THE IMPROVEMENT IN NUTRITION AS PROTECTION AGAINST INDUSTRIAL TOXICITY

W. E. CRUTCHFIELD, JR., PH.B., B. OF MED.[1]

THE subject of the increase or decrease of industrial poisonings as related to nutritional deficiency in industry is a field that has been, shall we say, neglected. It is a very fertile field for investigation and one which in the future is likely to achieve a status of vast importance.

Obviously, in any program dealing with this subject, protection of the worker, two methods of approach are essential. The first is the suitable installation of ventilation for removing such materials as dust, fumes, and vapors. This is generally accomplished by safety departments, and today a rather remarkable job has been done, considering the tremendously increased number of individuals exposed to various toxic substances. Acute cases of poisoning in industry are relatively rare. When they do occur, it is generally a function of carelessness on the part of the operator himself, oversight on the part of the supervisor or some person of like authority, or in times like these when we are subject to conditions which are not normal, a combination of these circumstances may be responsible for accidental exposure of personnel to dangerous substances.

The recent incident that occurred in a Kentucky parachute plant where 137 workers suddenly evidenced a rather marked and acute response to carbon tetrachloride may be cited. It was discovered that open bowls of the material had been left standing on the work tables for the purpose of cleaning machine oil from the nylon materials from which the chutes were made. Because of the fuel shortage and necessary conservation of heat, ventilation was reduced; the result was obvious and dramatic. One hundred and thirty-seven workers presented gastrointestinal complaints. As soon as the cause was determined, the solvent was immediately changed to a more innocuous one, notably warm water and soap.

[1] Merck & Company, Inc., Rahway, New Jersey.

Aside from such infrequent occurrence, however, the majority of industrial poisoning cases are of the chronic type and only a certain portion of employees are affected. It is in this group, wherein susceptibility plays such an important role, that the field of investigation should now be concentrated.

Human experience and animal experimentation have established the fact that susceptibility to any toxic substance varies tremendously between the species and even in given members of the same species. This variation is rather the rule and not the exception.

It has also been demonstrated that man, in general, is more susceptible to almost any toxic substance than any given type of animal. Public health studies in various occupations by industrial physicians and other industrial personnel indicate that individual resistance to poisoning varies quite widely, with age, sex, physical type, and, of course, general health. Perhaps if there is such a thing, the one common denominator is the nutritional status of the employee.

The importance of adequate and well-balanced nutrition on maximum work production, mental and physical alertness, nervous equilibrium, and general well-being, is becoming recognized, but it is only lately that it has become prominent. Its bearing on resistance to toxic environment has not yet been sufficiently investigated and certain deductions must be made largely by analogy. For example, it is well known that general undernourishment or a deficiency of some vital element of nutrition increases fatigue, and it certainly increases the susceptibility to infection. I do not feel that it is a long jump from this demonstrated fact to the assumption that such nutritional deficiencies increase susceptibility to toxic exposures.

This deduction has a certain amount of scientific background in animal experimentation and certain empirical evidence has been found in human beings. In many instances some particular element of nutrition has been shown to have a specific effect on the action of toxic substances, either increasing or decreasing their action within the body. This is exemplified by the various experiments, the

results of which you have seen, dealing with the addition of casein and riboflavin to the diets of rats. I have in mind a very dramatic experiment wherein the addition of these elements to the diet had a profound protective effect against the carcinogenic action of certain of the dye products, the dimethylaminoazobenzene and other nitro compounds, which have produced, experimentally, tumors of the liver.

High-fat diets in vitamin C deficiency are known to lower the efficiency of the liver too, and to render individuals suffering from such a complaint much more susceptible to such poisons as trinitrotoluene, which seem to have a specific effect on the liver. Certain other poisonous substances which are encountered in industry, notably benzol, a widely used compound, act more or less on the blood by destroying the red cells, and the effects are very dangerously increased in individuals who show some evidence of anemia, this certainly is a function of nutrition in many instances.

Diets low in protein, and a lack of iron, generally speaking, are essentially inadequate in maintaining the normal blood constituents. It is particularly important in those individuals who in industry are being depended on to do a specific job and do it well.

Although the study of diet with relation to industrial poisoning is certainly in its infancy, there are a number of reports in the literature which show the effective use of food, both experimentally and clinically, in the prophylaxis as well as the treatment of poisoning.

More than a decade ago, Lamson (1) and his co-workers found that dogs fed on normal diets tolerated well very large doses of carbon tetrachloride. When the calcium content was reduced by withholding bones from the diet, the dogs developed in a relatively short time tetanic convulsions, gastrointestinal distress, hemorrhages, vomiting, retention of urine. Upon restoration of bones or calcium in some other form to the diet, these symptoms disappeared, and carbon tetrachloride in the previously administered dosage was tolerated quite well by these animals.

Similar symptoms, unquestionably, develop in humans. Consequently, the dietary regime for industrial persons who might be exposed to compounds such as carbon tetrachloride by inhalation of the fumes should have their diet rather well supervised.

In the Kentucky incident that I mentioned a moment ago, blood serum estimations on sixteen of the patients with symptoms of poisoning showed that in 50 per cent, or eight of these individuals, the serum calcium was well below the normal. The attending physicians recommended that the persons unavoidably exposed to such a compound be given a quart of milk a day in addition to their regular diet to increase their blood calcium level. They were also asked to avoid greasy foods, oily laxatives, and particularly to avoid alcohol, which apparently increases the toxicity of carbon tetrachloride and such substances.

Calcium is also a very important factor in poisoning from hydrofluoric acid. This substance is encountered in various industries, such as bleaching, dyeing, brewing, the manufacture of insecticides, and in the finishing of decorative glass. When hydrofluoric acid vapor, or fluorine gas, is inhaled, it acts more or less as a protoplasmic poison and also interferes with the normal metabolism of calcium. The most common clinical symptom resulting from calcium deficiency is, again, tetany; death has resulted from massive exposures. Chronic symptoms are loss of appetite, anemia, eczema, conjunctivitis, muscular cramps, and in individuals and animals exposed to moderate quantities over long periods of time, a change in skeletal structure resembling a type of osteosclerosis or exostosis.

In this country to date, we have had no outstanding examples of fluorine exposure and subsequent exostosis, but in cattle that have grazed continually through a good portion of their life span in the vicinity of a foundry where the flux used contained a large amount of cryolite, x-ray examination revealed a porous structure of the mandible. This was due to the amount of the material ingested with their grazing food.

Treatment of this type of poisoning or prophylaxis where exposure is inevitable, certainly should include the dietary intake of extra calcium in the form of milk or calcium lactate by mouth. Dietary calcium also plays a rather important role in lead poisoning. Lead enters the system chiefly by way of nose and throat, by inhalation, where it is absorbed from the lung in the circulating blood. It has an injurious effect on the capillaries, red blood cells, and nerve tissue. Eventually much of this circulating lead becomes stored in the long bones in the form of tertiary lead phosphate, where it does relatively little damage. The remainder is excreted by the kidneys. The storage and excretion of lead appear to be controlled by the calcium metabolism. If the patient's diet has a high calcium content, lead is deposited in the bones, immobilized, so to speak.

In cases where some systemic change causes a demobilization of lead and its return to the circulating blood, acute poisoning symptoms appear. Some things which might effect the mobilization of lead are administration of thyroid extract, low calcium diet, acute infection, or anything having a tendency to promote acidosis.

In the treatment of acute lead poisoning the administration of calcium intravenously and orally is essential and chronic cases should be placed on a diet rich in calcium and given about sixty grains of calcium lactate daily by mouth. Nutritional prophylactic treatment for workers exposed to lead, even at its irreducible minimum concentration, is essentially the same as that for preventing rickets; that is, a quart of milk daily, a tablespoonful of cod liver oil or vitamin D in some other form. This regimen is usually sufficient to maintain a calcium balance that is definitely positive and reduces the appearance of this condition markedly. Milk, as a matter of fact, I think can be used most efficaciously in any industry wherein heavy metals are extensively employed and where small particles of these heavy metals might be accidentally deposited in the nose and throat and subsequently swallowed.

Investigators have advocated the administration of vitamin C in

lead poisoning. Now it is true that vitamin C inactivates lead more or less by formation of an ionizable lead ascorbate salt or complex of such a salt in the test tube. Unfortunately, extensive controlled clinical experiments do not bear this out.

Nickel poisoning is an entity which is being seen now a little more than previously because of the wider use of nickel carbonyl, which is sufficiently volatile to be inhaled. Nickel poisoning causes degeneration of the heart, the liver, the kidneys and treatment includes forced elimination through the bowels and kidneys, and placing the patient on a low-fat diet. Although no reference has been found in the literature on the prophylactic use of a low-fat diet in workers exposed to nickel, such a procedure seems to be indicated and is one which might be used very effectively.

Benzol and its compounds are very important sources of poisoning. Their fat-solvent properties permit a very rapid penetration into the blood stream and subsequent concentration in the bone marrow and the brain, with destruction of the red cells, of course, in the bone marrow where they are manufactured.

The blood picture in the early stages of benzol poisoning shows anemia, leukopenia, thrombopenia, and diminished clot retraction. Clinical symptoms include nausea, vomiting, headache, dizziness, weakness, and hemorrhages from the mucous membranes, or into the skin in the form of purpura. Women appear to be much more susceptible than men and, if pregnant, exposure to benzol tends to promote abortion. According to Seyfried (2), nutritional deficiencies, especially in vitamin C and riboflavin, and obesity, cause greater susceptibility to the aromatic hydrocarbons. Administration of vitamin C is said to correct the hemorrhagic tendency. Moreover, experiments on guinea pigs conducted by Demole (3), of Basle, have shown that chronic benzol poisoning inhibits the normal storage of vitamin C in the adrenal glands and the liver and increases the vitamin C requirement. Meyer (4) has observed a deficiency of vitamin C approaching scorbutic levels in human cases

of benzol poisoning. Hence, a greatly increased dietary intake of ascorbic acid by exposed workers might be useful as a prophylactic measure. Other nutritional factors which have been found beneficial are liver, iron, calcium, lactoflavin in the form of whole milk, and yeast.

Among workers in nitrobenzol and other nitro compounds of the benzol homologues, poisoning results from inhalation of the vapors and absorption of these compounds through the skin. These chemicals act chiefly by causing a type of decomposition of the red blood cells and formation of methemoglobin which produces a secondary anemia similar to that seen in carbon monoxide poisoning, or intoxication. Exposed workers should by all means avoid fats, milk, and especially alcohol, all of which increase the absorption of the toxin into the tissues.

Poisoning by TNT, popularly manufactured in practically every section, constitutes a very large hazard and appears to be influenced somewhat by diet. Experiments with rats have shown that severe symptoms and pathologic lesions result from this substance when the animals are given a ration high in fat, whereas the effect of the exposure to TNT was decreased by very high carbohydrate rations and was found to be almost nil in high protein diets. A reduction of hemoglobin in the blood and fatty infiltration and necrosis of the liver are among the severe effects produced on a diet with a high fat content.

The effects of trinitrotoluene poisoning are very similar to this in man. This is borne out by an examination of Finnish munition workers, reported by Noro (5) who showed that the blood levels of vitamin C in about half of the cases of TNT poisoning were notably low. He recommended a treatment which included a high-carbohydrate, low-fat diet, with additional protein and vitamin C and B complex.

In 1942, Dr. Foulger (6) studied the prophylactic effect of administration of 100 mg. of vitamin C daily to workers exposed to

TNT. He found indications of a beneficial effect of this type of treatment.

The much higher incidence of this form of poisoning reported among munition workers in England may be due in part to the notoriously poor diet of the English working man since the outbreak of the war. British investigators have suggested the use of a diet augmented with protein as a prophylactic measure in workmen under this exposure, but no reports as to the effect of this type of regime have as yet become available.

There is a certain relationship between exposure to carbon bisulfide and vitamin B_1. It has been demonstrated by Lewey, who found a remarkably diminished urinary excretion of thiamine in viscose rayon workers who were chronically exposed to carbon bisulfide vapor. Chronic poisoning may affect all parts of the nervous system, both central and peripheral. These effects may be due to thiamine deficiency resulting from liver damage and also to direct poisoning of the coenzymes of nerve metabolism and of respiration.

At any event, treatment with massive doses of vitamin B_1 rapidly improved the peripheral nervous symptoms and Lewey recommends meals very rich in vitamin B be provided by cafeterias of plants using carbon bisulfide, and the same advice might well be extended to plants using other industrial solvents, almost all of which have a damaging effect on the central nervous system.

Another compound, tetrachlorethane, an organic solvent used almost universally, and particularly in connection with war production, is responsible for a large amount of the industrial toxicity that is seen. Inhalation of its vapors and absorption through the skin may cause severe symptoms and one fatal case has been reported as a result of direct contact with the substance. The predominating symptoms may be related either to the nervous system or to the gastrointestinal tract. Common manifestations of the nervous form are abnormal perspiration, twitching of the facial muscles, disturbances of the motor and sensory reflexes, particularly in the

extremities. The chief effects on the gastrointestinal tract are anorexia, vomiting, nausea, jaundice, a hemorrhagic tendency, and in some cases the appearance of acites. In six nonfatal cases reported by Coyer (7) in 1944, treatment included the administration of vitamin K, injections of liver extract and glucose, and a high carbohydrate diet. Alkaline drinks and fruit juices were given freely. The treatment seemed to be very efficacious.

Wilson and Brumley (8) observed twenty-five cases of intoxication in varying degrees, among 1,000 persons exposed to tetrachlorethane. The substance appeared to act directly on the liver rather than on the blood cells, and the icterus index is now believed to be the earliest method of detecting this type of intoxication. Persons in the older age groups, obese individuals, and the colored were found to be especially susceptible to this form of poisoning. A high-fat diet appeared to be a very prominent factor in susceptibility. The authors recommended the distribution to exposed workers of printed diet instruction lists, recommending a reduction of fat consumption with an increase of carbohydrates, proteins, and vitamins, and the avoidance in all instances of alcohol. The cases reported were treated with intravenous glucose, liver, and iron for the anemia, and multiple vitamin capsules, and they did well.

Selenium is a compound which is beginning to come to the front now as an offender. It has been rather widely studied in South Dakota, where this substance is present in the soil and consequently present in substances grown in the soil in such abundance as to render it toxic to animals and to some extent to human beings. Selenium poisoning may constitute an industrial risk in the refining of copper, lead, zinc, in which the substance is often present, and also in the roasting of pyrites, and the making of lime and cement. Compounds of selenium are used in the manufacture of glass and ceramics, vulcanization of rubber, and various other processes. The substance is also an essential element in the making of the photoelectric cell.

Selenium poisoning has been investigated chiefly in animals. The most constant symptom is a progressive anemia with degenerative changes in the liver. Feeding experiments in rats have been made to determine the relationship of diet to the severity of symptoms. Vitamins A, D, and the B complex were found to have no beneficial effect; crystalline vitamin B_1, as a matter of fact, greatly intensified the symptoms in every case. Cystine, likewise, proved to be ineffective. Rations containing a high protein content have produced the best prophylactic results. From various reports, it would appear that the proteins of casein are the most beneficial. It has lately become apparent that the addition of the amino acid, methionine, to a diet low in calcium has an equally favorable effect and is one that should be borne in mind.

It has been pointed out by Reed and Harcourt (9) that most of the soluble selenium compounds are capable of producing acute and chronic symptoms in man, either through inhalation, skin absorption, or by way of the gastrointestinal tract. Whatever may be the mode of entry, they give rise to gastrointestinal symptoms, irritation of the nose and throat, and a metallic taste. The diagnosis of selenium poisoning in all instances may be confirmed by the finding of this compound in the urine. A high-protein diet is urgently recommended in the treatment, and while, again, I have seen no reports of its use as a prophylactic among the industrial personnel, such a diet, preferably rich in casein, certainly appears to be indicated.

Rösing (10) has reported the beneficial effects of a general improvement in nutrition among arc welders in Germany. After a study of the high incidence of gastrointestinal disorders at the Krupp Works, he concluded that the causative factor was the inhalation of metallic fumes in the process of welding, an entity which we are becoming acquainted with in this country. Such exposures in confined spaces, when the workers refuse to wear protective masks, give rise to the symptom complex of acute gastric pain, nausea, and vomiting known as "fume fever."

In the prophylaxis of this condition, the importance of a good diet is stressed. Warmed-up food, poor in vitamins, cold drinks, the excessive use of tobacco and alcohol, all contribute and were considered as one of the prime conditioning factors. In some industries, welders have been given soup, gruel, or milk, during working hours, with excellent results.

The need for improvement of diet among industrial workers as a whole has been demonstrated sufficiently in numerous surveys and studies, both by groups and individuals, and I have particular reference to the work done by Dr. Borsook, Dr. Alpert, and Dr. Keighley (11) among the aircraft workers in Southern California, and by Dr. Goodhart, who has done so much work among the industrial personnel in the East. With such data as we have in mind from these sources, it is hoped that further attention may be directed toward the nutritional needs of employees in those industries which present such specific and special hazards. I think that it is fairly obvious that certain of these conditions may be greatly ameliorated by protective diets, designed in accordance with specific needs for these compounds. It is becoming very increasingly apparent that the approach and solution to this problem can only be done through groups, or a group such as your own, and industry has become dependent on you.

Too many of the larger industries in this country are not sufficiently aware of the hazards or are not willing to allocate funds to maintain a laboratory or department with facilities for studying the nutritional status of the personnel. Therefore, it obtains that this, at the moment, is about the most fertile field that I can think of for scientific research, particularly with a view to mass improvement of a vital and necessary sort.

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