One of the worst cases that I have seen was that of C. Y., who was attended by Dr. Inglis, of Hebburn, and in the brain no lead was found on most careful chemical analysis. The absence, too, of albuminuria removes the case from simple uræmic poisoning, but not altogether from the pale of imperfect renal function.

Metabolism is not only imperfectly carried on, but the elimination of waste products is interfered with. Add to this the fact that before the explosive outburst there has been a gradual failure in renal activity owing to arterial spasm—and thus not only are waste products not eliminated, but even the water itself is not removed from the system—and we must admit that, such conditions being present, they are quite capable of causing convulsions. My colleague, Dr. Drummond, has observed perivascular dilation of the small cerebral arteries amounting to varicosity. The most careful microscopical examination of all parts of the brain has hitherto failed to demonstrate the existence of any well-defined lesion. This remark, however, does not apply to the naked-eye appearances of the brain. The surface of the brain is dry and flattened, just as if it had been pressed; the brain tissue is dry, or it is hydræmic; it is firm, as a rule, to the touch, and always extremely pale. Many conditions, therefore, are present at the time when death occurs. A primary poisoned blood, due to the presence of lead alone, or more probably to animal poisons of a much more subtle and dangerous character, and depending upon deranged liver and kidney function, may explain the severe headache which is complained of before the attack; but if the kidneys perform their work well, this and the other symptoms may subside. On the other hand, if the case is progressive, the urine is noticed to be daily becoming scantier—sometimes even it ceases to be secreted—and then, owing to retention of animal poisons, eclampsia occurs.

Treatment.—To the treatment of lead poisoning I have little to add. Preventive measures are provided at all the lead factories, but the workers are frequently careless in regard to them. From the fact that during proteid digestion in the stomach less lead is dissolved, no man or woman should be allowed to engage in any work where lead is handled without first having had a good meal. I shall not deal with the measures that ought to be adopted to correct lead contaminated waters, or as to how the solvent influence of water upon lead may be avoided. To the treatment of lead colic I have but little to add—opiates and belladonna, castor oil and sulphate of magnesia, enemata, external applications and warmth are called for. Paralytic conditions improve but slowly under electrical treatment, sometimes they disappear without ever having had any electrical application at all, iodide of potassium giving, on the whole, the best general results. If the patients are anæmic, iodide of iron will be found useful. Lithia has little influence upon the pains either in joints or muscles, but it steadily increases the amount of urine. For the attacks of acute lead encephalopathy nothing gives such good results, in my opinion, as inhalation of nitrite of amyl, the slow pulse under its influence becomes quickened, the arterial tension is reduced, and convulsions are undoubtedly warded off. In other cases, particularly where there is complete suppression of urine in addition to the convulsions, pilocarpin has been followed by most successful results.

² BRITISH MEDICAL JOURNAL, 1890, vol. ii, p. 1164.

³ *Recherches Expérimentales sur les Phénom., etc., dans le Saturnisme Chronique.*