

THOMAS (J. D.)

WITH THE AUTHOR'S COMPLIMENTS.

Nitrous Oxide Gas Viewed from a Practical Standpoint.

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NITROUS OXIDE GAS VIEWED FROM A PRACTICAL STANDPOINT.

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I DESIRE to acknowledge the compliment paid me in the invitation to present a paper upon a subject of so much importance to the dental profession as nitrous oxide gas ; yet I respond with feelings of the greatest trepidation and reluctance, being borne down by a consciousness of my inability to present the subject in a way at all commensurate with its merits.

It has been my lot in life to have been connected with its use in an entirely practical way ; so, with your permission, I shall confine my paper to the consideration of the subject from this standpoint, leaving the questions of its physiological and pathological action for others to consider who make a special study of these departments of science.

It is now some twenty-eight years since nitrous oxide was introduced, or rather its use revived, by the efforts of Dr. Colton, for the purpose of extracting teeth, when, like every new thing, it had its way to make against opposition and prejudice in the profession and the suspicion and fear of the public. Like everything which possesses true merit, it grew from the first in popularity, and has continued to do so, until to-day it is regarded by everyone as the safest of all anesthetics, and pre-eminently the most desirable for dental purposes.

That nitrous oxide is a perfectly safe anesthetic—safe, I mean, from fatal consequences—seems hardly to admit of question, as is demonstrated by the testimony exhibited in the thousands, if not millions, of people to whom it has been successfully administered.

There is no record by which it can be accurately ascertained how many people have taken it since it was introduced in 1863 ; but the



latest, and probably most nearly correct, computation is that given by the late Dr. J. W. White in Dr. H. C. Wood's paper upon anesthesia, read before the Berlin Medical Congress in 1890, in which it is estimated that fully seven hundred and fifty thousand people annually inhale it in this country alone.

Dr. W. F. Litch, in an article upon anesthesia published in the "American System of Dentistry," has made a very careful and complete compilation of all the fatal cases attributed to nitrous oxide, and he there shows eleven cases of death; but in a recapitulation he eliminates four of them from the list as being in no way connected with the gas. Of the seven remaining, you will notice five of them occurred in Europe and but two in this country. If, as they say in stock speculation, we strike an average by dividing twenty-eight, the number of years in which nitrous oxide has been in use, by two, which would give fourteen, and multiply the annual number—750,000—by it, we would have 10,500,000 people who had taken the gas in this country, with but two deaths resulting therefrom. Of these, the first occurred in 1864,—within a year after the beginning of its use. It is said the patient recovered from the effects of the gas and walked into an adjoining room apparently well; he shortly returned and complained of shortness of breath, sank upon a sofa, and expired in a few moments. The coroner's verdict was that death was caused by congestion of the lungs, induced by the inhalation of nitrous oxide.

It is difficult to comprehend how the inhalation could have produced congestion of the lungs, as an after-effect to have caused immediate death; and I would be inclined to think it more from nervous depression and final heart-failure, which could have been from reaction rather than congestion. At all events, the explanation of the result seems hardly satisfactory in the light of our present knowledge, and the case is a doubtful one as attributed to the effects of the gas.

The second case is reported as follows: "In Chicago, October, 1871, a patient died under the influence of nitrous oxide, in the office of a dentist two or three days before the great fire which destroyed the most important part of the city. As a consequence of the confusion produced by that event, the fact of the death became known to but few persons, and was soon forgotten." Here, then, are two cases only, which at best are somewhat obscure, which can be produced in a record of a possible 10,500,000 administrations, after having been used by practitioners of all grades of experience and capability, from the young graduate just out of the clinic to the specialist who may have given it to thousands; from the most ignorant to the most learned in the profession. This is why we can claim for nitrous oxide that it is the safest of all anesthetics, and yet I do not think anyone would presume to declare that there is no danger to be

feared from its use ; on the contrary, there are serious forms of dangers in connection with its use which, as one becomes familiar with its effects, lead him to marvel that so many have escaped. Any agent which will produce unconsciousness in the strongest man within a minute, as nitrous oxide will do, we must admit is carrying him toward the point of final dissolution at a pretty rapid rate ; but fortunately the natural effects of the gas are accompanied by such distressing appearances that even the most inexperienced is made cognizant of approaching danger, and herein lies a principal element of the safety with which its use has been attended.

While from the foregoing facts you may agree with me that nitrous oxide is as nearly an absolutely safe anesthetic as would seem possible to obtain, it has not proven so perfectly satisfactory in other respects to the general practitioner. In our cities, extracting and using the gas have been in a large degree transferred to those who make that branch of dentistry a specialty ; and it is here where its great advantage to the dentist, as well as to his patient, is particularly demonstrated, but it nevertheless possesses great benefit in general practice.

To make the use of nitrous oxide perfectly successful, there are some factors which are absolutely necessary.

In the first place, the gas must be perfectly pure, and, if kept over water, must be fresh. The ammonia nitrate should always be tested before decomposition, and if there should be found the slightest trace of any chlorides it should be discarded. Although you may use wash-bottles for the purpose of eliminating the chlorine, experience shows that it will fail to do so, and the presence of chlorine in the gas will produce very grave depression of the heart's action, as well as general prostration. Care should also be taken to guard against the application of excessive heat in its manufacture. Gas made at too high a temperature will cause your patient to exhibit rapidly the signs of anesthesia, with highly accelerated heart-action and respiration ; yet the moment the operation is commenced he will manifest great mental excitement and become almost unmanageable in his struggles, followed with general lassitude from reaction ; and though no particularly alarming or serious symptom may appear, there is dissatisfaction to both your patient and yourself.

At the present time, however, the dentist is relieved of the cares of manufacture by being supplied from the dental depots with the gas compressed in cylinders, which from the precautions taken in its preparation ought to be free from impurities.

The inhaling apparatus should be as simple in its construction as possible, with openings sufficiently large to permit the patient to breathe with no more exertion than is required in natural respiration. In my own practice we use a large inhaler made of vulcanized rubber,

with flexible valves made of rubber-dam. It is necessary to use props to keep the jaws apart. During complete anesthesia the muscular system becomes more or less rigid, and, unless the prop is used, the time necessary for the operation is lost while endeavoring to force the mouth open.

It is desirable also that the chair used for extracting with the gas should have the footstool detached. Patients are sometimes restless, and any movement of the legs or feet upon a stationary footstool will be felt upon the head and upper part of the body, resulting in great interference with the operation. With the stool separate and on casters, it is readily pushed away and the head kept in repose.

With pure gas and a perfect inhaler, together with the foregoing precautions, one is well equipped for a successful administration.

For extracting, it is desirable that the forceps should be so constructed that the operator may stand in one position, and make one pair do as much as possible; in this way six or seven pairs will be found sufficient for all ordinary purposes. The beaks should be well sharpened, so there will be no slipping; serrated points and beaks, except in the molar pairs, are of little use in extracting with the gas. You want your forceps so that it will not be necessary to make a second effort upon one tooth.

With these essentials, together with a proper amount of experience in its management, nitrous oxide will justify its claim to being the best anesthetic for dentists' use, for under such conditions you can put your patient to sleep, perform the operation, and have him return to consciousness inside of from one minute and ten to one minute and fifty seconds; and during this interval, with conditions favorable, the patient will pass into what is to him a pleasant sleep without the least excitement or resistance, and awaken delighted with the result, sometimes declaring he was not cognizant of a moment's unconsciousness, and wondering when and how the tooth could have been extracted without his knowledge. During this short period the operator will have had time to extract from one to twelve, fifteen, or eighteen teeth, according to the character of the teeth and his own dexterity.

Your essayist recently took from a lady, in the presence of her dentist and her family physician, the whole number of the thirty-two teeth; of these the upper sixth-year molars were decayed to the bifurcations, which necessitated the removal of each of the six roots separately, making the operation equal to thirty-six extractions, while the patient remained unconscious of a single tooth having been taken from her mouth. This case is not cited to claim any superiority in skill or dexterity, but to illustrate what can be accomplished by adopting a system which will enable one to perform as much as possible in the shortest space of time.

I have said these results will appear when conditions are favorable, by which I mean, besides the essentials of pure gas, etc., you must have a patient of good health, whose circulation and respiration are in a condition of normal equilibrium. Under such circumstances the results may nearly always be counted upon as proving satisfactory to both the operator and the patient, and such will appear in the great majority of cases.

While the foregoing is true, it may also occur that some cases may be met in which the results are not entirely satisfactory even to the most experienced operators, or at least require the greatest amount of effort and care to make them so to the patient. The idiosyncrasies of different people are as varied as are the temperaments of the individuals.

The most common of the disagreeable cases are those of overwrought nervous organizations, who, from trepidation in anticipation of the operation, will be under great excitement, but at the same time keep themselves under splendid control until they are recovering, when they will give way unconsciously to more or less violent crying and lamentations; particularly is this the case if the patient has recently been the subject of family bereavement. Others, again, will make such an exhibition just at the point of unconsciousness, and continue until anesthesia is thoroughly produced, when they will become quiet, and remain so until the same point is reached toward recovery. These cases require care to prevent stoppage of respiration by allowing the blood or saliva to flow into the larynx during the paroxysm, otherwise they need cause no anxiety, and they will afterward express satisfaction with having been relieved of the pain of the operation, and soon forget that which was disagreeable.

Besides these, you may meet men upon whom the effects produced will be in keeping with their habits of life; for instance, a policeman may imagine he is about to arrest a desperate character, and will probably mistake the operator for the villain. A trainer of trotting horses may think he is driving his pet horse at a high rate of speed; or you may meet a man of a quarrelsome disposition, and if he be one addicted to the whisky habit, he will be all the more difficult to manage; but they are all easy of control. The excitement lasts but a few seconds, and you want to be prepared to hold them firmly in the chair until they are reasonable, and under no circumstances allow them to get away from you.

The explanation of these phenomena is easily found when we understand how the gas generally produces its effect upon the nervous system.

Dr. Arthur S. Underwood, of London, very aptly illustrates the progressive action of the gas when he says in his notes upon anesthesia that it paralyzes the nerve-centers in a certain order, as follows:

1. The cerebrum, destroying volition so that action is no longer designed or controlled by the intelligence of the individual.

2. The sensory centers of the cord, after which movement is erratic and not even responsive to the sensory stimulus.

3. The motor centers of the cord, after which movement ceases ; and lastly, the sensory and motor centers of the medulla, after which respiration, the heart's action, and all the functions of life cease.

Anyone familiar with the progressive effects of the gas will readily recognize the correctness of the foregoing divisions, which explain the phenomena referred to in the cases cited. Take cases of exhibition of grief. The sensory and motor action of the cord being impressed by the weight of mental anxiety from fear of the operation and grief, will give way independent of volition ; so also in the cases of the policeman, the trainer, and the fighter. In this condition of cerebral paralysis, while the spinal cord may yet be in its normal state, the reflex impression will cause the patient to cry out and give every indication of suffering pain when the operator begins too soon or continues too long, and yet upon recovery from the effects of the gas he will declare that he was unconscious of anything.

I could relate numerous instances of this condition, but will only mention one, of a servant girl who was to have the two superior wisdom-teeth extracted. After one was removed and the prop taken away, the mouth closed so tightly that it was impossible to get at the other tooth. My assistant commanded her in a loud tone to "open her mouth," which she immediately did, and the tooth was extracted. Upon her recovery she asserted that she knew nothing of the command or the extraction. The sensory and motor nerves were not at that time affected by the gas, while the cerebrum was. With these points in view many of the disagreeable features may be averted, if care be taken not to begin too soon or to continue too long.

These cases constitute the great majority of all that one has to operate for in a general practice which are likely to cause annoyance ; but with them all the question of danger can be largely left out of consideration, for with proper care to protect them from accident nothing more serious than the hysterical excitement will occur.

You will, however, occasionally meet a case which will cause you great anxiety, beside exercising your energy to its utmost to bring about a recovery. Fortunately these occurrences are very rare, and as you gain in experience you can make them more and more so.

These conditions are exhibited in cases of constriction of the glottis, or swallowing of the tongue, as it is sometimes called ; suspension of breathing ; convulsions ; heart-depression ; and a prolonged narcosis, similar in its expressions to laudanum-poisoning. Of these, the first two are, I think, produced by and dependent upon the condition of

asphyxia, which I will refer to again, which accompanies the inhalation of the gas.

In cases of constriction of the glottis or swallowing of the tongue, the patient presents an appearance of endeavoring to breathe with violent effort from the diaphragm and chest-muscles, while the passage of air to the larynx is prevented by complete closure. He will become very dark in the face, with eyes protruding, and show signs of rapid strangulation, accompanied with extreme rigidity of the whole muscular system, which adds to the difficulty. This stoppage may be effected by a spasmodic contraction of the palatal and hypoglossi muscles,—drawing the palate closely to the base of the tongue, which is also well drawn toward the throat. This condition is not necessarily alarming, for by pulling the tongue well forward air will pass readily to the lungs and recovery rapidly follow.

The serious cases, however, are those where the contraction includes the whole pharyngeal space about and above the larynx, drawing the tissues over the glottis so tightly that to produce a passage for air seems almost impossible. The remedy is to pull the tongue well out of the mouth with a dry napkin if possible; or with a tenaculum or tongue-forceps, being sure that the back part of the mouth is free from blood and saliva, then with the fingers upon the roof of the mouth lift the head as though you would raise the whole body. This motion will produce the effect of stretching the neck, and is usually sufficient for relief. In the one case in my experience where this was not effectual, relief was obtained by placing the first and second fingers far down the throat and separating them opposite the glottis. After you have succeeded in admitting air to the lungs, say two or three breaths, the blood assumes its red color, the constriction is relieved; and if you are strong-nerved and sufficiently composed you can proceed with your operation, and have ample time to complete it before recovery, at which time your patient will have no knowledge of anything having been done or of the precarious position he has been in; and what is to me the most astonishing thing about it, he seldom feels any ill effects from his strangulation further than, perhaps, a heaviness about the head and a soreness about the throat the next day.

These are cases which will occur less frequently as one becomes familiar with the use and effects of the gas, and yet the peculiarities are such that it would be impossible to describe them so as to enable a novice to avoid them. From experience, one grows to recognize in people idiosyncrasies which are indescribable. I have gone from my office and met people a square away and turned to follow them directly to the house, recognizing the peculiar expression of supplicating timidity, combined with anxiety and suffering. So one can become familiar with the appearance of people in which the different exhi-

bitions of the gas may take place. I have noticed that the men in which the effect occurs (I have never noticed it in a woman) are of medium build, with light florid complexion, exceedingly red lips and mucous surfaces, rims of the eyelids more or less congested, and small or receding chin. These persons show markedly the oxygen starvation which accompanies the inhalation of the gas, and exhibit the muscular contraction and convulsive action very readily.

The second class of cases which exhibits elements of danger is that of suspension of breathing. By this I do not mean the hysterical strain in people who recover with violent crying,—this is more noticeable in children, but seldom goes to a point to excite anxiety,—but the suspension of breathing from physiological causes. Of these, three kinds are recognizable :

The first will take place immediately upon loss of consciousness, and is a repetition of the effects described before, where the patient, while volition lasts, has been persuaded against his will to continue breathing the gas. The sensory and motor ganglia, being as yet unaffected, will afterward carry out the feeling of resistance by a sort of mentality of their own, and breathing will cease ; sometimes this persistence will continue so as almost to produce suffocation. On removing the mouth-piece and pressing a finger against the fauces he will resume respiration with a gasp, and you can proceed with the administration.

The second kind consists of those who exert themselves to breathe immoderately deeply and rapidly, so that when the action of the lungs is no longer controlled by volition breathing will cease from fatigue and rest follow involuntarily for several seconds, sometimes requiring considerable effort to bring about a resumption of the normal action. In both of these cases it is important to recognize early the cause and effect, and to apply the proper remedy promptly, remembering that while respiration is suspended the anesthetic effects are continually increasing, particularly that phase which is produced by what is known as the want of oxidation.

The third state of suspension is produced legitimately by the physiological effects of the gas, and its accompanying asphyxia directly upon the nerves which control the action of the diaphragm and lungs. To my mind this condition is caused more by the apparent asphyxia, or want of oxygen, than by the actual effect of the gas. Of course, an excessive dose of the gas might produce this effect, as it has been reported in most of the cases of death in animals that the lungs ceased their action before the heart ceased beating ; but in the cases to which I refer there will be no indication of an overdose ; in fact, it will sometimes take place before the patient is sufficiently under the influence of the gas to permit of operating.

The appearances presented by persons in whom this phenomenon is likely to take place are sufficiently clear to excite suspicion and to put one on guard, and with these premonitory indications it is usually an easy matter to avoid the point of danger. This suspicion may be aroused by persons of dark-colored blood, as shown at the lips, and you will notice that such people take very slow and shallow inspirations naturally, showing that their blood appears already heavily charged with carbonic acid ; or rather they do not breathe a sufficient amount of oxygen to relieve the blood of its accumulated carbon, and at the first inhalation the dark appearance begins to deepen. They will be in apparently good health, and as far as the lungs are concerned may be entirely free from disease, but are seemingly particularly weak in their breathing function, which will sometimes be as low as twelve or fourteen respirations to the minute. As the effects of the gas progress, the discoloration increases, the breathing grows slower and less deep, and, should you continue the administration, would cease entirely. By a wise dispensation, the admission of atmospheric air to the lungs is the great antidote for the ill effects produced by the gas in these especial cases, so if one grows sufficiently familiar with the indications preceding this effect and admits the air soon enough, respiration will be resumed and no bad result will occur.

Should the respiration cease, then every effort should be made by artificial means to restore it as quickly as possible, remembering that the condition of deoxidation is in a great measure responsible for the effect ; and the heart's action still going on, every second lost adds so much more to the depth of the impression on the nerves already paralyzed.

Several methods of artificial respiration have been recommended. The idea, of course, is to get air to the lungs with as little loss of time in preparation as you can, and before resorting to other methods I would suggest that (your patient sitting in the chair with his feet resting on the footstool) you press the body forward until the chin will come as near the knees as possible. This motion will force the abdominal viscera toward the lungs, thereby emptying them of the gas ; then raise the body to the perpendicular position—keeping the tongue well forward in the mean time—and lift the head and arms, which will tend to inflation ; then again pressing forward to the knees, repeating until the blood begins to assume a red color, when the diaphragm will take up its natural action and recovery will be speedy and complete.

I have said that to my mind these effects are produced more by the accompanying deoxidation of the blood than by the direct effects of the gas ; and it is of interest that we should discuss just what the effects of the gas are and how produced.

There have been different theories upon the subject. First, it was thought to produce anesthesia by overoxidation, because of its containing another equivalent of oxygen as compared with atmospheric air; but it has been shown that it goes into the lungs nitrous oxide and comes out the same, with a decreasing amount of carbonic acid, showing that no separation of the oxygen from the nitrogen takes place. A later theory assumed that the gas possessed no anesthetic properties in itself, but its effects were produced solely by the condition known as the want of oxidation, or deoxidation of the blood.

If such were the case, any agent which would cut off the oxygen supply would produce the same effect; but there is nothing known that will produce a similar result in the like space of time. Probably the most nearly correct theory is, that we have a dual effect produced: one by the gas, which is as pure and legitimate an anesthetic or narcotic as any now known, and we have the accompanying effect of deoxidation, which helps to produce the anesthesia, but which is responsible for the disagreeable symptoms such as the asphyxiating appearance, violent twitching, and convulsive muscular contraction. If we could eliminate that which produces this condition, we would, I think, have all that could be desired in an anesthetic for dental use.

To meet this great desire, it has been suggested that the gas should be mixed with pure oxygen, or diluted with atmospheric air, but I have never learned that these efforts have proven satisfactory.

It is not admissible to previously dilute the gas with air, for the reason that you meet patients of such diverse constitutions that some will fail to come under its influence at all. There are some men who can drink an inordinate amount of whisky with impunity, while others are easily affected with half the amount or less; so you will find it with the gas: some will require a greater quantity than others, and if it is diluted with air complete narcosis is utterly impossible.

However, the evil effects of the lack of oxygen can be mitigated very perceptibly by allowing a small amount of atmospheric air to pass through the nose and between the lips when the inhalation is about half completed; not enough to counteract the effects of the gas, but just sufficient to supply a little oxygen to relieve the intensity of the discoloration, and herein lies the secret of avoiding the dangerous symptoms which I have endeavored to describe in the constricted glottis and suspended breathing. By so doing I have frequently administered the gas in this way to the same patients without the least inclination to contraction or stoppage of respiration. In long operations, where the patient has been under the influence from three to eight or nine minutes, alternating a breath or two of the gas with one of air, there has been but the least discoloration imaginable, and none of the stertor and severe twitching which were shown where the pure

gas was given. It is the knowledge of this fact which leads me to condemn the use of the hood or face-piece so much in vogue in Europe, and which I am sorry to see is recommended in this country. You want full view of the lips, so that you may see to what extent discoloration is taking place, which with the mouth-piece and face uncovered can be relieved to a great extent, and that, too, without prolonging the period of inhalation more than a breath or two.

Convulsions will sometimes occur in young persons subject to epilepsy, and it is well to refuse to administer it to those who are liable to frequent attacks, although that fact does not render it certain that such an effect will be produced. In one case in my own experience the young man was sixteen years of age, and had been subject to these fits about every four or five weeks, and it had been just four weeks since his last attack when I successfully gave him the gas. Another case was a boy fourteen years old, who had never had an attack since his fifth year, before which time he was seriously affected by them, and I have never learned that he has had any since; and yet we have given the gas to probably hundreds who were thus afflicted who in no way exhibited the least sign of anything of the kind.

There is little that you can do in the treatment other than to try and prevent deoxidation of the blood as much as possible, and relieve that which is present by placing the patient upon the floor, resorting to means for producing artificial respiration, and waiting until the spasm is relaxed and breathing is voluntarily resumed. After he has recovered he will feel the usual dullness of intellect, which gradually passes away, and a disposition to sleep, which is permissible.

We have another exhibition which I have spoken of as extended narcosis, resembling laudanum-poisoning. These are cases of hysterical subjects who have catalepsy in addition, and I suppose the condition might be considered perhaps more properly a severe cataleptic fit, produced by the gas, except that it is an effect produced upon the cerebro-spinal system by the action of an agent which is narcotic, and the cataleptic rigidity is wanting. I suppose in the use of any anesthetic or opiate the result would be the same.

No unusual symptom is noticeable during the inhalation, nor until recovery should be looked for; the blood resumes its natural color, and the heart's action appears to be normal, but respiration will be at this time slightly enfeebled; the muscular system will be perfectly relaxed, and yet unconsciousness remains. If the patient is undisturbed, respiration gradually becomes slower until it ceases altogether, and I believe life would gradually ebb away. In one case of this kind which occurred in my hands the lady's physician was present, and thought he recognized the attack of catalepsy which he had frequently seen before, and expressed no concern even when suspension of breathing

took place, as he remarked that patients of this particular temperament were not apt to hold their breath to the point of suffocation ; but in this instance it continued until the heart showed signs of marked depression, and it required our most strenuous efforts for her resuscitation. The remedies employed were artificial respiration, strong ammonia to the nose, and mustard plaster over the cardiac region. When she had recovered sufficiently to swallow, a generous dose of valerian with three or four drops of laudanum was administered internally, and later the circulation was further assisted by walking, and by rubbing the hands. The resemblance to laudanum-poisoning was recognized when consciousness was partly restored, by the patient resisting every effort made for her relief, and begging to be let alone so that she could go to sleep.

The success attending these cases depends upon the early recognition of the situation, and the promptness with which one employs the measures for their speedy restoration. Fortunately, these occurrences are very rare, as are also the three preceding forms of danger which I have endeavored to describe ; but that they are likely to and do take place is demonstrated by the experience of those who have extensively used the gas, and they constitute to my mind the four classes of dangerous effects in which, should a death occur, no other verdict than "death from the inhalation of nitrous oxide" could be rendered.

I have seen perhaps a dozen cases of constriction of the glottis, nearly a score of suspension of the breathing function, four convulsions, and five or six cataleptic cases. As one gains in experience, he is enabled to avoid almost entirely these risks by the knowledge he has acquired, which causes him first to anticipate the danger, and secondly, being familiar with the indications, avoiding it, as in the cases of constriction and suspension, by admitting a small portion of air to prevent deoxidation ; and in convulsions and prolonged narcosis using great care not to anesthetize the patient further than is just necessary for the purpose. It is better to do less than is desired in instances of this kind, so as not to produce the impression of profound anesthesia.

Other cases requiring special care are persons of large physique and plethoric habit ; persons whose vital force is below par from overwork and worry, or from the effects of the late epidemic la grippe ; intemperate people ; consumptives ; and persons whose heart's action is weak without exhibiting any organic lesion.

In the plethoric habit, the appearance of deoxidation is so marked that it is impossible to carry these patients to the profound anesthetic state you would otherwise do for fear of actual asphyxia, and when you operate in the partial state of anesthesia—that is, when the cerebrum is paralyzed and the sensory and motor ganglia not—the involuntary resistance to the operation is such that an arterial rupture is possible.

In people whose vital force is below par, we must bear in mind that we are depressing a nervous system whose recuperative power is confined to the amount of strength the individual may possess. In such cases, a little sherry wine given as a gentle stimulant immediately before administering the gas is desirable.

Persons at all under the influence of liquor should be refused, not from the fear of danger, but to avoid annoyance, for a nervous system partially narcotized from whisky will become pretty thoroughly so if the effects of the gas or any anesthetic be added.

Consumptives require great care, for the reason that the aerating surface of the lungs is so impaired by disease that the anesthesia progresses for some seconds after the discontinuance of the inhalation ; so that in some cases it is necessary to remove the mouth-piece at the moment of unconsciousness or immediately before, and wait until the full force of the gas has been spent before operating.

In cases of weak heart-action the greatest amount of care is needed ; as much perhaps in judging when it should be given or whether it should be given at all, as in the administration. In speaking of the weak heart, I do not mean one affected by the different phases of organic disease to which the heart is liable, but where no lesion can be detected, and, indeed, the patient may even be unaware of any functional disturbance.

It is generally conceded that in cases of heart-disease where the patient is in comparatively good health there is less risk attending the administration than doing without it ; so it is a matter upon which each operator must decide by his own judgment as to whether the patient would suffer more from the gas than from shock if operated upon without it. But in cases of debilitated heart the administration seems to be attended with some risk, and it has been a matter of great interest to me to understand just what effect is here produced. The patient will seldom exhibit signs of syncope while under the gas, so it is fair to presume that it has not had a depressing effect, and yet when recovering, or shortly after, a feeling of faintness seizes him. In some people who are subject to fainting at the sight of blood this may be expected at this time, but the cases to which I refer were probably never known to faint. This effect is usually seen in patients mostly of fleshy build and of sallow complexion, indicating liver-congestion and consequently vitiated blood. I have seen blood in some patients almost of the consistency of cream in these cases. Under such circumstances the heart is under great exertion at all times to propel the circulation, but particularly so under the nervous excitement from the anticipation of having a tooth extracted, when the pulsations will run up to one hundred and twenty or one hundred and thirty. After the exciting stimulus is removed the heart will fall much

below the normal beat, which to my mind seems to be the expression of a demand for a period of rest, and is independent of any physiological effect of the gas. In such cases it is better to administer a light stimulant, and let the patient wait until he becomes more quiet and composed, when the gas may be given and the operation performed with this effect greatly mitigated if not entirely obviated.

In the event of a death taking place, under the circumstances I do not think it could be charged upon the effect of the gas, as from a physiological standpoint the anesthesia has left the nerves of the heart untouched, and the verdict would necessarily be that it was heart-failure caused by debility and excitement, or perhaps shock.

It will never cease to be a matter of wonderment, when we contemplate the thousands who take the gas while they may be unconsciously suffering from some form of heart or other affection, and consider the great nervous tension they labor under both by suffering and loss of rest in addition to the fear of the operation, that cases of death do not frequently occur from tooth-extraction even without taking the gas, for we have numerous instances where sudden fatalities have taken place,—notably Secretary Windom after finishing his post-prandial speech in New York, and the Rev. Dr. Breckinridge at the close of his argument upon the Dr. Briggs case in the Presbyterian Assembly at Detroit. These are happenings which are constantly recurring in every-day life, and there is nothing by which such a condition could be recognized as a warning against administering the gas ; so I repeat that it is a most wonderful thing that such occurrences are not frequent in the dental office.

Now, gentlemen, I have endeavored, though I feel very imperfectly, to describe the principal features of interest in the administration of nitrous oxide gas. I have been compelled to omit much detail for fear of wearying you, and I submit the matter for your discussion.

Discussion.

Dr. J. A. Osmun, Newark, N. J. The paper just read is one of the most instructive and comprehensive to which it has been my good fortune to have listened, and we are to be congratulated that we have had this subject so cleverly presented to us. The subject and its manner of presentation brings us face to face with the most important operation within the domain of dentistry, and shows most conclusively that it is no child's play to properly comprehend all the dangers that lurk around this apparently easy operation.

The doctor has gone into the practical issues and methods of procedure so thoroughly from a clinical point of view that there is little to add, except in the way of commendation and emphasis. However, there are other questions of importance involved, and it may be profit-

able to look at this subject from another standpoint in order that the fullest light may be thrown upon it.

Some of the experiences quoted are to a greater or less extent familiar to each one of us who has had any extended experience in the use of this agent. I do not wonder, therefore, that the speaker expresses surprise that so few fatal cases have resulted from its indiscriminate administration. The statement so often made, and by dentists as well as by those not familiar with its manifestations, that nitrous oxide is a perfectly safe anesthetic, should be modified to some extent, as I doubt not nearly all present will indorse. Once let the idea prevail that nitrous oxide is a *perfectly safe* anesthetic, and there will be less precaution taken than there is now, and Heaven knows that there is enough carelessness in its use at the present time.

The point is well presented, that any agent capable of producing unconsciousness and insensibility in a strong man within so short a period calls for caution, judgment, and a knowledge of no mean order; and when we take in the full significance of the condition of complete anesthesia, of the grave and frightful condition in which the patient is placed, with more than half of his vitality suspended, and the boundary line between life and death narrowed to such a near approach, coupled with the startling fact that in the hands and to the knowledge, the fidelity, and the skill of the administrator rests to a very great extent the issues, it is difficult to overestimate the great importance of this subject.

The fact so ably presented, and supported by the figures, to the effect that nitrous oxide is the safest anesthetic now known to us, is undoubtedly true; yet there have been some deaths recorded that cannot be explained away on any other basis than that they were caused by the inhalation of nitrous oxide. Then, again, many serious charges have been brought against it by persons who have inhaled it for the purpose of having teeth extracted, and who date from such a time a condition of ill health. This does not imply that it was improperly administered, nor can it be charged to a mere coincidence. There must be some foundation for the statement so often repeated.

We recognize the fact that there is a wonderful difference in the susceptibilities of different persons, as well as a difference in their recuperative powers, and also the fact that the same person will exhibit at different periods of life various degrees of vitality. All this needs to be impressed upon our minds frequently, and to be remembered when diagnosing a case for the use of this agent.

The essayist has directed our attention to the importance of being thoroughly equipped with inhaling apparatus of simple construction, gas of known purity, etc., and all other necessary adjuncts at hand, and then adds, "With a patient of good health, normal circulatory and

respiratory organs, one can expect happy results." But unfortunately all are not of this order, as is so ably shown by the writer. This fact suggests the thought, How much of a preliminary examination must be made to ascertain these facts?

The essayist has touched to a limited extent upon the supposed verdict in a case of death in some of the cases submitted for your consideration. This opens up a wide field for investigation and thought, and it cannot be well ignored by anyone who assumes the responsibility of administering an anesthetic.

I do not believe that as yet in the eyes of the law dentistry has been recognized as a specialty of medicine. If I am right in this position, then when a dentist assumes the responsibility of administering an anesthetic he must use all the precautions that would be expected to have been used by the medical man,—first, in diagnosis; second, care of the patient while under the influence of the anesthetic; third, the means used for resuscitations in case of unfavorable results ensuing; and at this point each would stand upon equal footing and be amenable to the same law. I leave with you this thought as to the necessity for the precautions I have indicated.

I will cite, with your permission, a part of a charge lately made to a jury in New York in reference to this subject: "As an anesthetic deprives a patient of the control of his faculties and renders him unable to take any precautions or make any effort for his own safety, the physician or surgeon administering it must exercise the highest professional skill and diligence to avoid every possible danger. The professional man, no matter how skillful, who leaves an essential link wanting or danger unguarded in such treatment, is chargeable with negligence and answerable for any resulting ill consequences."

This charge places us in a position that cannot be very well evaded, and points out very clearly to our mind that we are expected to know something of the previous physical history of our patient before administering this agent; and while I do not ignore the fact that the experience of the operator can see and take into account many things at a glance that will enable him to arrive at a very accurate diagnosis, I also do not forget the fact that there is an adage which reads something like this: "Familiarity breeds contempt," and the importance of the previous examination of the colleges should make this a feature of great importance.

However, the question of unskillful treatment of a patient is one not easily determined; but it seems to be a settled principle in law, that a reasonable degree of skill must be shown, and everyone who enters into a profession undertakes, in so doing, to bring to the exercise of it such knowledge. Enough along this line.

After listening to the various cases cited, of which we are all to a

greater or less degree familiar, and which we can substantiate from our own experience, we can only regret that so little is known positively of its real action upon the human economy. The therapeutic value of this agent has only been recently recognized, but in many instances physicians who have made the acquaintance of this gas have found it of value in many disorders, notably those of nervous and respiratory diseases. I have administered it with the happiest results to patients who were suffering from asthma. For insomnia it has been recommended by high medical authority, and it has been also highly urged as a therapeutic agent of great value in hysteria and melancholia.

The doctor has given us the details of the various means and methods he uses in cases of resuscitations, and there is but little to add. However, he did not mention the use of the hypodermic syringe, and the insertion under the skin of equal parts of brandy and ammonia; this is always my sheet-anchor of hope. I never administer the gas without looking at my hypodermic syringe to see if it is in good working order; it acts like magic, stimulating the heart's action and the respiration. I should like to commend this practice to you.

The paper is so full of good things, that it is only possible to touch upon a point here and there.

The experiences related, the suggestions offered, all tend to emphasize the fact that in the administration of nitrous oxide we assume a serious responsibility, and in order to measure up to the requirements we must study the question carefully, diagnose critically, exercise great care during the period of insensibility, be fertile in resources at dangerous places, and always have the third person present. I will not trespass longer upon your time; I realize how inadequate these thoughts are compared to the importance of the paper.

I can only add my personal thanks for all the many valuable suggestions I have gotten from our Philadelphia friend.

Professor S. H. Guilford, D.D.S., Philadelphia. I think I am only paying a deserved compliment to our friend Dr. Thomas when I say this is the best paper on nitrous oxide I have ever listened to or read.

The use of nitrous oxide gas has taken a firm hold upon the affections of the dental profession. It has done so because of its many advantages. There are some things connected with it that, I think, will bear repeating and keeping in mind.

First of all, in regard to its discovery and introduction. About the time that our forefathers were striking for their liberty, and in the very year, and possibly about the very time that they were framing the Declaration of Independence, nitrous oxide gas was first dis-

covered in his New England laboratory by Dr. Joseph Priestley, in 1776. About the beginning of our present century, Sir Humphry Davy first suggested the possibility of its possessing anesthetic properties. About fifty years ago, Dr. Horace Wells, of Kentucky, was the first to practically demonstrate that it did possess anesthetic properties; and though Dr. Priestley was not an American, he was an adopted citizen of America, and remained here until his death. Sir Humphry Davy was an Englishman, but Dr. Wells was American born; so that of the important facts connected with the early history of nitrous oxide, we, as Americans, can lay claim to the first discovery of the gas and the first practical application of it.

Another point to be considered is its relation to the ordinary atmospheric air. Both these substances, nitrous oxide gas and atmospheric air, are composed of nitrogen and oxygen, atmospheric air consisting of four parts nitrogen and one part oxygen, and nitrous oxide gas of one part nitrogen and two parts oxygen. In air we have nitrogen and oxygen simply mixed, with no chemical union whatever; whereas in nitrous oxide gas we have an absolute chemical combination, and we cannot, under ordinary circumstances, separate the two. So that while we breathe the air which contains a certain proportion of oxygen, that oxygen is taken up by the blood in the lungs and carried through the system and does its proper work. When we breathe into our lungs nitrous oxide gas, it is carried into the system as nitrous oxide gas, and is eliminated as such. The two elements are not separated at all. In early days it was noticed when gas was given from an ordinary gas-bag and inhaler, that when the inhalation was continued for a little while the eyelids and lips of the patient became peculiarly purple and the face assumed a singular color. That of course indicated a certain amount of danger. And it showed that the cells in the lungs were being filled with a substance that prevented the admission of oxygen. It was reasoned that it must produce its effect in one of two ways,—that it was filling the lungs to the exclusion of atmospheric oxygen, or else producing an effect upon the brain. It was supposed that as nitrous oxide gas contained an excess of oxygen over atmospheric air, it stimulated the brain; but when it was found out that it passed off as nitrous oxide, not losing any of its oxygen, that idea had to be abandoned.

Nitrous oxide acts as a powerful stimulant, and when the system is exhilarated beyond the feeling of pain it naturally produces an effect somewhat similar to hysterics.

In early days the gas was made by the dentist himself. There was great ignorance upon the subject, and there were many cases that were serious in their aspects. And it is not to be wondered at under the circumstances that a certain number of cases should be found

where death occurred. The only wonder is that death did not occur oftener. Only a certain change in the amount of heat required will form another gas which is poisonous and deadly. No doubt that gas was often formed mixed with the nitrous oxide. But as we came to better understand how to make it, the unpleasant results grew regularly less, and to-day, where the gas is manufactured pure and in large quantities under careful supervision, and is compressed into bottles that can be carried anywhere, there has not been a record of a single death that I have anywhere been able to find since we have had it in its liquefied form, showing very plainly, I think, that where the gas is properly made, and where it is pure, there is scarcely any danger. When you consider that the gas was made by the dentist himself, that it was administered almost indiscriminately without regard to the patient's condition, can you help wondering that more serious results did not follow?

Now that it has been used so often, and under so many circumstances with comparative safety, I think dentists are likely to become careless. They have secured such immunity from serious results that they may feel that the administering of gas is a perfectly safe thing. But as the essayist said, there is no absolute safety. Any change from ordinary conditions in life is dangerous. We cannot take a patient and change his condition of life, bringing him to a state of unconsciousness, to that narrow line that separates life from death, without running considerable risk. And it is for this reason that persons who give the gas, even though they perfectly know how, and it is perfectly pure, should never undertake to administer it without having at hand those remedies which will counteract serious effects. And in addition we should understand how to make use of the different methods of artificial respiration, because many patients would have died but for the application of this knowledge.

Another thing the essayist did not speak of. That is the mixing of nitrous oxide gas with other anesthetic agents. In this country dentists found that in a great many cases its effects did not last long enough to fully satisfy them. Under those circumstances, and not feeling that they wanted to risk the use of ether or chloroform, they cast about for some method by which they could prolong the anesthetic state after having administered the gas, and it led to the combination of the gas with some of the more lasting anesthetic agents. The difficulty is, what means should we resort to to counteract the possible ill effects of such a combination? Shall we apply the remedies of nitrous oxide, or of ether, or of chloroform, etc.?

In this way, I think, we would be liable in case accident occurred to be brought into court, and when questioned, if obliged to confess that we used a preparation like Vail's vapor, for example, and did not

know what it was composed of, our confession that we used a combination of anesthetics would be apt to cause the case go against us. Combined anesthetics have been given successfully in this country, and I notice by the English journals that they are being used in England. At the same time I agree with the essayist that nitrous oxide gas, pure and simple, answers all the purposes of the dentist so far as the extraction of teeth is concerned.

