

At every meeting I am asked for the formula of this alloy. It contains 50 per cent. lead, 25 per cent. tin, 12.5 per cent. cadmium and 12.5 per cent. bismuth. The wire loop stabilizers are not through and through devices. I have seen real pus accumulate about them and flow out over the skin without one degree of temperature rise. They are so constructed as to provide sufficient outlet from their base out.

I am very glad that Dr. Ryerson has called attention to the possibility of establishing crutch paralysis by using the splint for fractures of the humerus. Like any crutch made on the nonrigid straplike plan there is less danger of crutch paralysis than with the rigid type of crutch. But it must be remembered that any crutch paralysis also depends on a prolonged and a considerable degree of pressure which is never necessary in this system of treatment for the following reasons.

In the first place there is little or no traction necessary to hold broken bones in their proper place after they have once been pulled down to their proper place. For twenty-five years I have worked diligently on the application of mechanical principles to surgical procedures and I want above all else to have orthopedic surgery put on a sound dynamic basis, since it represents the mechanical division of all medicine and surgery and it should be unassailable in its very foundation. Not one has come out and attempted to discuss the basic principles I have come to present to you. There is not one who can logically account for the basic mechanical principles that he uses every day.

THE THERAPEUTIC VALUE OF ORAL RHYTHMIC INSUFFLATION OF OXYGEN

WITH DESCRIPTION OF A SIMPLE APPARATUS
FOR ITS EXECUTION *

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The literature on the relation of oxygen to the processes of life, the rôle which oxygen plays in internal and external respiration, and the availability of that gas as a therapeutic measure, is immense. I shall not attempt to review it even in a cursory way, but it may not be amiss to discuss some of the problems of this subject, especially those which we encounter in recent medical literature. We may conveniently divide the discussion of our subject into two aspects: the physiologic and the therapeutic.

THE PHYSIOLOGIC ASPECT

It seems to be the dominant opinion among physiologists that inhalation of pure oxygen or air strongly enriched with oxygen is of no greater oxidative value to the normal organism than the inhalation of simple atmospheric air, which contains about 20 per cent. of oxygen. This view seems to be upheld by two considerations. In the first place, it is a fact that the oxygen in the blood is carried chiefly by the hemoglobin, which, it is generally assumed, is nearly saturated with oxygen and would not take up more of it even if the individual were breathing pure oxygen. The only part of the blood which may take up more oxygen when offered under higher pressure is the serum; but it seems to be generally accepted that the amount of oxygen which the serum is thus able to take up is a small and negligible quantity. The second influential consideration is the assumption, which seems now to be quite generally accepted, that the decision as to

the amounts of oxygen which the organism is to absorb rests finally and exclusively with the body cells, that is, with their necessities, activities and storing capacities, and is not influenced by the oxygen pressure within the tissue lymph. In other words, oxidation, the chief process of life, depends on cell activity and not on the tension of oxygen within the blood or within the tissue lymph.

The question under discussion has been the subject of numerous investigations. Lavoisier and Seguin, as far back as 1789, were the first to draw the conclusion from their experiments that "there was no increase in the vital processes as the result of breathing pure oxygen." Probably the last, and surely one of the best and apparently most careful investigation, is the one that was published a few years ago in this country by Benedict and Higgins.¹ They say that a critical examination of the entire literature strongly favors the belief expressed by Lavoisier. But they say that "nevertheless we find that there is much that is lacking in the evidence thus far secured, so that the matter is not yet definitely settled." Their careful investigations, however, led them to a similar result, namely, that there is no difference in the gaseous metabolism between breathing ordinary air and breathing oxygen mixtures of 40, 60 or 90 per cent.

But even with regard to this careful research, Krogh² said: "It is extremely probable, however, that there is in these experiments a slight systematic error," and he comes to the conclusion that the "breathing of oxygen does increase the metabolism to some slight extent."

Apparently there are many factors of greater or lesser importance that have to be taken into consideration before we shall be justified in accepting as final any estimate of the extent of the influence that the inhalation of air with a higher partial pressure of oxygen may exert on the normal gaseous metabolism. The hemoglobin is even normally not completely saturated with oxygen, nor is the oxygen in solution in the blood serum normally an entirely negligible quantity, and it is certainly not negligible during an increase of the partial pressure of oxygen of the inhaled air.

There is no real quantitative analysis of the amount of oxygen present in the tissue fluid. The analysis of the various body secretions does not mean the same as an analysis of the tissue fluid. There are some authoritative investigators who still believe in the storage of oxygen, intramolecularly or extramolecularly, in loose chemical combination or in physical solution. There are other considerations to be solved; but I shall not attempt to discuss any of these points. However, I wish to call attention to one factor which has not yet been taken properly into account, or at least not from the proper point of view, as it seems to me, and that is that element in biology which I designated, a decade ago, as the factor of safety.

All experiments under consideration start implicitly from the point of view that the oxygen content in the air is the physiologic amount sufficient for the maintenance of the life of the animal under normal conditions. But is this entire amount also indispensable? It has been established by many experiments that the

1. Benedict and Higgins: Effects on Men at Rest of Breathing Oxygen-Rich Gas Mixtures, *Am. Jour. Physiol.*, 1911, **28**, 1.

2. Krogh, August: The Respiratory Exchange in Animals and Man, London, Longmans, Green & Co., 1911.

* From the Department of Physiology and Pharmacology of the Rockefeller Institute for Medical Research.

organism remains in a normal condition even if the partial pressure of the oxygen in the air amounts to only 12 or 13 per cent. What is the significance of the considerable surplus of oxygen that the animal is normally breathing? From my point of view it presents a factor of safety in the function of respiration, a factor which I have shown to exist in most of the functions of the animal body.³ I shall not attempt to discuss again this problem in its details. But it will not be amiss to give an example taken from every day life which will suffice to illustrate the meaning of the underlying principle of the factors of safety and the simplicity of its requirements. Let us take, for instance, two houses of about the same size, of which we have good reasons to expect that each house uses up the same amount of coal in a given time. But while the occupant of one house, who may possess larger means and a greater foresight, lays in a larger supply of coal, let us say, twenty tons at a time, we find the occupant of the other house, perhaps because of lack of means or the necessary foresight, provides himself with only one ton of coal at a time. The difference in the fate between the occupants of the two houses becomes strikingly evident when unexpectedly necessities arise for greater consumption of coal, and when, furthermore, these necessities set in under circumstances of time and place that make coal difficult to obtain.

Life is characterized by the instability and variability of its states, and all its functions must therefore be so arranged as to be capable of being ready to meet the highest possible demands. The function of respiration has for its object chiefly the provision of the organism with oxygen, properly and safely. While, as far as the muscle system is concerned, the provision of the respiratory function with factors of safety is under normal conditions surely of a satisfactory extent, because, as we know, the muscle is capable of continuing its contractions even if the oxygen tension of its surrounding atmosphere is fairly low, it is different with the central nervous system. Here we know that a comparatively slight reduction in the oxygen tension interferes profoundly with the activities of this system. Are we justified in assuming that the addition of 7 or 8 per cent. of oxygen is just the limit of the factors of safety which the respiratory function may need and use under all conditions? Furthermore, in breathing normal atmospheric air, what is the fate of the 7 or 8 per cent. of oxygen present in the normal air above the amount actually indispensable for maintenance of life? Is this oxygen stored away somewhere and in some manner, to be ready for immediate use when needed, or is it normally unabsorbed and got rid of in the same manner as is assumed to be the case when 20 or 30 per cent. of oxygen is artificially added to the atmospheric air?

THE THERAPEUTIC ASPECT

The extensive experiments on which the prevailing view has been founded, namely, that the addition of oxygen to the atmospheric air does not affect the normal metabolism, were made on normal resting individuals. But the processes of life, even in the normal individual, and even while at rest, cannot be represented by a straight line. The processes vary continuously within certain limits; that is life. These variations in the demands have to be met by variations in

the supplies which have to be ready in store to the extent corresponding to the maximum limits of the demands of normal life. The 7 or 8 per cent. surplus of oxygen in the atmospheric air is apparently sufficient to meet the maximum demands of the respiratory function of the normal individual when at rest. But would it be sufficient to cover the demands when the individual is engaged in hard work? We know that unusual physical effort leads to shortness of breath, to dyspnea. Could this not be remedied by adding oxygen to the atmospheric air which the hard-working person has to respire? This is indeed the case, a fact which has been discovered and established by Leonard Hill⁴ and his co-workers. Hill and Flack⁴ found that inhalation of oxygen makes running up and down stairs easier, can be accomplished in a shorter time, relieves the feeling of dyspnea, and restores strikingly the vigor after fatigue from boxing, etc. They believe that the fatigue which follows an athletic feat is cardiac in origin and due to want of oxygen. Haldane,⁵ whose great merits in the elucidation of the physiologic relations of carbon dioxide to the function of respiration are well known, was inclined to explain Hill's observation as a result of the deep breathing which is apt to occur in persons to whom oxygen is administered. Haldane's view was later refuted by new experiments, carried out by Hill and Mackenzie,⁶ which brought new evidence that the favorable effects that they have obtained were indeed due to the inhalation of oxygen.

From the observations of Hill we learn that the addition of oxygen to atmospheric air exerts a favorable influence under conditions of greater bodily activities. Is inhalation of air enriched by oxygen also capable of exerting a favorable influence when the body is in a condition of rest but is undergoing pathologic processes? In other words, is there any evidence that inhalation of oxygen is capable of exerting a therapeutic effect? This question concerns a wider field than I intend to cover in this paper. There is no doubt now as to the therapeutic value of inhalation of air-oxygen mixtures in cases of poisoning by gases that affect the normal condition of the hemoglobin. But I wish to confine my remarks to the use of oxygen in certain types of diseases. Here we encounter a very unsatisfactory situation. On one hand, hardly a patient, sick with a respiratory or cardiac disease, will be permitted by the physician in attendance to die without trying oxygen inhalation. On the other hand, not many practitioners will readily admit that oxygen is doing much good in these cases.

Two factors are at the bottom of the skeptical attitude of physicians toward the value of oxygen as a therapeutic agent. In the first place, many clinicians are influenced by the view entertained by the great majority of physiologists that the addition of oxygen to the inhaled air is incapable of exerting a physiologic influence, that it does not affect the metabolism, and that the added oxygen returns unabsorbed. Furthermore, many clinicians and pharmacologists are still under the influence of the teaching that there is no fundamental difference between physiologic and pathologic processes. In this connection, the present attitude of the physiologist Haldane is very instructive.

4. Hill and Flack: The Influence of Oxygen on Athletes, 1909, **38**, *Jour. Physiol.*, **28**.

5. Haldane, J. S.: The Effects of Previous Forced Breathing and Oxygen Inhalation on the Distress Caused by Muscular Work, *Jour. Physiol.*, 1909-1910, **39**, *Proc. Physiol. Soc., London*, **1**.

6. Hill and Mackenzie: *Jour. Physiol.*, 1909-1910, **39**, *Proc. Physiol. Soc.*, **33**.

3. Meltzer, S. J.: The Factors of Safety in Animal Structure and Animal Economy, *THE JOURNAL A. M. A.*, Feb. 2, 1907, p. 655.

As stated above, Haldane doubted that the favorable influence which, according to Hill, the administration of oxygen exerts on the work of athletes is due to oxygen. Very recently, however, Haldane⁷ came out strongly for the administration of oxygen in inflammatory conditions of the lungs. He says:

It may be argued that such measures as the administration of oxygen are at the best only palliative and of no use, since they do not remove the cause of the pathological conditions. As a physiologist, I cannot for a moment agree with this reasoning. The living body is no machine, but constantly tending to maintain or to revert to the normal, and the respite afforded by such measures as the temporary administration of oxygen is not wasted, but utilized for recuperation.

The second, and probably the more influential factor, is the actual fact that practitioners rarely see any favorable effect that may have been brought about by the administration of oxygen. But the general conclusion drawn from this fact, namely, that the inhalation of oxygen is incapable of exerting a favorable influence in pathologic conditions, is unjustifiable. The failure to see such an influence is probably due essentially to the inefficient method of administration. In most instances oxygen is given in a weak current through a funnel which is kept an inch or more from the mouth of the patient. Under these conditions we can hardly speak of "inhalation of oxygen." The atmospheric air which the patient actually inhales is probably not richer by more than 2 per cent. of oxygen, if by so much. On the other hand, the funnel may be instrumental in making the inspired air richer in carbon dioxide and surely makes the air over the face warmer, an unpleasant sensation to the patient, who prefers to be fanned and cooled off. Therefore, we often see the patient pushing the funnel away or turning the head away from it.

THE AUTHOR'S APPARATUS AND EXPERIENCE IN THE USE OF IT

My personal experience dates back about two years. I was called up one night by a very unhappy mother who told me that her only son was dying and begged me to come over. The athletic young man of 25 years was sick with pneumonia, Type II. I arrived at about 2 a. m. and found several physicians around the patient, who was unconscious and deeply cyanotic. Respiration was rapid and very shallow. He had no corneal reflex and there was a thready pulse of about 190 per minute. The patient was apparently dying and the physicians expected death to take place within the next ten or fifteen minutes. Nurses were administering oxygen in the usual manner, that is, through a paper funnel, kept at some distance, the gas bubbling through a wash bottle at a moderate pace. I disconnected the rubber tube from the foot bellows of my pharyngeal insufflation apparatus⁸ that I brought along with me, and connected it with an oxygen cylinder. I then inserted the pharyngeal tube in the mouth (not in the pharynx), turned on the oxygen and started working the respiratory valve. Within a short time after the beginning of the oxygen insufflation in the new manner, the cyanosis disappeared and the face of the patient became actually pink. Several minutes after the discontinuance of the insufflation, the cyano-

sis began to reappear gradually. In the course of the next five hours the experiment was repeated numerous times and invariably with the same result, that is, the cyanosis disappeared promptly during the insufflation of oxygen and reappeared several minutes after cessation of the insufflation. There was no perceptibly favorable influence on the other symptoms of the patient, except perhaps on the pulse. In the morning hours it came down to 180 per minute and was perhaps slightly fuller. At any rate, in the bedside parlance, it could be honestly stated that "the patient was holding his own." The waste of the gas was considerable. A tank of oxygen was used up in a short time. About 7:30 in the morning the supply of oxygen of the neighboring drug stores became exhausted, and it took some time before another tank of oxygen could be procured. Five minutes after the last insufflation had to be discontinued the heart stopped suddenly. The resumption of the insufflation of oxygen about ten minutes later had no effect whatever.

This patient was not saved; but nobody could have expected it when beginning treatment at that terminal stage. His life, however, seemed to have been prolonged, and it is impossible to state how much longer death would have been deferred, if the supply of oxygen had not given out. But this is an insignificant issue compared with the fact that the insufflation exerted an unmistakable effect on the profound cyanosis. Cyanosis, of whatever origin and nature, is a sure evidence that the respiratory function is profoundly disturbed. In the present case the cyanosis promptly disappeared on the administration of oxygen by the new method. Although we are dealing with only one case, each instance in this case in which the cyanosis disappeared on the insufflation of oxygen and reappeared on stopping the insufflation presents a complete experiment, an experiment that we were able to repeat at will. We made more than a dozen such experiments, and the results were invariably the same. These experiments permit at least the provisional conclusion that the insufflation of oxygen by the method employed in this case affects favorably the function of respiration when it is pathologically profoundly disturbed.

In the case here mentioned the apparatus employed was provisionally arranged and applied in great haste without consideration for the great waste of oxygen and other shortcomings. After observing the results, which seemed to be very encouraging, I devised a special apparatus for our purpose which is simple, inexpensive and works very satisfactorily.

The thick walled rubber tubing that is connected with an oxygen tank terminates in a strong rubber bag which, at its distal end, is connected with the proximal end of the respiratory valve.⁹ The distal end of the last named device is connected by means of a short piece of rubber tubing with a flat metal tube which we may designate as a "hollow tongue depressor." If the ring of the respiratory valve is kept in the inspiratory position (right side), when the oxygen is turned on, the gas streams through the tube into the bag and from there escapes through the respiratory valve and the tongue depressor. If the ring is kept in the inspiratory position (left side) the oxygen cannot pass through the respiratory valve, and accumulates within the bag. The accompanying illustration shows the last mentioned position.

7. Haldane: Brit. Med. Jour., Feb. 10, 1917. Benedict and Higgins (Note 1).

8. Meltzer, S. J.: History and Analysis of Methods of Resuscitation, Med. Rec., New York, July 7, 1917; Pharyngeal Insufflation, a Simple Method of Artificial Respiration, THE JOURNAL A. M. A., May 11, 1912, p. 1413; Simple Devices for Effective Artificial Respiration in Emergencies, *ibid.*, May 10, 1913, p. 1407.

9. A description of this device is contained in the Medical Record, New York, July 7, 1917.

The tongue depressor should be inserted in the mouth not much farther than the middle of the tongue, so that, if the patient is conscious, the presence of the depressor may cause no gagging or other discomforts. The lips should be kept closed. The ring should be moved from left to right and from right to left (a respiratory circle) about twelve times per minute. The oxygen should be turned on slowly, and the velocity of its escape should be controlled, so that it does not cause an overdistention of the bag during the expiratory pause. The turning of the ring to the right should be done slowly, so that the inspiration may develop gradually; the turning to the left is preferably done abruptly. The expiratory air escapes during the closure of the valve through the nose and through the aperture that appears above the closed valve when the ring occupies an expiratory position. It is advisable to time the inspiratory insufflation synchronously with the inspirations of the patient. However, I found that after a while the respiratory phases of the patient become involuntarily adapted to the phases of the insufflation.

I have tested on myself the action of insufflation of oxygen by means of this apparatus. When the insufflation is carried on under moderate pressure, there are no unpleasant sensations whatever. When it is done under too much pressure, the surplus of oxygen escapes through the nose and never enters the esophagus; but it causes some unpleasant sensations which conscious patients will probably not be willing to stand for any length of time.

My chest was examined by auscultation while I was receiving oxygen insufflation. It was found that each insufflation produced a distinct inspiratory blowing sound which was distinctly recognized even while I was holding my breath. It seemed, further, that the oxygen was capable of entering my lungs even when I was endeavoring to keep the glottis in a state of adduction. Some other objective and subjective effects of the insufflation experiments on myself will be mentioned later.

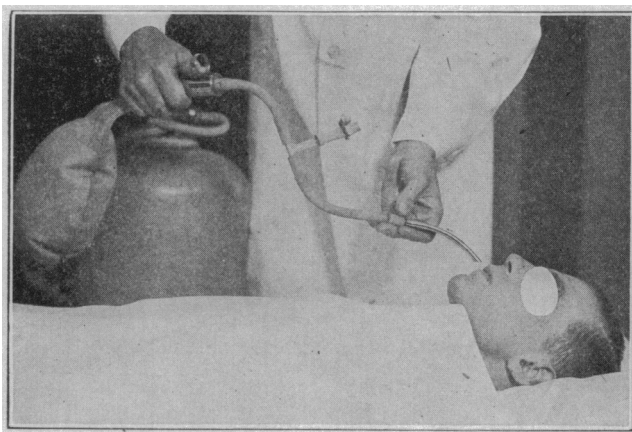
The results of the observations made by the method of auscultation induced me to make a few experiments on animals. In deeply anesthetized cats, with the thorax split transversely, the insufflation by means of the apparatus was sufficient to distend the lungs moderately with each insufflation, even when the "tongue depressor" was inserted in the mouth, as in the human being, not farther than the middle of the tongue. It appeared, however, that when the tongue depressor was kept at that position, life could not be kept up indefinitely. When the tongue depressor was inserted in the pharynx, the oxygen entered readily the gastrointestinal canal, which had to be prevented by keeping the abdomen compressed. With this precaution the artificial respiration was excellent and the animals

remained in good condition. But in this arrangement the method is identical with the method of intrapharyngeal insufflation that I have described elsewhere, and is not applicable to conscious patients.

Dr. A. L. Meyer of our laboratory performed on himself a couple of experiments with the apparatus. After having been insufflated for about eight minutes, he analyzed his expiratory air at the end of the insufflations and found it to consist of nearly pure oxygen. The nitrogen of the atmospheric air was displaced by the oxygen.

The foregoing observations demonstrate that by using the "apparatus for oral insufflation of oxygen" under moderate pressure, oxygen undoubtedly enters the lungs, assists in distending them during inspiration, and displaces largely the nitrogen of the "dead space." The assistance that it renders to the inspiration ought to be of special value when the respiration of the patient is very shallow. The rhythmic character of the insufflation is, on the other hand, of value, as it does away with the resistance which the pressure of the continuous insufflation undoubtedly offers to the expiration, especially when, owing to the low vitality of the patient, the expiratory efforts fail to get

succor from the activity of the expiratory muscles. Haldane administers the oxygen by means of a mask. The interruption of the continuous stream of oxygen in his method depends on the force of the expiration, which is expected to close a mica valve and, at the same time, prevents the entrance of the expiratory air into the bag that stores up the oxygen. I developed my simple apparatus about eighteen months previous to the appearance of the communication of Haldane. I then gave up the use of the mask even in my pharyngeal apparatus, mainly because it is liable to drive



The oral insufflation apparatus. The rubber tubing which is connected with an oxygen tank terminates at its distal end in a strong rubber bag which in turn is connected with the "respiratory valve." The ring of this device occupies in this illustration an expiratory position; hence the distention of the bag. Above the ring an aperture can be seen, which appears only when the valve is closed (expiratory position). The respiratory valve is connected at its distal end by means of a short piece of rubber tubing with the hollow "tongue depressor." The T tube is here unessential.

some deleterious material that may be present in the nasal and the postnasal cavities into the trachea and the lungs, there causing an infectious inflammation. Hill and Mackenzie⁶ stated that in giving oxygen during athletic work they did not use the mask, because it increases the dead space. In dealing with sick persons some other points must be regarded as more important. Either the patient is already unconscious, in which case the respiration will be shallow and the expiratory force will be insufficient to close the valves and overcome the pressure within the bag. Or the patient is still conscious and he will surely feel the face piece, which fits over mouth and nose and is kept in position by an elastic strap, as a great inconvenience, and will not tolerate it. Haldane says he had but few opportunities to give his method a practical trial, but he reports that in a case of valvular disease he has seen the cyanosis "clear up at once on the administration of oxygen." There is some other difference between Haldane's method and mine. By Haldane's arrangement the oxygen is accumulated in a bag of thin vul-

canized rubber. This oxygen enters, then, through mouth and nose, under comparatively low pressure, and it was not established whether the stream enters the lungs with any force capable of causing any degree of artificial inspiration. The bag in our apparatus, on the other hand, has thick walls and drives out the oxygen under a pressure which is sufficient, as we have previously shown, to cause a deeper inspiration and as a consequence also a stronger expiration. Haldane says that he knows from experiments on himself and others that the immediate effect of suddenly giving an abundance of oxygen may sometimes be unpleasant. I have taken oxygen many times by means of my apparatus, and sometimes as long as eighty minutes, and never felt any unpleasantness from it. Under stronger pressure and prolonged insufflation there might arise a sensation of dryness. This can be easily remedied by interpolating between the oxygen tank and the bag a wash bottle containing a Ringer solution. I agree, however, with Haldane that the oxygen should be turned on slowly.

Not being any longer in private and hospital practice, I am not in the favorable situation to have many opportunities for testing personally the value of the method. I am, nevertheless, in a position to report encouraging and instructive results obtained in a few cases, three of which were observed at the Rockefeller Hospital. I have to thank Dr. Chickering for the details in these cases. The first case was a most gratifying one. One forenoon in November, 1916, Dr. Cole, the director of the hospital, telephoned to our laboratory asking me to come over and administer oxygen with my apparatus to a pneumonia patient. To my reply that I would be over in half an hour, as I had to finish an experiment, Dr. Cole remarked that in all probability it would then be too late. I went over immediately and started the administration of oxygen by means of the oral insufflation. That patient recovered. Concerning the details of that case I shall quote Dr. Chickering.

REPORT OF CASES

CASE 1.—The patient came in on the second day of his disease having signs of consolidation of both lower lobes of the lungs. . . . A Type II pneumococcus was recovered from the sputum. . . . He was treated with ethyl-hydrocuprein (optochin) on the third day of his disease, and this treatment was continued during the fourth, fifth, sixth and seventh days. . . . partly by mouth and partly intramuscularly. On the fourth day of his disease the patient appeared extremely ill, temperature being 103.4 F., pulse 152, and respiration 40. He was delirious, color was ashy gray, lips and finger tips very cyanotic and tracheal râles were marked. At 10:45 a. m. the patient was given oxygen according to Dr. Meltzer's method intermittently for about two hours. While the oxygen was being given, his color changed surprisingly; his lips and ears lost their cyanotic color and took on a pinkish tint, and his general condition seemed decidedly improved. The following morning the patient's temperature and pulse were lower, 100.5 F., pulse 104 and the respirations 32. His temperature gradually came down by lysis to normal on the twelfth day of his disease. Convalescence was uninterrupted, no complications developing except a moderate amount of sterile pleural effusion which gradually cleared up without aspiration.

CASE 2.—The patient was admitted, Feb. 19, 1917, and the oxygen treatment was begun on the twelfth day of the disease, one hour before death, February 28. The patient received ethyl-hydrocuprein treatment every day from the fourth day of his disease to the twelfth, the day of his death. On the day of his death, his blood culture contained innumerable colonies of pneumococci of Type II. "On the afternoon of

his death his color suddenly changed . . . and severe cyanosis developed." Oxygen treatment was started. "While the oxygen was being administered, patient's cyanosis became less intense, but as soon as the oxygen was stopped cyanosis rapidly returned."

CASE 3.—The patient was admitted to the hospital, Feb. 25, 1917, on the first day of the disease. "The next morning the whole right chest was involved posteriorly, and on the following day signs appeared anteriorly. At the same time the left chest became filled with fine moist râles. From the sputum an atypical Type II pneumococcus was obtained. Blood culture was sterile, blood count 29,000. . . . On the fourth day of the disease the signs became more marked for the left lower lobe; the temperature rose to 104.5 F. and the pulse to 140. The patient became pale and cyanotic. The extremities were cold and expirations labored and moist. Ethyl-hydrocuprein was begun at 2 p. m., and oxygen at 3 p. m.¹⁰ . . . During the afternoon the pulse rate gradually increased to 142 (8 p. m.). The semicomatose, delirious condition deepened into unconsciousness about 7 p. m. From then on, the color could be maintained with oxygen, but the pulse quality became poorer; respirations increased from 44 to 60, and the patient's throat gradually filled with mucus. There was dulness over the left lower lobe, with râles throughout the left chest. From 2 a. m. to 6 a. m., the time of death, it was necessary to use oxygen continually in order to maintain respiration. If the oxygen was stopped for a few minutes respiration became more shallow and slow, and a dull blue flush appeared on face. This immediately disappeared with more oxygen. Gradually her color and respiration failed in spite of continual oxygen and the pulse, which was good almost to the end, became more feeble and gradually less rapid, until it failed entirely at 6 a. m."

COMMENT

In these three cases the pneumonia was due to pneumococcus of Type II, for which an efficient antiserum has not yet been developed. In all three cases the oxygen treatment was instituted very late, when the condition of the patient already appeared to be quite hopeless. Nevertheless in all three cases the oxygen insufflation manifested the tendency to exert a favorable influence. Even in the second case, in which the oxygen treatment began only one hour before death, the cyanosis of the patient became less intense while the oxygen was administered, to return rapidly when the oxygen was discontinued. This favorable effect on the cyanosis was still more striking in the other two cases, in which each short series of insufflations produced a change of color which outlasted the insufflation by shorter or longer periods. In the first case the face had a leaden, ashy gray color which is characteristic for oxygen deficiency.¹¹ This color disappeared quite soon after I started the insufflation, and the face gradually assumed rather a pinkish appearance. When I first saw the patient I understood why Dr. Cole thought that the administration of oxygen after half an hour might prove to be too late. I had little hope that the administration of oxygen would save the life of the patient. He was unconscious, had no corneal or lid reflex, the pulse was rapid, small, with very little tension, and the tracheal râles had the death sound. Nevertheless, that patient recovered. The third patient, who received oxygen insufflation for about fifteen hours, died; the pneumonia in this case was very extensive; it spread over both lungs. But here again, besides the pronounced action on the cyanosis, there seems no doubt that the oxygen insufflation prolonged the patient's life. We may be, in fact, we ought to be, optimistic

10. In the first few hours the oxygen was administered without expiratory interruptions.

11. Haldane: *Brit. Med. Jour.*, Feb. 10, 1917.

enough to assume that in conjunction with the use of some other efficient or even only semiefficient remedies, early insufflation of oxygen may offer a chance even to patients of this type.

The third patient has taught another favorable lesson, namely, that the oral insufflation of oxygen may assist in maintaining respiration. In the last few hours of her life, when the insufflation was stopped, the respiration became shallow and slow, and a dull blue flush appeared on her face which disappeared as soon as the oral insufflation was begun again. It acted apparently like artificial respiration. This fact reminds me of the statements previously made with reference to the auscultation of my chest while receiving oral insufflation, and to the behavior of the lungs in animals under the same condition.

I shall record further observations made by Dr. Victor Meltzer on a woman, aged 60, with marked arteriosclerosis and hypertension. For the last two years she was most of the time subject to cardiac dyspnea and had frequent and severe attacks of pulmonary edema. In the last two months of her life, oxygen was administered to her by means of the apparatus for oral insufflation during the attacks of dyspnea as well as those of pulmonary edema. It proved to be of great value, and afforded the patient great relief. When administered at the beginning of an attack of edema, not infrequently it prevented its full development. Among the most noticeable effects were the rapid disappearance of cyanosis.

Before concluding, I shall record briefly two observations made on myself. For experimental purposes I had oxygen administered to me several times by means of oral insufflation for periods lasting between thirty and eighty minutes. Objectively I can state that the insufflation brought high color into my face, which was noticed by persons who did not know of my experiment, and which did not leave me for several hours. Subjectively I found that it removed the sensation of fatigue and that I felt stimulated for the rest of the day. Of course, the latter fact might not have been due to the insufflation of oxygen. Not infrequently a successful experiment may bring about similar results. At any rate, both facts concern the problem of the possibility of a physiologic action of oxygen when administered by rhythmic oral insufflation, a problem which I shall not discuss here.

SUMMARY AND CONCLUSIONS

In four pathologic cases it was definitely established that the rhythmic oral insufflation of oxygen reduced or removed promptly the cyanosis, and in three of the cases the patient turned even pinkish shortly after the insufflation was begun. Without doubt these prompt effects must be ascribed in the first place directly to the action of oxygen. But it must be admitted that the rhythmic insufflation, since it is capable of assisting in the maintenance of the respiration, may be helpful in the ventilation of the lungs and thus helpful also in the removal of some of the accumulated carbon dioxid. The favorable action of the insufflated oxygen may be explained in various ways. It may simply be due to the presence of the oxygen in the blood serum in greater quantity, as a consequence of the greater oxygen tension in the alveolar air. It may be further assumed that in certain pathologic conditions the hemoglobin is not saturated with oxygen and therefore takes it up readily from the serum, and furthermore, in certain stages of the

disease the oxygen thus taken up may be retained by the hemoglobin for shorter or longer periods even after the oxygen tension in the alveolar air and in the serum is again reduced. The same may perhaps be said of the other vital body cells, the nerve cells of the medulla and the cells of the circulatory neuromuscular apparatus. In the course of a disease either the cells are gradually receiving less and less oxygen, or they gradually lose the capacity for storing up oxygen, or both. There are other possibilities; but I shall not merely speculate as to which of these possible factors were the effective elements in the observations previously mentioned. But I shall point out the following facts. In one case of pneumonia the cyanosis returned immediately when the oxygen insufflation was stopped. In this case surely the vital cells had no longer any storing capacity. This patient died one hour after the insufflation was installed. In the case of another patient the insufflation had at first a marked after-effect when the insufflation was discontinued, but gradually this storing capacity disappeared and the patient was kept alive for several hours longer by continuing the insufflation without intermissions. In this patient, when the insufflation was first begun, some degree of storing capacity of the vital cells for oxygen was still present, but it was on its down-hill course, which the oxygen insufflation could neither revert nor stay. In my first patient each series of insufflations was followed by a period of freedom from cyanosis. These periods were short, but for five hours the periods did not become shorter; "the patient held his own," and he died suddenly when the period before oxygen could be again administered became too long. In this patient the down-hill course was stayed; whether it could have been reverted by further administration of properly timed insufflations of oxygen was at that time more than doubtful. But the condition of the fourth patient, who actually recovered, was, when first seen, as grave as that of the last patient. Nevertheless, the rhythmic oral insufflation of oxygen not only stayed the down-hill course, but undoubtedly assisted in reverting it to normal.

To recapitulate briefly: Four cases of pneumonia due to pneumococcus Type II were treated by oral insufflation of oxygen. In all cases the treatment began when the condition of the patients was already very grave and apparently hopeless. In all cases the cyanosis improved soon after the insufflation was started. In one case the cyanosis returned immediately after the insufflation was stopped. There was apparently no more storing capacity whatsoever for oxygen. That patient died one hour after the beginning of the treatment. In the second case there was at the beginning a definite storing capacity for oxygen which, however, gradually disappeared. The life of that patient was then kept up for several hours by continually administering the (rhythmic) insufflation of oxygen. In a third case the storing capacity was small but remained unchanged for five hours. The patient died during a prolonged period when oxygen could not be readily procured. The fourth case, which practically was as hopeless as any of the foregoing, showed a definite reversion in the direction of recovery about two hours after the treatment by means of oral insufflation of oxygen was begun.

It seems justifiable to assume that the period of definite cyanosis is preceded by a more or less long period during which the capacities for taking up oxygen, and storing it, by the vital cells, are gradually

getting impaired; and it is further justifiable to assume that during early pathologic periods the insufflation of oxygen may be capable of restoring these capacities to their normal extent more frequently and efficiently than during later stages. The early insufflation might thus be the means of preventing the disease from reaching the stage of cyanosis. In other words, early administration of oral insufflation in pneumonia and similar diseases may prove to be a real therapeutic measure. In normal conditions the individual inhales air which contains about 30 per cent. oxygen above the physiologic need. This surplus presents the factor of safety for the healthy, moderately active individual. During sickness that gradually leads to respiratory insufficiency, the loss of the capacity of the vital body cells for taking up and storing oxygen, the factors of safety for this vital gas ought to be then considerably larger than in normal conditions. It is true that, experimentally, we shall be the losers. If the patient recovers under early administration of oxygen insufflation, we shall in most cases be deprived of the absolute evidence that the recovery was actually due to the treatment. But we must give the benefit of doubt to the patient.

I recommend, therefore, that in pulmonary and cardiac disease oxygen should be administered by means of the oral insufflation several times a day at an early period when there is not yet an urgent necessity for it. Oxygen should not be considered as a terminal measure. On the other hand, it ought to be emphasized that oxygen should not be considered as a specific, and its use should by no means eliminate the use of other promising remedies. On the contrary, oxygen may make the body cells more amenable to the curative action of other therapeutic agents. Furthermore, the oral insufflations offer a chance to other therapeutic agents to develop their favorable action.

THE PLACE OF INFANT WELFARE IN PUBLIC HEALTH INSTRUCTION*

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Hygiene has been defined as that department of knowledge which concerns the preservation of health. It not only includes the various branches of the so-called medical sciences, but lays tribute on any knowledge or practice which may be serviceable in combating disease and in promoting health.

It is the fundamental duty of all governments to provide for the safety of their people, even at the sacrifice of individual right, liberty and property. This function is exercised under the common law as a police power, and implies the right of a government to secure for its subjects healthful living conditions. Under the government of the United States, the authority for this sanitary provision is vested in the separate states, rather than in the federal government. The latter exercises its right of control only in exceptional cases, namely, in interstate traffic, in cases of threatened general epidemics, and in maintaining advisory authority over quarantine. This federal con-

trol is exercised through the Public Health Service, a branch of the Treasury Department, while supervision over food and drugs is under the control of the Department of Agriculture; whereas the vital statistics, which form so fundamental a part of all public health work, is a division of the Bureau of the Census of the Department of Commerce.

Prior to the nineteenth century, boards of health were organized in the larger cities along the Atlantic coast, but little was done except when outbreaks of severe epidemics required that unusual steps be taken to control them. Later, local boards of health were formed in other inland communities; but the first state board of health was organized in Massachusetts, in 1869. Since then, in practically all the states, some duly authorized body has had charge of matters pertaining to public health. In many states there are laboratories where various examinations are made for physicians practicing in the state. In the laboratories of other states valuable research work is being carried on.

The functions of the state boards of health have been developed in a haphazard rather than an orderly fashion. Each state has gone its own way, often regardless of the experience of other states and countries, and much time, money and labor have been wasted because of lack of cooperation. This is in no small measure due to the domination of politics and to the fact that there exists in the United States a serious lack of trained and experienced hygienists.

To supply this need for competent workers in public health, a number of medical schools are offering more or less extensive courses in preventive medicine, and there are a few thoroughly equipped institutes of hygiene.

In connection with ten medical schools, at present, graduate courses in public health have been established. Seven of these schools give the degree of Doctor of Public Health, three after a two years' course, and four after a one year course. The degree of Certified Sanitarian is given by one university, after a one year course, to graduates of arts and sciences. The degree of Master of Public Health is conferred by two medical schools, and the degree of Master of Arts of Public Health, or Master of Science of Public Health, is given by three other universities, and the degree of Graduate of Public Health by one.

The subjects considered in one of the more complete courses in public health include preventive medicine and sanitary science, consisting of epidemiology and tropical medicine; personal hygiene, having to do with choice of foods, ventilation, exercise, sleep, etc.; industrial hygiene; public health administration; sanitary biology and chemistry; communicable diseases; sanitary engineering; demography; eugenics; infant mortality; school hygiene, and tuberculosis and venereal prophylaxis.

Even such a cursory summary of information to be obtained at a well established school of hygiene must convince physicians and intelligent laymen of the value to the future well-being of the country of the propagation of such knowledge; and all physicians will admit that but a small proportion of this knowledge, in its relation to public health, is given in the ordinary medical school curriculum. In other words, it has become evident that preventive medicine is a distinct, specialized science, offering unusual opportunities of service to those well equipped students who care to pursue it.

* Read before the Section on Preventive Medicine and Public Health at the Sixty-Eighth Annual Session of the American Medical Association, New York, June, 1917.