THE ADMINISTRATION OF NITROUS OXIDE AND OXYGEN *

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Nitrous oxide has been used successfully for over one hundred years. During all this time it has been a storm center of controversy, starting with its discovery by Horace Wells, as an anesthetic. Claims and counter claims, lawsuits and Congressional investigations, abuse and insults have been bandied freely. The end is not in sight, but on some points agreement is possible.

From the patient's standpoint nitrous oxide is the most pleasant inhalation anesthetic. It is nonirritating, has an almost imperceptible odor and induces unconsciousness very rapidly, with a minimum of excitement, spasm or other disagreeable subjective symptoms. Although it is not a potent agent, anesthesia produced by nitrous oxide is adequate for extra-abdominal surgical procedures. It produces minimal postoperative vomiting and morbidity and causes the least disturbance of metabolic processes of any agent, provided adequate oxygenation is maintained. It is here that there is dissension. Is it possible to produce and maintain adequate anesthesia with nitrous oxide and at the same time avoid oxygen shortage, or is its use commonly associated with so much hypoxia that serious sequelae are to be expected?

Many authors have presented case reports describing neurologic damage attributed to hypoxia during nitrous oxide anesthesia, and the suggestion has been made that manufacturers of the gas incorporate 20 per cent oxygen in the cylinders in order to prevent hypoxia. This has even provoked favorable editorial comment in the Journal of the American Medical Association. Obviously, this is not the answer to the problem for every experienced anesthetist has seen numerous examples of hypoxia under drop ether anesthesia when the patients were breathing the 20 per cent oxygen contained in ordinary atmospheric air.

All mental abnormalities which occur after anesthesia are not the result of hypoxia. Toxic psychoses and delirium are common during the course of many diseases requiring surgical treatment. In unstable individuals the psychic shock of the operation and anesthesia doubtless serves as a trigger mechanism to initiate mental upsets of

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varying severity. Moreover, if hypoxia is the cause of the neurologic damage it may be owing to prolonged low blood pressure producing a stagnant anoxia, hemorrhage causing an anemic anoxia, or prolonged deep anesthesia so depressing the cellular enzymes that a histotic anoxia is produced. If the complications of hypoxia are to be attributed to nitrous oxide it must be shown that a true anoxic anoxia was produced by the inhalation of insufficient oxygen in the anesthetic mixture. Does nitrous oxide, therefore, produce anesthesia by an asphyxiating action because of low oxygen content in the inspired mixtures? It is true that asphyxia will produce unconsciousness, but this is quite different from true anesthesia.

A simple experiment demonstrates that nitrous oxide is not an asphyxiant but a real, although weak, anesthetic. If one breathes a mixture of 20 per cent oxygen and 80 per cent nitrogen (an inert gas) no effect is produced. If nitrous oxide is substituted for this atmospheric nitrogen most patients will enter the analgesic stage and some will be profoundly anesthetized.

Nitrous oxide anesthesia is not always accompanied by hypoxia. Anesthesia may be induced in many patients with oxygen above atmospheric concentrations; it is not uncommon to maintain good narcosis with concentrations of 30, 40 or even 50 per cent oxygen. Fifteen percent of patients will be in this class. The average patient, however, will require 13 to 15 per cent oxygen as the gas apparatus is calibrated. This does not represent the actual amount of oxygen received, for this oxygen is augmented by an appreciable volume in the lungs and blood stream.

It is true that many patients require less than atmospheric concentration of oxygen to obtain sufficient nitrous oxide for efficient anesthesia. How hazardous is this procedure?

The Army Air Forces, after testing a great number of individuals, decided that the atmosphere provided sufficient oxygen for combat air crews up to 10,000 feet. At this attitude, owing to the decreased atmospheric pressure, only 14.25 per cent oxygen is available, yet these fliers engaged in active combat without distress. It is true that they were normal individuals, but their demands for oxygen must have been much greater than that of the anesthetized, premedicated patient. In fact, it is common knowledge that altitudes of 11,000 to 12,000 feet, supplying as little as 12 to 13 per cent oxygen, are tolerable to average individuals. This might be explained by a study of the dissociation curve of hemoglobin which, at pressures of only 50 per cent of normal, still has an oxygen saturation of over 80 per cent. Furthermore, carbon dioxide flattens out the dissociation curve of hemoglobin, making more oxygen available in spite of reduced pressures. Small amounts of this gas, which are usually present when carbon dioxide absorption is not used, seem to be helpful clinically.

TABLE I

SIGNS OF HYPOXIA

	Mild	Severe
Respiration	Stimulated	Slow and irregular (Cheyne-Stokes)
Pulse	Increased in rate	Slow, irregularities common
Blood pressure	Increased	Depressed
Muscles	Spastic	Relaxed
Skin	Commonly cyanotic	Pale or gray

Only by continuous, close observation of the patient for signs of hypoxia can they be detected. The anesthetist must know them thoroughly (table 1). Manifestations of mild hypoxia should be corrected by the addition of more oxygen as soon as possible. Small volumes should be added and the results carefully observed. If this results in anesthesia which is too light, some supplementary agent must be used. Severe hypoxia is an emergency that requires immediate correction.

For safe and successful nitrous oxide anesthesia the following technical points are important.

Premedication must be used in every case in which prolonged or deep anesthesia is required. Let us assume that in a hypothetical case it is necessary to administer 15 per cent oxygen for basal requirements and to avoid signs of hypoxia. No more than 85 per cent nitrous oxide can be given. Leakage of nitrogen from the the atmosphere decreases both oxygen and nitrous oxide, making the administration inefficient, hypoxic or both. Air dilution is fatal to good anesthesia with nitrous oxide. If this individual is a difficult subject there will be a tendency to increase the nitrous oxide, with a resulting decrease in the oxygen, perhaps below safe levels. If a narcotic is given to this patient, reduction in the oxygen requirements will result. (Morphine sulphate, ¼ grain, will reduce the basal metabolic rate about 10 per cent.) Thus, more nitrous oxide can be given, producing more efficient anesthesia, and at the same time basal oxygenation can be maintained.

Fractional rebreathing has several advantages over a complete rebreathing technic. I have mentioned that the retention of small amounts of carbon dioxide increases the amount of available oxygen. Successful anesthesia is impossible to attain if the exhaled nitrogen from the lungs and circulation is allowed to accumulate in a bag and be reinhaled. Nitrous oxide is too weak to permit such dilution, and rebreathing during induction must be kept to a minimum or eliminated entirely until most of the nitrogen is eliminated. The administration of nitrous oxide is technically difficult, but smooth anesthesia can be obtained by close observation of the patients and rapid adjustment of the mixture to compensate for small variations from the proper plane. Small changes in the mixture cannot be made rapidly if the new mixture has to mix with a large volume of the old mixture in a large rebreathing bag.

Leaks in the system are disastrous to good anesthesia. No air must leak in, for it decreases both the oxygen and nitrous oxide. The administration of the gases under slight positive pressures keeps out air and thus greatly increases the efficiency of the administration. There is also evidence, though not conclusive, that the pressure administration of the gases results in better absorption in the circulation, with deeper anesthesia and less hypoxia.

Nitrous oxide is such a mild anesthetic agent that it must be given in high concentrations during induction if the excitment stage is to be avoided and smooth anesthesia is to be produced. The practice of diluting the gas during induction has no advantage from the patient's standpoint as small differences in the oxygen percentage cannot be detected, and excess oxygen may dilute the anesthetic to the point where induction of anesthesia is almost impossible in robust subjects.

During the administration of any general anesthetic agent it is fundamental that a free airway be maintained constantly. This is of the greatest importance when giving nitrous oxide, for the anesthesiologist is frequently obliged to give the patient a minimal amount of oxygen in order to provide sufficient nitrous oxide in the circulation for efficient anesthesia. Respiratory obstruction might curtail this minimal amount of oxygen to produce dangerous hypoxia.

Unsupplemented nitrous oxide is a pleasant anesthetic agent that is unexcelled for rapidity of induction, recovery and absence of "hangover." There is no danger of hypoxia if it is administered with ordinary care.

THE AMERICAN ASSOCIATION OF BLOOD BANKS ANNOUNCES SITE OF THIRD ANNUAL MEETING

The Third Annual Meeting of the American Association of Blood Banks is being planned for October 12, 13, and 14, at The Stevens Hotel in Chicago. The central location was chosen so that the meeting will be more accessible to members from all points of the country. The program which is being planed will be one which will attract blood bank personnel, hospital executives, pathologists, clinicians, surgeons, and other people interested in the procurement, preservation, and administration of blood and blood derivatives. For further information write the Office of Secretary, 3301 Junius Street, Dallas 1, Texas.