method. Of these fifty-one patients, 33.3 per cent died; in 44.5 per cent the results were classified as good, in 8.9 per cent as fair, and in 13.3 per cent as bad. Clinical union was obvious in twenty-four of the thirty-six patients that survived the treatment, while definite nonunion was present in six. Because of the high mortality, and the high percentage of unsatisfactory results in this particular fracture, it is our belief that some early operative procedure will probably be the method of choice in the future. Dr. M. N. Smith-Peterson of our clinic has devised a three-flanged nail which is very effective. It allows early motion and requires no constricting apparatus to interfere with circulation. It allows the patient to get out of bed in an extremely short time. He has not yet reported this work, but has treated twenty-five cases and so far the end-results are better than in our cases treated by the Whitman method.

DR. KELLOGG SPEED, Chicago: In pelvic fractures one sees immediately that the mortality lies in the complications. For that reason the physical examination and clinical observation of the patient should be done carefully. In a series of more than 300 fractures of the pelvis at the Cook County Hospital in Chicago dating back for some years, our mortality has been between 9 and 10 per cent, never much higher, never much lower. Most of that mortality lay in the complications. Sacroiliac separations are not serious unless there are bladder or urethral injuries, and should be reduced because they lead to the leg pain, backache and disability that require prolonged treatment and rest. I would invite attention to a certain group of fractures of the neck of the femur well reduced, held in Whitman's position, or in any other position one cares to use, in which the neck of the femur after several weeks of proper immobilization begins to dissolve and disappear. An accepted explanation for this absorption is not yet given. It may lie in a change of the p_H of the blood in that situation, or in a change in the circulation which leads to complete absorption and no effort at union in the bone.

DR. G. A. HENDON, Louisville, Ky.: My method of choice in the management of fractures of the long bones and fractures involving the neck of the femur is so diametrically opposed to any that have been presented here that I feel apologetic. I am quite sure that we have all labored under a delusion regarding the susceptibility of bone to infection. Bone resists infection with the same vigor and the same success that fascia does, and there is no more danger in operating on a fracture than there is in operating on a hernia if one does not embarrass the circulation of the adjacent soft tissue. By using a principle that is quite old and a material that is older still, the principle being the relationship between a square tenon and a round mortise, I have been able to make a key that securely locks the fragments of broken bones and retains them in alinement without the aid of external immobilization. By the use of this key, which is made from the cortex of beef bone, I have been able to treat, with uniform success, more than 100 fractures of the long bones without the use of any external immobilizing apparatus whatever, and with infection occurring in only two cases. One patient had diabetes, and in the other there was a serious rupture of operative technic. The method appeals to me particularly in the treatment of fractures of the neck of the femur which occur in people advanced in life. They are pitiful objects when encased in any sort of immovable dressing. The method has been used with success in the treatment of five gunshot fractures involving the humerus and the femur. I have used it in all kinds of compound fractures. There is no fracture of a long bone to which it cannot apply, except a pathologic fracture.

DR. C. E. RUTH, Des Moines, Iowa: I want to call attention to the action of this artificial psoas iliacus. When I make extension with the psoas iliacus taut across the anterior portion of the capsule of the articulation, the muscles act as powerful internal rotators. When the femur is flexed to a right angle with the trunk, the psoas and the iliacus are far above the neck of the femur, but in extension they are in contact. Suppose solution of continuity takes place in the neck of the femur. What happens? Instantly they become external rotators and the soft tissues are forced between the fragments. That is the reason so many surgeons do not get reduction, and when they get what they think is reduction it does not hold. Why operate if one can get a perfect reduction and hold it without operation? We showed that it is possible, if the details of the method we indicated are followed, to produce not a questionable but an absolute and perfect reduction, and the bones can be held absolutely and perfectly reduced provided the anterior portion of the capsular ligament is kept taut. That is the secret of the whole procedure, whether treatment is by the so-called Ruth, Maxwell, Whitman or any other method. But as to the Whitman method, I think it is next in order to this, the method that we use at the present time. Why try to fix an abnormally mobile fractured point against a dozen or more mobile points in the spinal column when the sound leg can be abducted to the limit and an absolute guide secured as to the degree one should abduct the other? They both can be fixed, and they will stay, provided the cast is kept fitting closely about the pelvis all the time. As to the case of Perthes' disease, the epiphysis slipped; it had been five months in slipping without injury. The adjustable footpiece slides on the board with the traction on. If the fracture of the shaft of the femur is just below the trochanters and there is flexion and complete eversion of the short fragments that cannot be controlled, what is to be done, especially if the lesser trochanter is broken off? Of course one has to flex the thigh heavily to get the lesser trochanter as near in contact with its normal place as it can be. If the fracture leaves the psoas iliacus attached to the lesser trochanter there is complete eversion of the upper fragment and heavy flexion, and it is necessary to put the thigh in flexion, abduction and heavy external rotation to the limit to correspond to the position assumed by the proximal fragment that cannot be controlled.

Special Article

THE DANGERS OF CARBON MONOXIDE POISONING AND MEASURES TO LESSEN THESE DANGERS

REPORT 1 OF THE COMMITTEE ON POISONOUS GASES OF THE AMERICAN MEDICAL ASSOCIATION *

DRAFTED FOR THE COMMITTEE BY YANDELL HENDERSON PH.D., NEW HAVEN, CONN.

Poisoning by carbon monoxide is one of the hazards of civilized life that can never be entirely eliminated. It is inherent in the use of fire. Automobiles, city gas, and the use of wood and other inflammable building materials in homes are also now essentials of civilization. But the hazard of carbon monoxide asphyxia which their use involves should be kept as low as practicable. Many of the fatalities from carbon monoxide now could be prevented. There is grave danger that during the next few years the number of these fatalities will be considerably increased.

CONDITIONS PRODUCING CARBON MONOXIDE

Whenever organic materials such as wood, coal, the various products of petroleum and other carbonaceous substances are burned, the combustion tends to take place in two stages. The first stage of the combustion produces the poisonous gas carbon monoxide (chemical symbol, CO). A second stage then produces the comparatively harmless gas carbon dioxide (chemical symbol, CO_2). In the first of these stages each carbon atom of the material unites with one atom of oxygen. The general character of the reaction may be roughly indicated by the equation: $2C + O_2 = 2CO$. In the

* The committee consists of: H. Gideon Wells, M.D., chairman; Yandell Henderson, Ph.D.; Paul Nicholas Leech, Ph.D.; Carey P. McCord, M.D., and L. R. Thompson, M.D. Reports on other topics in the field of its investigation are being drafted by other members of the committee and will be published subsequently.

second stage each molecule of carbon monoxide then unites with another atom of oxygen to form carbon dioxide ($2CO + O_2 = 2CO_2$). If the supply of air to the burning material is insufficient to supply the second molecule of oxygen, or if the temperature of the gas when it reaches the outside air is not sufficiently high, there is no second oxidation. Carbon monoxide is then liberated into the air in considerable amounts.

In a coal fire a slightly different process may occur. If the bed of coals is too deep for air to pass easily, or if the air supply is checked in any way, the combustion in the lower layer of red hot coal may indeed proceed to the stage of carbon dioxide; but this carbon dioxide in passing through the upper layers of coal gives up some of its oxygen, or, rather, it takes up more carbon and forms carbon monoxide ($CO_2 + C = 2CO$). This carbon monoxide can often be seen burning with a pale blue flame above a layer of black coal in a stove or furnace. In this flame some of the carbon monoxide is burned to carbon dioxide ($2CO + O_2 = 2CO_2$), but some usually escapes as the monoxide.

A third mode of formation of carbon monoxide occurs in the gas stoves used for cooking and in water heaters. The manufactured gas supplied in most cities where natural gas is not available usually contains about 20 per cent of carbon monoxide. But even when natural gas consisting of the relatively nontoxic gas methane is burned, carbon monoxide may be produced in the burner itself. This occurs not because of a deficient supply of oxygen from the air but because the flame of the burning gas is chilled when it comes near a cooking utensil or pipe containing cold water. The chilling stops the combustion at its first stage and large amounts of carbon monoxide may thus be produced and liberated. Cooks working over such stoves are sometimes more or less affected by the headache which low grade intoxication by carbon monoxide induces.

Occasionally in closed rooms such a stove or water heater may continue to produce carbon monoxide until the amount is sufficient to cause the death of persons sleeping in the room. When this accident occurs it is commonly explained as "not due to carbon monoxide but to exhaustion of oxygen in the air by the fire," which is found still burning. This explanation, however, is not correct. Both the slight effects and the deaths are due solely to carbon monoxide produced by the flame. If the oxygen were reduced from 21 per cent, the amount in air, to 16 per cent or a little lower, the fire would cease to burn; for 16 per cent oxygen will not support a flame. On the other hand, life is not seriously threatened by deficiency of oxygen until the reduction is about twice as great. In reality all such fatalities are therefore due to carbon monoxide, of which a very low concentration, even a few tenths of one per cent, is sufficient in time to cause death.

It is probable that most of the cooking stoves and heaters in this country in which gas is burned have this defect to a greater or less extent. The defect can be partially overcome by increasing the distance between the orifice of the gas burner and the cooking utensil or water pipe. They should be just above, not in, the visible flame.

In burning buildings, carbon monoxide is produced in large amounts. Although carbon monoxide itself is colorless and nearly odorless, it is the constituent of smoke which chiefly overcomes firemen. Similarly in fires and explosions in mines, particularly coal mines, the carbon monoxide that is produced is often the cause of more deaths than the explosion or fire itself.

In industry there is a rapidly increasing use of carbon monoxide from water gas as the starting point for the manufacture of such substances as methanol.

ASPHYXIATION BY CITY GAS [1]

The chief source of fatalities from carbon monoxide poisoning is city "illuminating" or "manufactured" gas. Natural gas, used in some cities, contains no carbon monoxide; but when the supply of natural gas is insufficient, manufactured gas is mixed with it or is supplied in its stead. Many of the fatalities from manufactured gas are suicides; but in addition this gas is the cause of many unintentional deaths in every large American city. Manufactured gas is produced in two ways: (*a*) by the destructive distillation of coal, producing "coal gas," containing about 7 per cent carbon monoxide; and (*b*) by blowing steam through red hot coal, thus producing "water gas," containing 40 per cent (theoretically nearly 50 per cent) of carbon monoxide. City gas is now usually a mixture of these two products, to which vaporized petroleum may be added, and contains about 20 per cent of carbon monoxide. Statistics show that, when city gas is chiefly "coal gas" and contains only a low percentage of carbon monoxide, the deaths from this cause are few; but when it is chiefly "water gas" and the percentage of carbon monoxide is high, the deaths caused by it are numerous; for instance, more than 500 a year in New York City.

The problem of decreasing the number of deaths from city gas is one not merely of sanitation but also of expense. The public objects strongly to paying more than a minimal rate for its gas. It generally costs more per cubic foot to manufacture gas of low carbon monoxide content than the gas of high carbon monoxide content now chiefly supplied. The difference in cost per heat unit of the two kinds of gas is much less than that per cubic foot. The chief assistance that the public can give toward introducing city gas of higher calorific value and lower carbon monoxide content is to approve and support the fixing of the price of gas on the basis not of the cubic foot but of the heat unit.

There are reasons for expecting that, unless counteracting measures are taken, the number of deaths from asphyxiation by city gas will increase considerably during the next few years. Gas is now used chiefly for cooking. A vastly increased use of gas for the heating of homes is developing. In spite of its greater expense, gas is beginning to displace coal and is competing increasingly with oil for domestic heating. Among the factors contributing to this development are the increasing price of the grades of coal used for heating homes, the demand of thinly dressed women for evenly heated houses, the rise in the wages of servants, and the convenience of automatic control of temperature. The larger quantities of gas that will be needed to heat houses will require higher pressures in the pipes in the streets and the use of reducing valves on the house supply. The seriousness of a break, leak or defective valve will be much greater than at present. Prevention of a corresponding increase in the number of persons and even entire families asphyxiated in their sleep is a problem demanding the most serious consideration.

1. Henderson, Yandell; and Haggard, H. W.: Noxious Gases and the Principles of Respiration Influencing Their Action, American Chemical Society Monograph Series, Chemical Catalog Company, 419 Fourth Avenue, New York City, 1927. Haldane, J. S.: Respiration. Yale University Press, 1922.

There is a possibility that, during the next few years, scientific advances may lead to the manufacture from cheap grades of coal of a gas low in carbon monoxide, high in calorific value and at a moderate price. Still more advantageous from nearly all aspects would be the development of methods for the manufacture of a fairly cheap liquid fuel from coal. Properly used, supervised and controlled, a gas of high calorific value and low carbon monoxide content need not involve a very great increase of fatalities, even when used in the enormous quantities that house heating will consume. Experimental investigation directed to the development of methods for the manufacture of such a gas, or a liquid fuel, deserves liberal financial support by the gas industry. The asphyxiation of even a few households by gas of high carbon monoxide content would largely dissuade the public from adopting gas for heating homes. Scientific investigation for the production of better and safer gaseous or liquid fuel will cost less than the laying of new, larger, stronger and tighter mains through the streets, as a gas of low calorific value will require.

Until a less poisonous gas is available, and even thereafter, the conventional "campaign of education of the public" should be continued; but, unless reinforced by regulations and their enforcement, it promises little help in this matter. The public already knows the lethal properties of city gas. It uses gas oftener than any other means for suicides. No official warnings can be as impressive as the reports of accidental deaths which the newspapers now publish almost daily in every large American city. Every one of us knows that each of these so-called accidents is due to the carelessness of some individual, usually the victim himself or one of his family. Yet each of us is so familiar with his own gas stove or hot water heater, used day in and day out for years without trouble, that he neglects the danger to his family and to himself.

It is not only individuals who take a chance. The public health authorities are even more reckless; for they face not a chance but a certainty. The number of accidents each year in a large city is almost as definite as the calendar, more each month in winter, fewer in summer. It is fairly certain also that if the whole number of these accidents were distributed into groups according to their common causes, each of these groups would show a quite definite mortality per hundred thousand of the population. There is the group in which asphyxiation results from flexible hose that is old and defective or is accidentally disconnected. There is the group in which the tea kettle boils over and puts out the fire. There is another group in which the hot water heater or bathroom stove is without a flue. There is still another group in which the quarter meter is started by one boarder after the light or stove has gone out in the room of another boarder. Each group takes its regular fraction of the fatalities and will continue to do so until a general change in conditions is enforced by the public health authorities.

The American Gas Association, representing the entire manufactured gas industry, has in recent years shown a commendable desire to assist in protecting the public from the dangers inherent in the use in homes of a gaseous fuel and the carelessness that results from common use. But there is still much that the public utility companies can do. They now generally sell only a good quality of appliances; but low grade and dangerous appliances are still sold in large quantities by other concerns. Much can be done toward excluding low grade appliances by enlisting the powerful influence of the fire insurance companies. The inspectors of the city fire department could act also for the board of health and report conditions dangerous to life, as well as those endangering property.

In addition, the public health bureaus, public service commissions, and the building and plumbing inspection services of cities should make and enforce regulations against the sale to the public of badly made and unsafe appliances. All agencies should help to stop the use of flexible gas hose. Even the best quality may be accidentally disconnected. In homes, gas should be burned only in appliances with fixed connections. The municipal building and plumbing bureaus should see to it that hot water heaters are connected to flues. As gas comes into use for heating homes, the furnaces and their connections should be subjected to periodic inspection. If quarter meters are to be used at all, they should be so connected that the common accident referred to cannot happen.

But the most important of all measures is that the gas industry shall aim to reduce the amount of carbon monoxide in city gas. If it were reduced by one half, the number of accidental deaths from gas would be reduced to a fourth, or less, of the present mortality.

EXHAUST GAS FROM AUTOMOBILES[2]

The internal combustion engine now used in automobiles, motor boats and airplanes gains its power from the explosion of a mixture of air and gasoline under pressure. The combustion occurring under these conditions is never complete. The exhaust gas always contains some carbon monoxide. The amount varies according to the proportion of air and gasoline vapor. In order that the motor shall act with maximum power and afford a "quick pick up" in city traffic, the carburetor of the engine must be set to supply a mixture rich in gasoline. The amount of carbon monoxide in the exhaust gas may then be as much as 7 per cent. With less rich mixtures the combustion is more nearly complete and the amount of carbon monoxide produced is correspondingly less. As a rough figure it may be stated that for each 20 horse power of the motor, when run on the usual mixture, one cubic foot of carbon monoxide is produced each minute. If this amount is discharged for even as short a time as five minutes into a small garage (cubic capacity of 2,000 cubic feet), the resulting concentration in the air rises to about a fourth of one per cent. Such an amount of this gas is sufficient to paralyze a man in a few minutes and to produce death in a short time if he is not discovered and removed from the poisonous atmosphere.

On account of this danger it is important that the health officials each year before cold weather begins shall publish in the daily newspapers, and send through the commissioner of motor vehicles or the state or local health officials to all automobile owners, warnings against starting the engine of an automobile before opening the garage doors. The memory of the public is short. Although many deaths have been reported from lack of this precaution, there are still persons who are unaware of the danger or who carelessly take the

2. Fieldner, A. C.; Henderson, Yandell; and others: Tunnel Gas Investigations—Report of the New York and New Jersey State Bridge and Tunnel Commission, 1921, pp. 91-140. Henderson, Yandell; Haggard, H. W.; Teague, M. C., and Prince, A. L.: Physiological Effects of Automobile Exhaust Gas and Standards of Ventilation for Brief Exposures, J. Indust. Hyg. **3**: 79-92, 137-146 (Aug.) 1921. Fieldner, A. C.; Henderson, Yandell; Paul, J. W.; Sayers, R. R., and others: Ventilation of Vehicular Tunnels, J. Am. Soc. Heating and Ventilating Engineers, Jan.-Dec., 1926, New York, February, 1927.

risk. They suppose that they will feel some effect which will warn them before they are overcome. But carbon monoxide gives no warning. The first effect is often a sudden muscular weakness which causes the victim to fall to the floor and renders him helpless. Unless he is discovered in time, unconsciousness soon follows and then death.

For large garages the city health department should make regulations, and the regulations should be enforced, against running the engine of any car and discharging its exhaust gas into the air of the garage for more than a very short time before it goes out. If this regulation is not enforced, no amount of artificial ventilation of the garage will keep the air healthful. To change the entire air of the garage every few minutes would require an enormous fan and would lower the temperature of the garage to that of the outside air during cold winter weather.

In repair shops, workmen are often seriously affected by inhalation of exhaust gas. The conditions are greatly improved in shops in which a flexible hose is connected to the exhaust pipe of each car under repair, so as to conduct the gas outdoors. The sanitary advantage of this device is now well established by experience. It should be required by law in all repair shops.

POLLUTION OF AIR IN STREETS

Pollution of the air in streets where the traffic is heavy is an increasing cause of complaint. Present conditions probably contribute to respiratory diseases. It is, however, the fumes of oil, dust and smoke that cause these complaints, rather than the invisible and nearly odorless carbon monoxide. Analyses of street air have shown that the amount of carbon monoxide is not sufficient to be distinctly poisonous. But it is sufficient to contribute to the state of fatigue of those who breathe this contaminated air throughout the day.

A device that has been used on bakery wagons and other small trucks with doors opening at the back, and also on some omnibuses, is the vertical exhaust. Observations were made on this device by Henderson and Haggard[3] which led them to suggest that its general use on taxi-cabs and other commercial vehicles might considerably decrease the contamination of the air with exhaust gas in congested traffic. These investigators consider that the practical value of the device should be given a large scale experimental test.

POISONOUS ACTION OF CARBON MONOXIDE[1]

The poisonous action of carbon monoxide is due almost entirely to the fact that it combines with the red coloring matter, called hemoglobin, in the blood. It is the hemoglobin that normally takes up oxygen as the blood passes through the lungs and gives this oxygen off again to the tissues of the body as the blood circulates through them. To whatever extent carbon monoxide has been absorbed from the air and combined with hemoglobin, the blood is to that extent limited in its power to take up and transport oxygen throughout the body. Thus the poisonous action of carbon monoxide is due to the deprivation of oxygen, or asphyxia, that it induces. The severity of the intoxication and the seriousness of the after-effects are determined both by the amount of carbon monoxide absorbed and by the length of time it remains in the blood; that is, by the duration as well as by the intensity of the asphyxia.

The attraction of hemoglobin for carbon monoxide is more than two hundred times as great as for oxygen. For this reason when air (21 per cent oxygen) containing even a few hundredths of one per cent of carbon monoxide is breathed for a considerable time, the hemoglobin of the blood becomes largely combined with carbon monoxide, and oxygen is correspondingly excluded. When a larger amount of carbon monoxide (a few tenths of one per cent in the air) is breathed, the gas is absorbed in correspondingly greater amount and rapidity. The combination of carbon monoxide with hemoglobin is, however, a loose one and, in the presence of sufficient oxygen, carbon monoxide may be driven out of the blood again. Accordingly, when fresh air containing no carbon monoxide is breathed, the oxygen of the air gradually displaces the carbon monoxide from the blood. If there has been much delay in displacing the carbon monoxide from the blood, ill effects may follow, especially an intense headache due to edema of the brain and occasionally impairment of the heart and nervous system. These effects are not due to a permanent retention of carbon monoxide in the body but are the secondary results of the injury done to the brain and to the heart while carbon monoxide was in the blood, thus temporarily excluding oxygen. They are the after-effects of asphyxia. The attraction of the "respiratory ferment" (Warburg)[4] for carbon monoxide is low in comparison to hemoglobin. Its part in carbon monoxide intoxication in man appears practically negligible.

Generally a person who has been partially asphyxiated by carbon monoxide, even to the point of complete unconsciousness, and who is resuscitated in time by the method to be described, recovers completely. Less acute but more prolonged are the effects of repeated exposure to small amounts of carbon monoxide, such as a mechanic in an automobile repair shop breathes day after day, or a workman at a blast furnace or gas plant, or a cook working in a small, badly ventilated kitchen with a defective gas stove. The results of such conditions are impairment of general health, nervousness, ill temper, and a condition similar to "over-training" in an athlete or to the "air staleness" of an aviator who has made many high ascents.

For such low grade chronic intoxication the only proper treatment, and all that is necessary, is the improvement of the conditions, especially the ventilation, under which the persons concerned live and work.

GAS MASKS[1]

Since the war the military gas mask has undergone development for industrial use until masks are now available which protect against all of the common noxious gases. It is important that every one using a gas mask should make sure that the mask is supplied with the correct absorbent for the particular gas. Each particular gas or type of gas has its own particular absorbent or catalyst. A mask not containing the requisite substance, or used too long, or allowed to get into bad repair, affords no protection, and even increases danger by false confidence. The so-called all service mask protects against practically all gases, but for only a short time. It contains some of each absorbent and catalyst, but the amount of each is small. The period of protection in each gas is therefore

3. Henderson, Yandell; and Haggard, H. W.: Health Hazard from Automobile Exhaust Gas in City Streets, Garages and Repair Shops: The Vertical Exhaust as a Practical Measure of Amelioration, J. A. M. A. **81**: 385-391 (Aug. 4) 1923. Also Bloomfield, J. J., and Isbell, H. S.: The Problem of Automobile Exhaust Gas in Streets and Repair Shops of Large Cities, U. S. Public Health Report no. 1217, March 30, 1928.

4. Warburg, O.: Ueber die chemische Konstitution des Atmungsferments, Die Naturwissenschaften **16**: 345 (May) 1928.

much shorter than is that afforded by a mask with a full charge of a particular absorbent or catalyst.

A wet handkerchief or towel tied over the face is not a gas mask. It removes some of the irritant substances from smoke but gives no protection whatever against carbon monoxide. Even the best mask of the absorbent type gives no protection against an atmosphere deficient in oxygen. The common test for deficiency of oxygen in any atmosphere is that a candle will not burn in it, but this test should not be applied when the air may be contaminated with a combustible and explosive gas. A flame safety lamp is, however, free from this danger; it is the historic Davy lamp of the coal miner. The best test of the quality of an atmosphere is afforded by a mouse or a canary. Such small animals are overcome much more quickly than a man and thus give a timely warning of danger.

The safest form of mask, and the one to be recommended whenever conditions permit, is the so-called hose mask. In this device a long hose is connected at one end to the mask and at the other end to an air pump. An assistant outside the gaseous chamber works the pump so as to supply fresh air to the man wearing the mask. This type of mask gives perfect protection to the wearer even in atmospheres deficient in oxygen, as in silos, sewers, the hold of a ship, and other places where the oxygen of the air has been absorbed by some chemical process.

A third type of mask, the so-called self-contained oxygen apparatus, is heavy and liable to dangerous defects. It should never be used except by men specially trained, and by them only when neither of the other forms of mask will serve.

In using a gas mask or even the safer hose mask for the rescue of a person overcome by any gas, the rescuer should avoid risking his own life unnecessarily. If it is necessary to go down into a cellar or sewer, a rope should be tied around him and held by an assistant, so that he can be hauled out if he also is overcome.

RESUSCITATION [5]

The modern inhalational method of resuscitation is based on the fact that carbon monoxide asphyxia, if untreated, may continue in almost full force for a considerable time after the victim is removed from the poisonous atmosphere. Formerly the victim was often sent to a hospital in an ambulance. Sometimes he died on the way. More often, even after he reached the hospital, the carbon monoxide remained for a time almost undiminished in his blood, or was at first eliminated very slowly. Every minute increased the chance of fatal injury to the brain, or at least of a subsequent pneumonia or damage to the heart.

The object of the inhalational treatment is to eliminate the carbon monoxide from the blood as soon as possible. The victim should not be moved at all, or for only a few feet. If he is not breathing, artificial respiration by the prone pressure method should be started without a moment's delay and should be continued until spontaneous breathing returns, or until death is fully established. Spontaneous breathing is much more quickly restored if, while one operator does artificial respiration, another operator administers an inhalation of oxygen and carbon dioxide.

If the victim is breathing, as is often the case even in dangerously severe asphyxia, artificial respiration should not be given. But inhalation of oxygen and carbon dioxide should be immediately begun. If this mixture of gases is not available, oxygen should be used.

It is important to keep the patient warm. This precaution is often neglected, and with serious consequences. If he has to lie on the ground or pavement, coats or blankets should be put under him. This is more important than to put them over him. If he has been asphyxiated in a room, the poisonous atmosphere should be replaced with fresh but not cold air. He should not be handled roughly, as this may cause serious injury. After the return of spontaneous breathing, the inhalation should be continued until the patient's condition is virtually normal again, as indicated by a quiet pulse and the return not only of consciousness but of good humor.

Until the patient is fully restored to normal condition he should be prevented from making any exertion, even to sit up. The practice, formerly common, of making a partially resuscitated person walk may injure the heart. Men in the city fire departments sometimes strain their hearts by intense exertion after absorbing carbon monoxide. After a severe but short asphyxiation, as in the case of a workman overcome by gas in a manhole in the street or a member of the fire department overcome by smoke, resuscitation by the inhalational treatment is often complete within an hour or even less time. Provided the pulse and temper have returned to normal, the man can safely go back to work, and often does so.

The less the ambulance surgeon uses his hypodermic syringe on patients with carbon monoxide asphyxia, the better. The more completely he leaves them to the ministration of the rescue crews of the gas company and of the fire and police departments, the more likely the patients are to make a rapid and complete recovery. The rescue crews in general are trained for this particular procedure according to the carefully worked out directions of investigators and physicians especially experienced in this field.

Transfusion of blood in cases of carbon monoxide asphyxia, although not harmful, is certainly quite useless. It is perfomed only when the patient is still unconscious several hours after the asphyxiation. Most of the carbon monoxide, even in a patient not treated by inhalation, has by that time been eliminated from the blood. The continued coma is due to edema of the brain [6] and other postasphyxial injuries to the nervous system which transfusion of blood does not benefit. All efforts should instead be directed to assisting the patient by means of the inhalational treatment to ventilate the carbon monoxide out through his lungs as early as possible. His own blood is thus restored to normal condition and the harmful after-effects, which may otherwise follow asphyxiation, are in most cases completely prevented.

INHALATIONAL TREATMENT

Inhalation of oxygen and carbon dioxide was introduced by Henderson and Haggard [7] a few years ago and has received strong support in the valuable work of Drinker.[8] This treatment is now applied in thousands

5. Henderson, Yandell: Resuscitation from Carbon Monoxide Asphyxia, from Ether or Alcohol Intoxication, and from Respiratory Failure Due to Other Causes, J. A. M. A. **83**: 758-763 (Sept. 6) 1924.

6. Forbes, H. S.; Cobb, Stanley; and Fremont-Smith, Frank: Cerebral Edema and Headache Following Carbon Monoxide Asphyxia, Arch. Neurol. & Psychiat. **11**: 264-281 (March) 1924.

7. Henderson, Yandell; and Haggard, H. W.: Report 1 of Commission on Resuscitation from Carbon Monoxide Asphyxia to American Gas Association, J. A. M. A. **79**: 1137-1145 (Sept. 30) 1922.

8. Drinker, C. K.: The Efficiency of the Oxygen-Carbon Dioxide Treatment of Carbon Monoxide Poisoning, J. Indust. Hyg. **7**: 539 (Dec.) 1925. Heller, E.; Killiches, W., and Drinker, C. K.: The Evaluation of 5 and 7 per Cent Carbon Dioxide Mixtures as Respiratory Stimulants, ibid. **11**: 293 (Nov.) 1929. Drinker, C. K., and Shaughnessy, T. J.: The Use of 7 per Cent Carbon Dioxide and 93 per Cent Oxygen in the Treatment of Carbon Monoxide Poisoning, ibid. **11**: 301 (Nov.) 1929.

of cases each year by the rescue crews of the gas and electric light companies and of the police and fire departments in all of the larger and many of the smaller American cities. It has proved much more effective than such mechanical devices as the "pulmotor" and "lungmotor." These devices have now been almost entirely discarded in America, although the inhalators that have replaced them are still often erroneously called "pulmotors" in the newspapers. More than 2,000 inhalators are now in use, 300 of them in the metropolitan district of New York. Each rescue crew contains three or four men trained in resuscitation.

The inhalator usually contains a cylinder, or two cylinders, of oxygen under pressure with which 5, or better 7, per cent of carbon dioxide has been mixed. By means of a mask and suitable valves the victim of asphyxia is made to breathe this mixture of gases. The only considerable organization not using oxygen and carbon dioxide is the United States Bureau of Mines, which still uses oxygen alone.

Few hospitals have as yet equipped their ambulances with inhalators. Some of them claim that it is superfluous for more than one agency in a city to provide the means of resuscitation. But experience shows that if an ambulance without an inhalator is first called to a case, the delay in sending for the inhalator from the gas company or fire department may result in the loss of a life that could have been saved by prompt treatment. Every ambulance should carry an inhalator. Hospital interns should learn how to use it.

The reason for the use of oxygen, either pure or in a mixture, in these inhalators is that this gas tends to displace carbon monoxide from the blood more rapidly and effectively than does air, which contains only 21 per cent of oxygen. It is of critical importance, if the victim is to be restored to health and to suffer no aftereffects from asphyxia, that the carbon monoxide shall be eliminated from the blood and exhaled through the lungs as quickly as possible. Every minute counts. Late inhalation is of relatively little benefit.

The reason for the use of carbon dioxide, with oxygen, is as follows: The carbon dioxide continually produced in the living body is the stimulus that causes normal breathing. It is particularly the carbon dioxide coming from the muscles which induces the deep breathing during and after physical exercise. On this principle as a basis, carbon dioxide is added to the oxygen in the inhalator to stimulate deep breathing. It thus causes a larger volume of oxygen to be inhaled and aids greatly in displacing carbon monoxide from the blood.

In persons who have inhaled only a moderate amount of carbon monoxide and whose breathing is therefore not depressed, carbon monoxide may be almost all eliminated within half an hour under inhalation of oxygen alone, as Sayers and his collaborators in the Bureau of Mines have found.[9] But in serious cases when the victims are so deeply asphyxiated that the breathing is greatly depressed or has ceased altogether, oxygen alone may be of little benefit, for the patient does not inhale it adequately. Oxygen is not a respiratory stimulant; it may even depress respiration. Carbon dioxide, on the contrary, is effective even in profound asphyxia in restoring full deep breathing. The addition of carbon dioxide to oxygen for the inhalational treatment of asphyxia is thus of the first importance for rapid resuscitation.

An additional reason for the use of carbon dioxide is that oxygen has no displacing action on poisonous gases, other than carbon monoxide, that are absorbed into the blood. City gas in addition to carbon monoxide contains other poisonous substances, particularly those of the benzene series; without these substances city gas would not burn with a luminous flame. The use of the inhalator is not limited to cases of carbon monoxide asphyxia. In modern industry many workmen are overcome by such toxic vapors as those of methyl alcohol, gasoline and benzene. Oxygen alone is of little benefit in such cases. But inhalation of carbon dioxide induces a rapid ventilation of the poison out of the body by way of the lungs.

Some other advantages of using carbon dioxide mixed with oxygen in the inhalational treatment of gas poisoning also deserve mention here: (*a*) Full dilation of the lungs after asphyxia tends to prevent a subsequent pneumonia.[10] Without this treatment, postasphyxial pneumonia is common and has a high mortality. (*b*) Under asphyxia, the acid-base balance of the blood and tissues of the body is profoundly disturbed. Inhalation of carbon dioxide induces a rapid restoration of the blood alkali to a normal value.[11] (*c*) In cities where there are many rescue crews equipped with inhalators, as in Chicago and New York, these crews, with their inhalators, are frequently called on to treat new-born babies when the obstetrician or the midwife has been unable to effect resuscitation and start the child to breathing.[12] In such cases it is the stimulation induced by carbon dioxide on the respiratory center which, just as in asphyxiated adults, sets the machinery of breathing in operation.

The inhalational treatment is applicable to practically all forms of asphyxia and to all forms of gas poisoning. But for the pulmonary edema induced by irritant gases, such as chlorine, sulphur dioxide and "nitric fumes," oxygen should be used without carbon dioxide.

CONCLUSIONS AND RECOMMENDATIONS

Education of the public regarding the hazard of carbon monoxide in daily life now is not enough by itself to prevent numerous cases of asphyxiation. In addition, regulations and their effective enforcement are needed to remedy the common household conditions leading to asphyxiation, such as badly designed stoves, flexible tubing, the quarter meter, and lack of flues on water heaters.

The increasing use of city gas for heating homes may involve a large increase of fatalities both of individuals and of entire families unless an efficient inspection, supervision and control of household gas appliances is established.

City gas of high calorific value contains much less carbon monoxide than gas of low calorific value. It is in the interest of public health and safety that the amount of carbon monoxide in city gas should be reduced. To this end the price of gas should be based on the heat unit instead of the cubic foot. Scientific investigation for the development of less poisonous gas deserves liberal financial support.

The hazard to life of automobile exhaust gas in private garages should be called to public attention by annually repeated warnings, just before cold weather

9. Sayers, R. R.; Yant, W. P.; Levy, E., and Fulton, W. B.: Effect of Repeated Daily Exposure of Several Hours to Small Amounts of Automobile Gas. Public Health Bulletin no. 186, March, 1929.

10. Henderson, Yandell; Haggard, H. W.; Coryllos, P. N., and Birnbaum, G. L.: Treatment of Pneumonia by Inhalation of Carbon Dioxide, Arch. Int. Med., January, 1930.

11. Henderson, Yandell: Physiological Regulation of the Acid-Base Balance of the Blood and Some Related Functions, Physiol. Rev. **5**: 131 (April) 1925.

12. Henderson, Yandell: The Prevention and Treatment of Asphyxia in the New-Born, J. A. M. A. **90**: 583 (Feb. 25) 1928.

begins. The hazard to health in large garages and in repair shops should be controlled by sanitary regulations actively enforced.

For use in rescues and repairs, the hose mask is safer than the absorbent type of gas mask. Both these types of mask are much safer than self-contained oxygen apparatus.

Pulmotors, lung motors and other mechanical devices for artificial respiration should be discarded and replaced by general training in the prone pressure method of artificial respiration.

Carbon monoxide combines with the hemoglobin of the blood. It thus excludes oxygen and causes asphyxia. Inhalation of oxygen and carbon dioxide induces a rapid elimination of carbon monoxide. In many other forms of gas poisoning as well, stimulation of breathing by this inhalation accelerates the elimination of the toxic gas or vapor through the lungs.

The victims of carbon monoxide asphyxia should be treated as follows: (*a*) Immediate artificial respiration by the prone pressure method, if respiration has stopped. (*b*) Inhalation of a mixture of oxygen and 5, or better 7, per cent carbon dioxide—or, if this is not available, oxygen alone—continued until the pulse and temperature are normal. (*c*) Measures to keep the patient warm. (*d*) Prevention of any muscular exertion. (*e*) No transfusion of blood. (*f*) No hypodermic medication.

All rescue crews of the public service corporations and of the fire and police departments, and certainly all hospital ambulances, should be equipped with inhalators.

Council on Pharmacy and Chemistry

NEW AND NONOFFICIAL REMEDIES

THE FOLLOWING ADDITIONAL ARTICLES HAVE BEEN ACCEPTED AS CONFORMING TO THE RULES OF THE COUNCIL ON PHARMACY AND CHEMISTRY OF THE AMERICAN MEDICAL ASSOCIATION FOR ADMISSION TO NEW AND NONOFFICIAL REMEDIES. A COPY OF THE RULES ON WHICH THE COUNCIL BASES ITS ACTION WILL BE SENT ON APPLICATION.

W. A. PUCKNER, Secretary.

CURDOLAC CASEIN-BRAN IMPROVED FLOUR.—A flour prepared from casein, carbohydrate-free bran, and soya bean, to which leavening and flavoring have been added, having approximately the following composition: protein, 38 per cent; fat, 9 per cent; carbohydrate, 4.5 per cent; other nitrogen-free extract (by difference), 36.99 per cent; fiber, 6.53 per cent; ash, 7.78 per cent; moisture, 4.98 per cent.

Actions and Uses.—Curdolac casein-bran improved flour may be used for the preparation of muffins or bread having a relatively low carbohydrate content and low food value, with bulk. The nutritive value of 500 Gm. corresponds approximately to 1,185 calories, of which 779 are yielded by protein, 414 by fat, and 92.2 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC SOYA-BRAN FLOUR.—A flour prepared from soya bean and a starch-free bran with a leavening mixture, having the following approximate composition: protein, 27.31 per cent; fat, 15.70 per cent; carbohydrate, 7 per cent; other nitrogen-free extract (by difference), 23.86 per cent; fiber, 8.92 per cent; moisture, 4.61 per cent; ash, 13.70 per cent.

Actions and Uses.—Curdolac soya-bran flour may be used for the preparation of bread and muffins for use in diets in which a comparatively low carbohydrate content is desired. The nutritive value of 500 Gm. corresponds approximately to 1,195 calories, of which 355 are yielded by protein, 722 by fat, and 14 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC BREAKFAST CEREAL.—A medicinal food prepared from soya beans blended with wheat products, including starch-free bran, having the following approximate composition: protein, 25.99 per cent; fat, 10 per cent; carbohydrate, 14.9 per cent; nitrogen-free extract (by difference), 14.04 per cent; fiber, 8.68 per cent; moisture, 3.94 per cent; ash, 12.40 per cent.

Action and Uses.—Curdolac breakfast food may be used as a hot food in diets in which a comparatively low carbohydrate content is desired. The nutritive value of 500 Gm. corresponds approximately to 1,297 calories, of which 532 are yielded by protein, 460 by fat, and 305 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC CASEIN COMPOUND.—A flour prepared from casein, vegetable fiber and a leavening mixture to which sodium chloride and gluside (0.00313 per cent) are added, having approximately the following composition: protein, 42.7 per cent; fat, 0.75 per cent; nitrogen-free extract (by difference), 42.35 per cent; ash, 5.6 per cent; moisture, 5.23 per cent; fiber, 3.36 per cent.

Actions and Uses.—Curdolac casein compound may be used for the preparation of carbohydrate-free bread, muffins, cake, etc., for use in diets in which a relatively low carbohydrate content is desired. The nutritive value of 500 Gm. corresponds approximately to 909 calories, of which 875 are yielded by protein and 34 by fat.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC SOYA FLOUR.—A flour prepared from the soy bean, having approximately the following composition: protein, 42 per cent; fat, 18 per cent; nitrogen-free extract, 30.5 per cent, of which less than 0.10 per cent yields carbohydrate in assimilable form; crude fiber, 7.86 per cent; ash, 4.1 per cent; water, 6 per cent.

Actions and Uses.—Curdolac soya flour may be used for the preparation of foods in diets in which a relatively low carbohydrate content is desired. The nutritive value of 500 Gm. corresponds approximately to 1,709 calories, of which 861 are yielded by protein, 828 by fat, and 20 by assimilable carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC WHEAT-SOYA FLOUR.—A flour prepared from soya beans, starch-free bran and a small proportion of wheat, with leavening and flavoring, having approximately the following composition: protein, 23 per cent; fat, 9.3 per cent; carbohydrate, 20.5 per cent; other nitrogen-free extract (by difference), 23.86 per cent; fiber, 6.02 per cent; moisture, 5.52 per cent; ash, 11.8 per cent.

Actions and Uses.—Curdolac wheat-soya flour may be used for the preparation of muffins, cakes, waffles, etc., of well balanced food value for use in restricted diets. The nutritive value of 500 Gm. corresponds approximately to 1,383 calories, of which 471 are yielded by protein; 427 by fat, and 420 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC SOYA-CEREAL JOHNNY CAKE FLOUR.—A flour prepared from soya beans and cereal products, to which leavening and flavoring have been added, having approximately the following composition: protein, 35.25 per cent; fat, 16.3 per cent; carbohydrate, 20 per cent; other nitrogen-free extract (by difference), 10.52 per cent; fiber, 6.22 per cent; moisture, 6.58 per cent; ash, 5.13 per cent.

Actions and Uses.—Curdolac soya-cereal johnny cake flour may be used in the preparation of muffins, cakes, waffles, etc., for use in diets relatively low in carbohydrate, designed for those who cannot use products made with bran. The nutritive value of 500 Gm. corresponds approximately to 1,901 calories, of which 722 are yielded by protein, 769 by fat, and 410 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.

CURDOLAC SOYA-BRAN BREAKFAST FOOD.—A medicinal food prepared from soya beans and a starch-free bran, to which has been added leavening, flavoring, gluside (0.0225 grains to the ounce), and oils without food value, having approximately the following composition: protein, 15.19 per cent; fat, 5.26 per cent; available carbohydrate, 17.8 per cent; other nitrogen-free extract (by difference), 50.39 per cent; fiber, 17.8 per cent; moisture, 2 per cent; gluside, 0.0006 per cent.

Actions and Uses.—Curdolac soya-bran breakfast food may be used in diets in which a low carbohydrate content is desired. The nutritive value of 500 Gm. corresponds approximately to 833 calories, of which 698 are yielded by protein, 107.8 by fat, and 26.6 by carbohydrate.

Manufactured by the Curdolac Food Company, Waukesha, Wis. No U. S. patent. U. S. trademark 145,646.