to be used with the greatest care in all cases of acidosis. In spite of the great relief which follows its use for the paroxysms of nephritis, theoretical considerations, as well as certain observations on patients, would seem to indicate that the drug may be highly dangerous.† The hyperpnea represents the effort of nature to keep the acid concentration of the blood below dangerous limits, and if the respiratory mechanism is depressed by morphine, the compensation may fail, and a fatal acidosis develop.

NOTE.—Between the writing and the publication of this paper a number of articles have appeared on the subject of acidosis. Of these, probably the most important is one by Marriott and Holland,²⁹ who have demonstrated in nephritis a very marked increase in the phosphates of the blood, seeming to indicate, as was suspected, that in many of these cases of the retention type the acidosis is largely due to the failure of the kidney to eliminate the acid phosphate.

† Cheyne-Stokes breathing regularly develops in many patients after even a small dose of morphine. We must regard the recurrent periods of asphyxia in this condition as being harmful.

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CHRONIC CARBON MONOXIDE INHALATION AND SOME OF ITS UNTOWARD RESULTS.

BY WM. J. MCGURN, M.D., BOSTON.

IN all probability there is no other known chemical substance, with which a high percentage of our urban and suburban population is brought into such frequent contact, that has attracted so little attention and yet is so capable of inducing such insidious and widespread destruction of health as carbon monoxide gas.

Several years ago, while engaged in the study of family syphilis, the writer was strongly impressed with the number of obscure nervous disorders that were found to have been associated with the inhalation of either coal or illuminating gas. On investigation it was found that these gases are capable not only of producing many diseases and conditions peculiar to themselves, but also of simulating nearly every disease known to modern neuro-pathology as well as many of the so-called "idiopathic" and "functional" abnormalities.

While it is true that relatively few physicians have recognized carbon monoxide to be an important etiological factor in the development of some of the most profound nervous disorders, it is also true that a most splendid outline of the possibilities of this subtle poison is furnished by an eminent American physician. This most illuminating discussion may be found in Osler's "Modern Medicine" of 1907, and was written by Dr. David L. Edsall, now Chief of Service at the Massachusetts General Hospital. While it is true that Dr. Edsall's article is replete with facts well worthy the attention of every living physician, it is also apparently true that the subject has not been given the respect and universal consideration that it surely deserves.

On careful inquiry, the writer found but one physician (out of more than sixty interviewed) who possessed more than a fragmentary knowledge of chronic carbon monoxide poisoning and no school or public clinic where the dangers of chronic gas poisoning are taught or considered at all, and it is owing to these deplorable facts that the above comment is respectfully offered.

Referring again to the article in "Modern Medicine," the writer wishes to say that while the number of symptoms, diseases and conditions therein mentioned as results of chronic carbon monoxide poisoning are sufficient in number not only to index a small library upon the subject but also to introduce one into the realms of nearly every branch of medical science, the full story of this odorless and invisible gas remains untold; and it seems highly probable that many years will elapse before the promulgation of adequate knowledge regarding its sources and dangers will be universally disseminated.

Realizing that it would be impossible, in an article of this kind, to discuss in detail the multitude of conditions known to be produced by the prolonged inhalation of carbon monoxide, the writer will be content merely to mention a group of symptoms, diseases, and conditions with which he has had to do and, for the sake of brevity, will limit the list to those of which he has had ample opportunity of personal observation and study.

For lack of a better method the symptoms and conditions about to be mentioned will be arranged in alphabetical order and appear under two headings, namely: first, those conditions known to have been caused by carbon monoxide intoxication; and second, those which have occasionally been found associated with the inhalation of this toxic substance but remain of unproven origin.

LIST 1.

Conditions known to have been caused by carbon monoxide intoxication:

Abolition of the deep reflexes.
Akinaesthesia.*
Anaemia.
Angina pectoris.
Ankle clonus.*
Arteriosclerosis.
Asthma.
Ataxic gait.†

Babinski's sign.†
Bronchitis, acute.
Bronchitis, chronic.
Burning and itching of the toes and fingers.†

Cardiac angina.†
Cardiac neuroses.
Catalepsy, simulating that of dementia precox, with apparent recovery.
Central and marginal scotomata of optic disks.*
Chills and fever.
Color blindness, transitory.*
Combined cerebrospinal and peripheral nerve lesions and irritations.
Constipation, chronic.
Contractures of skeletal muscles.
Convulsions, clonic.*
Cyanosis.

Delusions, both transitory and permanent.
Diabetes mellitus.
Diplopia.
Disseminated sclerosis, distinct types of (two cases reported).
Dyspnoea.

Engorgement of retinal vessels.*
Epileptoid seizures.
Exaggeration of knee jerks and other deep reflexes.
Excessive appetite (a very frequent but not a constant symptom).

Fibrillary twitching of muscles.

General weakness.
Girdle pain.*
Glycosuria, sudden and prolonged, transitory.

Hallucinations of sight (nocturnal).
Headache (frontal, coronal, and occipital).
Hemic murmurs (cardiac).
Herpes labialis.
High blood pressure (225 to 300 with return to 140).
Hippus.

Hyperaesthesia.†
Hypersensitiveness to pain.†
Hypochondriasis (so called)
Hysteria.
Hysterical joints (so called).
Hysterical paralysis (so called).

Illusions (varied, nocturnal).
Impairment of pupillary light reflexes.*
Impairment of the thermological sense.*
Impairment of vision (toxic amblyopia).
Insanity.
Insomnia.
Intercostal neuralgia.
Intention tremor.*
Irregular pupils.*
Itching of skin.

Lancinating pains.†
Languor (usually more pronounced in early morning).
Lightning pains.†
Localized anaesthesia.*†
Localized weakness.
Loss of knee jerks and other tendon reflexes.†

Migraine (simulating that of brain syphilis).
Mono- and multi-muscular spasms.
Multiple neuritis, distinct types of.
Multiple sclerosis, distinct types of (two cases reported).
Muscular contractures.

Narrowing of the fields of vision.*
Nausea and vomiting.
Nightmare (shouting in sleep with illusions and optical hallucinations).
Numbness and tingling of extremities.
Nystagmus.*

Oedema of optic disks.*
Optic disk, sectional blanching of.*
Optic nerve atrophy (secondary).*

Pain, excruciating, including every other known character of.†
Pain in head accompanied by tenderness of scalp.
Pain unrelieved by morphia or other heroic treatment.†
Paresthesia (itching, tingling, formication, etc.).
Patella clonus.*
Peripheral neuritis (localized).
Polyuria.
Pseudo angina pectoris.
Pseudo tabes.†

Repeated rigors without elevation of the temperature.

Scanning speech.*
Shrinking and atrophy of muscles.*†
Skin lesions (chronic).
Spastic gait.*
Sphincter control, impairment and transitory loss of.*
Spinal irritations.
Stereognostic sense, loss of.
Sudden changes in temperament, irritability, etc.
Syncope.
Synovitis, chronic.

Tachycardia.
Tactile sensation, disturbances of.
Tenderness of nerves and muscles.†
Tinnitus aurium.
Typhoid state, distinct.
Thyroid enlargement.

Unequal pupils.

Vertigo.

*Seen in cases of multiple sclerosis caused by chronic carbon monoxide inhalation in furnace gas.

†Seen in cases of multiple neuritis caused by chronic carbon monoxide inhalation in illuminating gas.

LIST 2.

Conditions which have been found associated with the inhalation of carbon monoxide but remain of unproven origin.

Aphasia, transitory.

Cancer.
Cerebral Haemorrhage.
Chlorosis.

Haemoptysis (autopsy six years later revealed a moderate arteriosclerosis and carbon deposits in lungs, but no tubercular lesion).

Menière's disease (one case only)

Nephritis, chronic.

While the sources of intoxication in the above-named conditions are almost as varied as the number of cases involved, it may be worth while to mention those with which the writer has had to do, some of which may be of interest to others in making a study of industrial and hygienic conditions.

The known sources from which men, women, and children have suffered the pangs of chronic carbon monoxide poison, in the experience of the writer are: Leaky or imperfectly fitted gas appliances such as flexible gas tubes, permanent metal gas fixtures, gas stoves and gas ovens (improperly regulated), hot water heaters, gas heaters, extinguished pilot jets, and leaky gas meters; also house furnaces (hot-air type) with uncemented fire-pot, house furnaces (hot-water type) faultily installed or with inadequate and improper draughts; coal stoves and ranges with leaky pipes or insufficient draughts, gasoline and kerosene automobile engines, steam-heating furnaces, in schools and other public buildings, with various types of forced draught appliances; also from railroads and factories burning soft coal, bakery ovens and leakage from gas plants and main pipings.

Obviously, the amount of gas that might escape and be inhaled from some of the above-named sources must be exceedingly small; indeed so moderate in amount that there is a tendency on the part of many casual observers to discredit the possibility of such profound toxic and paralytic symptoms being produced by such minute quantities of carbon monoxide; and it is here that the gravest danger, to the individual and to the general public, exists.

While it appears that several physicians who have had to do with *acute* carbon monoxide poisoning have expressed the opinion that "if the patient survives for one week after the exposure, complete recovery usually takes place," and while the writer has ample cause to regard this opinion as an extremely erroneous one, it is a fact that repeated inhalation of very minute quantities of carbon monoxide are far more dangerous to the future health of the individual than one exposure where the patient is rendered fully unconscious.

Several hypotheses have been advanced regarding the rôle played by carbon monoxide in combination with blood elements; and while a number of articles have recently appeared that would tend to place discredit upon some of the older observations that have long been accepted as conclusive, it is highly probable that carbon monoxide does unite in a more or less fixed combination with the haemoglobin of the red blood cells.

The opinion has recently been advanced in a journal of good standing that carbon monoxide is not an actual poison, but acts *solely by asphyxiation* in producing anaemia of the brain and nerve centers with the result that functional disturbances and structural lesions sometimes follow; and an attempt was made by its author to substantiate his theory with test-tube "proof." It would seem that adherence to the sphere of common sense, together with our knowledge of other asphyxiating agents, to say nothing of the facts already proven by many independent observers, should render this theory, bolstered up by observations on blood under conditions not at all similar to those of its natural existence, unworthy of serious consideration.

After prolonged clinical observations on the behavior of many cases of chronic carbon monoxide intoxication (a report on thirty-one cases will follow), the results of which are fully consistent with our knowledge of carbon monoxide haemoglobin as observed with the spectroscope, the writer wishes to express the opinion that CO is a chemical substance capable of a peculiar selective affinity; that it enters into a more or less fixed combination with the haemoglobin of undiluted blood and yet possesses a stronger avidity for certain nerve elements that are not found in other structures of the body; also that when carbon monoxide pervades the general circulation it is *slowly liberated* from its haemoglobin combination and reabsorbed by receptive brain and nerve tissues so that irritative and permanent degenerative changes often result; and that when such irritations and degenerations of the central or peripheral nervous systems are once established, an infinitely small quantity of this gas (one part to two hundred thousand) is capable of aggravating and hastening the retrogressive changes which it has already produced.

In support of the above opinion there is ample and undeniable proof that carbon monoxide, when inhaled in quantities entirely too small to interfere materially with the amount of oxygen carried by the blood, does often produce profound degenerative changes in the central and peripheral nervous systems as above mentioned; also that new signs and symptoms of these changes often continue to appear for weeks after the removal of the patient from all sources of intoxication, and that evidence of its complete elimination from the body is finally recognized in marked improvement of the general health

and in the disappearance of hemic and functional murmurs under proper hygienic environment.

At present (October, 1916) the diagnosis of chronic carbon monoxide poisoning depends upon a definite history or actual knowledge of repeated or prolonged exposures, together with the finding of a group of nerve symptoms compatible with the lesions that it is known to produce, and finally upon excluding the possibility of the said conditions being due to disease or other toxic agent. In chronic poisoning the spectroscope does not show the presence of CO in the blood unless the patient is asphyxiated from an added acute exposure.

The differential diagnosis of chronic carbon monoxide poisoning is chiefly against lead, alcohol, tobacco, arsenic, carbon bisulphide and syphilis. The first four can be excluded by the history, clinical picture, and progress of the case, together with chemical analysis of the blood and urine. The fifth may be excluded by the history and occupation of the patient, while the sixth, syphilis, where a history of an exposure to either is unobtainable, is the most difficult of all to exclude. In such cases the clinician should remember that in carbon monoxide poisoning the subjective symptoms usually outnumber the physical signs, and while the signs of structural changes are often similar to those produced by syphilis they are never quite typical of that disease; also that the signs and symptoms produced by carbon monoxide do not respond to potassium iodide or to any other known medication. In syphilis we have the blood, spinal fluid, and luetin tests, also the time-honored therapeutic test, all of which are of great value in reaching a definite conclusion.

A most perplexing problem is occasionally met with in cases where one condition overlaps the other, the greatest difficulty being to determine which is the chief offender. The question very properly arises as to whether some persons are much more susceptible to carbon monoxide than others. It is safe to state positively that this question can be answered in the affirmative. There are a number of instances in the experience of the writer where a group of four or five persons were exposed under seemingly like conditions with the result that but one out of the party suffered severe, permanent results, while the others escaped with but slight untoward symptoms.

Probably the only efficient treatment of chronic carbon monoxide poisoning will be found in the future development of preventive medicine, while the principal armamentarium will be: 1st—Education of the public to a realization of its dangers. 2d—Rigid inspection of public buildings by men highly proficient in the study of hygiene and toxicology. 3d—More rigid smoke and fuel laws with enforcement of the same. 4th—The abolition of all flexible gas fixtures, forced draught appliances, faulty chim-

ney draughts, basement openings into cold-air shafts connected with hot-air furnaces, and finally, a legal responsibility on the part of contractors for the proper installation of house furnaces and gas fixtures; also the compulsion of property owners to keep all permanent fixtures in occupied tenement houses in a reasonably safe condition.

No doubt the question of greatest importance to those already afflicted is the prognosis, about which there is much uncertainty, but the writer feels that if a diagnosis can be made from the history and subjective symptoms before definite physical signs appear, immediate removal of the patient from all sources of intoxication to a place of better hygienic conditions will finally* result in recovery, but in cases where definite signs or objective symptoms have made their appearance, it is very doubtful if anything like complete recovery ever takes place.

THE EPIDEMIOLOGY OF ANTERIOR POLIOMYELITIS EPIDEMICA, 1916.

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THE following facts are warranted as proving the epidemiology of this disease, being based not alone on the study of 85 reported cases in this city, but upon the neighborhood and house infections for the past two years. During that period I have seen not only all individuals in all houses where any communicable disease or suspected case has existed, but through my system of obtaining examination of a large part of school absentees, I have come in contact with practically all neighborhood illnesses.

In March, 1915,¹ I stated as follows: "At this time true influenza is appearing, manifested in the children that we have seen, mostly as a unilateral tonsillitis, spreading through the members of the family. Less in number are those with central nervous system signs and symptoms. It is of importance to control these to prevent later epidemic incidence, of importance to differentiate them from diphtheria and scarlet fever." In February, 1916,² I showed that not true influenza, but a streptococcal "grip" had been and was epidemic, there being numerous cases of such reported as scarlet fever and diphtheria.³

Since then I have shown⁴ that anterior poliomyelitis was present in this vicinity in two types. The one characterized as a general infection was similar to that prevailing in New York City and in near by towns in this vicinity where I was called in consultation. The following are facts:—

*Usually from three to twenty months are required.