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# AEROMEDICAL REVIEW

## NITROUS OXIDE-OXYGEN SEDATION: USAF DENTAL GUIDELINES

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USAF SCHOOL OF AEROSPACE MEDICINE  
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These guidelines were submitted by personnel of the Dental Investigation Service Branch, Clinical Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order DSB38200.

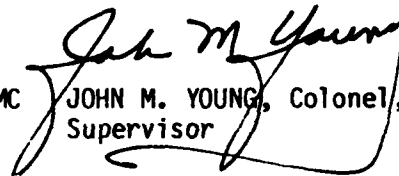
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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This aeromedical review has been reviewed and is approved for publication.



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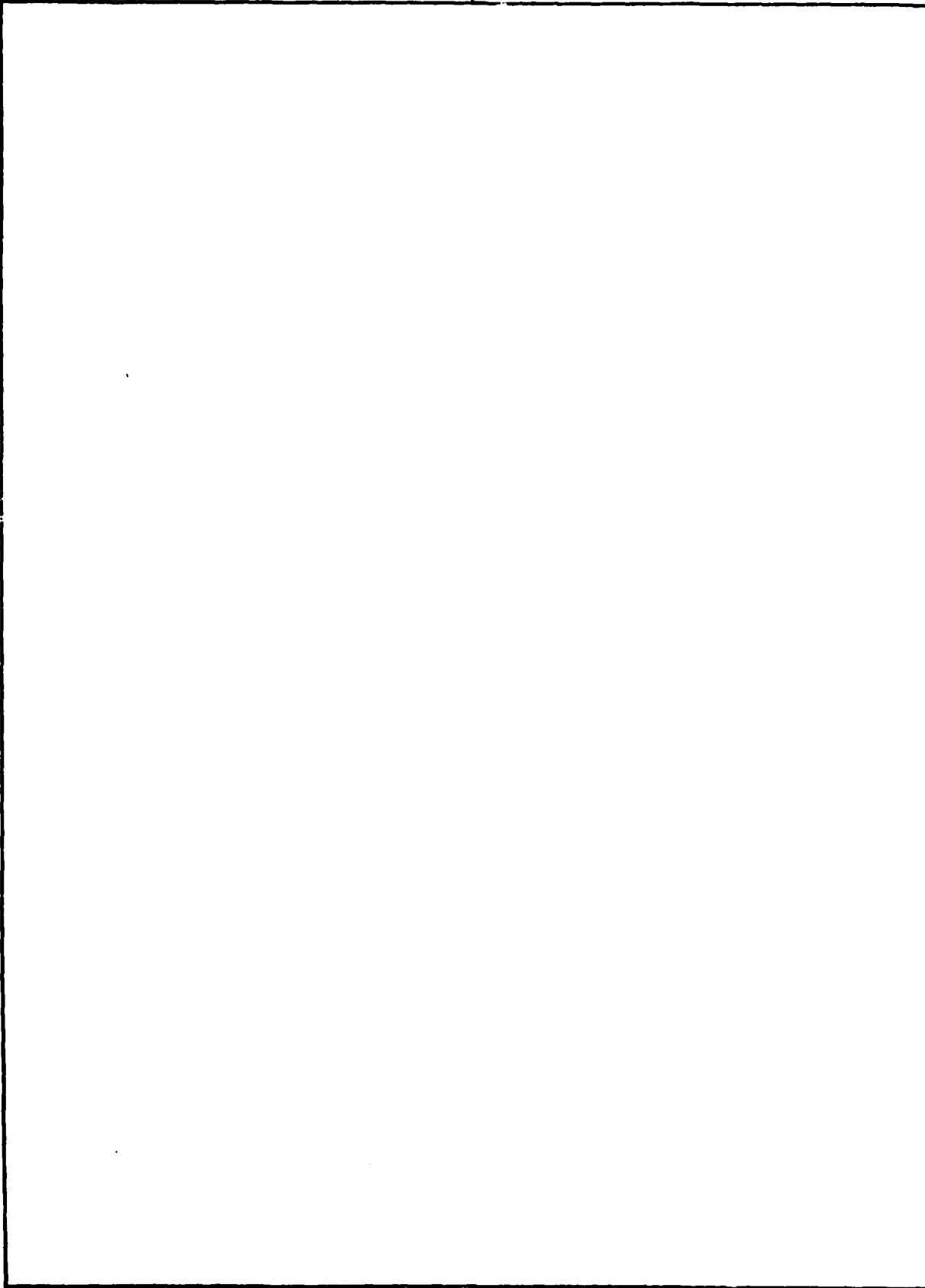
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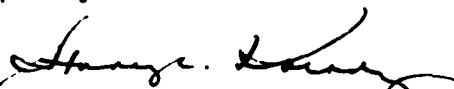
## FOREWORD

This training text is the foundation for the USAF Dental Service in-house certification course in Nitrous Oxide/Oxygen Conscious Sedation.

Nitrous oxide must be used discriminately. It may be professionally prescribed for the purpose of sedating an anxious patient or for the production of analgesia, such as might be employed for subgingival prophylaxis. Nitrous oxide will not be used in dental facilities as a general anesthetic agent.

The dental officer must be aware of the potentially dangerous side effects of chronic exposure to trace amounts of nitrous oxide gas. Equipment and delivery techniques should be monitored for gas leakage. Another potential problem is the hazardous self abuse of nitrous oxide gas. The base dental surgeon should periodically discuss the use and abuse of nitrous oxide with the dental staff and develop appropriate clinic operating instructions.

Nitrous oxide/oxygen sedation has been proven safe when used by qualified practitioners. The addition of this technique to our armamentarium will offer our patients one more treatment modality for quality care.



STANLEY C. KOLODNY, Major General, USAF, DC  
Asst Surgeon General for Dental Services  
Office of the Surgeon General



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## PREFACE

This review is the basis of the nitrous oxide-oxygen ( $N_2O-O_2$ ) sedation course and is not meant to replace textbooks of this subject. The material is primarily drawn from the following texts: *Relative Analgesia in Dental Practice* (Harry Langa, 1976), *Conscious Sedation in Dental Practice* (C. R. Bennett, 1978), *Respiratory Physiology--The Essentials* (J. B. West, 1974), *The Management of Pain* (J. J. Bonica, 1953), and *Principles of Anesthesiology* (V. J. Collins, 1976). All of these books are highly recommended as being invaluable to the dentist using  $N_2O-O_2$  sedation.

Major Ronald I. Miller, Jr. (Staff, Department Oral/Maxillo Facial Surgery, Wilford Hall USAF Medical Center) and Colonel W. Ralph Sellers (USAF Dental Investigation Service) initiated the USAF "Nitrous Oxide Feasibility Study" in 1978. As a result, Major Miller published "Synopsis of Nitrous Oxide Sedation" which was the manual used for the first USAF dental courses in  $N_2O-O_2$  sedation. The present manual is a significant revision of the previous one, but retains the many excellent points that those authors contributed. In addition, Richard S. Alley, D.D.S., University of Texas Health Science Center at San Antonio, who has taught  $N_2O-O_2$  sedation for many years and is the author of "Nitrous Oxide Conscious Sedation: A Course Manual," invited us to attend his course and provided us with many useful ideas for this manual.

Integrated with the didactic portion of this course will be several clinical sessions. These clinical sessions will--

- (1) Introduce the equipment and its parts.
- (2) Demonstrate the technique to be used on patients.
- (3) Demonstrate the effectiveness (in procedures such as scratch skin, periodontal probing, and scaling teeth) of  $N_2O-O_2$  sedation on each student taking the course.
- (4) Evaluate the student's proficiency with the  $N_2O-O_2$  sedation equipment.

A written examination will be given at the end of the course. The questions will be derived directly from the material in this manual.



## TABLE OF CONTENTS

	<u>Page</u>
INTRODUCTION .....	5
HISTORIES, PROPERTIES, AND CHARACTERISTICS .....	9
ABUSE OF NITROUS OXIDE .....	12
PROS AND CONS OF USING NITROUS OXIDE .....	13
Advantages and Disadvantages for the Dentist .....	14
Indications and Contraindications for Patients .....	15
PATIENT MONITORING .....	18
EQUIPMENT .....	20
Nitrous Oxide-Oxygen Sedation Equipment .....	20
Scavenging Equipment .....	27
Waste-Gas Monitoring Equipment .....	28
HEALTH HAZARDS AND PROTECTION FOR THE DENTAL STAFF .....	30
Area Contamination .....	30
Self-Administration .....	32
TECHNIQUE .....	33
Fundamentals .....	33
Administration .....	33
Records .....	35
REFERENCES .....	36
BIBLIOGRAPHY .....	37

### Illustrations

Figure 1. Central gas delivery system .....	21
Figure 2. Flowmeters.....	23

## NITROUS OXIDE-OXYGEN SEDATION: USAF DENTAL GUIDELINES

The objective of this course is to enable each student to:

1. Define sedation.
2. Be aware of the benefits of sedation, for the patient and dentist.
3. Know the indications and contraindications for using nitrous oxide ( $N_2O$ ) and complications associated with its use.
4. Be familiar with the potential health hazards of  $N_2O$  to dental personnel.
5. Understand and be familiar with the techniques of administering  $N_2O$ , including adequate monitoring of patients as they receive the gas.
6. Administer nitrous oxide-oxygen ( $N_2O-O_2$ ) conscious sedation in a safe and effective manner.

### INTRODUCTION

Nitrous oxide is the principal adjunct to most general anesthetics used in this country. In modern dentistry, however,  $N_2O$  is used neither as a general anesthetic agent nor as a substitute for intravenous sedation; rather it is used in combination with oxygen ( $O_2$ ) as a sedative and has its own distinct place in the control of pain. In 1978, The American Dental Association (ADA) estimated that 35% of the practicing dentists in the United States employed  $N_2O-O_2$  as an inhalation sedative-analgesic agent, and its use appears to be increasing (16). The foremost use of analgesia is to eliminate fear of the dental experience (17). In certain parts of the country, hygienists are permitted to use  $N_2O-O_2$  sedation on their patients (11).

Despite the large number of practitioners who administer  $N_2O-O_2$ , training has been relatively limited in availability and inconsistent in quality. Most dental schools have spent little time instructing their students in the use of  $N_2O-O_2$  sedation. A recent survey of technique courses on  $N_2O-O_2$  sedation found that on the average these courses lasted only two days (11).

Nitrous oxide-oxygen sedation should not be used as a pain control agent to replace narcotics, local anesthetics, or general anesthetics; it should be used only as an analgesic. In dental treatment, the greatest sources of fear appear to be the needle and the drill (3). For the patient, then, the greatest benefit of  $N_2O-O_2$  sedation is to minimize or eliminate the apprehension and fear of dental procedures.

*If we can, with the help of sedation (nitrous oxide-oxygen), repeatedly expose our fearful patient to a pleasant, non-fearful dental experience, and thereby decrease the patient's fear of future experiences, we then may be performing that patient's service far greater than the bit of dentistry we might accomplish.*

Local anesthetics are routinely used for most modern dental procedures, and N<sub>2</sub>O-O<sub>2</sub> sedation can be used in conjunction with these anesthetics to help patients tolerate the more difficult procedures such as exodontia, periodontal surgery, fixed prosthodontic tooth preparations, and quadrant dentistry. Also, N<sub>2</sub>O-O<sub>2</sub> sedation can be used alone to make some procedures, such as periodontal scaling, orthodontic adjustment, and the endodontic treatment of nonvital teeth, more easily tolerated.

The dental procedure to be performed does not dictate the particular pain control technique to be used. Rather you have a spectrum of such techniques from which to choose. The technique chosen for a particular patient should depend not only on the procedure to be accomplished, but also on the patient's psychological needs.

The following definitions will clarify the difference between sedation, analgesia, amnesia, and anesthesia--local and general:

- sedation - mild state of cortical depression in which the patient is calm and tranquil, but awake.
- analgesia - insensibility to pain without loss of consciousness.
- amnesia - loss or impairment of memory; inability to recall past events.
- anesthesia - loss of feeling or sensation, especially tactile sensibility, with or without loss of consciousness.

local anesthesia - loss of pain sensation over a specific area of the anatomy without loss of consciousness.

general anesthesia - an irregular, reversible depression of the cells of the higher centers of the central nervous system that makes the patient unconscious and insensible to pain.

Pain has been closely associated with dental procedures in the past and is one of the main reasons why people avoid routine dental care today. Pain can be divided into two phases: (1) the perception of pain and (2) a person's response to that perception. Thus to control pain, we must address and treat both of these phases. A dental patient whose pain perception is blocked by a local anesthetic may still subconsciously misinterpret modalities such as simple pressure or touch as being painful during dental treatment. In other words, controlling pain by using only local anesthetics may be very difficult in patients who have an altered pain-reaction threshold because of their fear of dental treatment. These are the patients who benefit most from some form of sedation, such as N<sub>2</sub>O, to supplement local anesthetics.

Several methods of pain control are available (3). One is to remove the cause of pain; for example, if a tooth is in traumatic occlusion, take it out of occlusion. In dentistry, the most important and widely used method for eliminating pain is to block the pain pathway with local anesthetics. Another method is to raise the pain reaction threshold with a narcotic that alters the patient's reaction to pain. This method depends on the pharmacological action of drugs that possess analgesic properties. The degree to which the pain reaction threshold is raised depends on both the drug and its dosage. In similar fashion, N<sub>2</sub>O-O<sub>2</sub> sedation raises the pain reaction threshold, but with the distinct advantage of being easily controlled. You can turn it off at any time during or at the end of a procedure.

Pain arising from a severe stimulus should be managed by one of two means: (1) a local anesthetic to block the stimulus or (2) a general anesthetic to render the patient unconscious, thus eliminating a response to the stimulus. Often neglected in dentistry is the use of psychosomatic methods (for example, hypnosis) to control pain. These methods affect only pain reaction and depend on placing patients in the proper frame of mind by gaining their trust and confidence. This is achieved in part by keeping the patient informed about the procedure that is being performed. This does not mean that you must say that you are about to push a 301 elevator into the patient's periodontal ligament to check for anesthesia. Rather, you should inform the patient that you are going to push on a tooth and some feeling of pressure can therefore be expected. The power of suggestion plays a strong role in this method and should not be overlooked (2). In fact, unless you use "suggestions" in conjunction with N<sub>2</sub>O-O<sub>2</sub> sedation, you will not realize the full potential of the technique!

To better understand the role that N<sub>2</sub>O-O<sub>2</sub> sedation plays in pain control, consider the signs and stages of anesthesia. Collins (5) bases his discussion on the four stages of anesthesia reported by Arthur Guedel in 1920.

<u>STAGE</u>	<u>CHARACTERISTIC</u>
I	- analgesia and amnesia
	Plane 1 - sedation
	Plane 2 - partial analgesia, total amnesia
	Plane 3 - total analgesia and amnesia; leads to loss of consciousness
II	- dream and/or delirium (unconsciousness)
III	- surgical (four depths)
IV	- respiratory arrest (can lead to cardiac arrest).

Maintaining the patient in a state of partial analgesia and total amnesia (stage I--plane 2) is best; avoid anything beyond this level. Unfortunately,

plane 3 leads rapidly to loss of consciousness, and once this occurs, no objective sign indicates transition to stage II. Stage II, the stage of dreams and delirium, is the state of unconsciousness with uninhibited reactions; stimulation of any kind (noxious or otherwise) can cause an undesirable or injurious response in the patient (6). Also important, only a conscious patient can cooperate by keeping his mouth open. If a patient's mouth begins to close during dental procedures, sedation may be too deep. If the patient does not respond when asked to open his mouth, sedation has definitely become too deep! (20)

For a more complete understanding of pain control by  $N_2O-O_2$  sedation, a form of conscious sedation, a discussion of the definition of consciousness is necessary. According to The American Dental Society of Anesthesiology, Inc., this definition is as follows (3):

*A patient is said to be conscious if he is capable of rational response to command and has all protective reflexes intact, including the ability to clear and maintain his airway in a patent state.*

Objectives of conscious sedation are to (3)

1. Reduce fear and apprehension.
2. Obtain patient cooperation. Once a nervous, fidgety patient is made more cooperative with sedation, the dentist can operate more efficiently.
3. Avoid loss of consciousness, thereby maintaining all protective reflexes. Primarily this includes an unobstructed airway and the patient's ability to cough and clear that airway.
4. Maintain vital signs within normal limits. The blood pressure and pulse of an apprehensive patient will be elevated. Once the apprehensions are abated by sedation, the blood pressure and pulse rate return to more normal values.

Only with experience and skill can the art of  $N_2O-O_2$  sedation be mastered.

## HISTORY, PROPERTIES, AND CHARACTERISTICS

Nitrous oxide was discovered in 1779 by Joseph Priestly. Twenty-three years after its discovery, Sir Humphrey Davey recommended using  $N_2O$  for surgical anesthesia because it could relieve pain. However, it was not used for that purpose until 1844 when a lecturer chemist by the name of Colton demonstrated "laughing gas." Horace Wells, a dentist, saw this demonstration and asked to use  $N_2O$  the next day when one of his teeth was to be extracted. Colton consented and the results were successful--Wells felt no pain. Despite this initial success, a following demonstration of  $N_2O$  by Wells was a failure. Wells was humiliated, and the use of  $N_2O$  was not revived until 1868 (5,6).

An inert, colorless gas,  $N_2O$  has a sweet nutty taste and odor. Ordinarily stored in cylinders as a liquid, it becomes a gas at room temperature and pressure.

Nitrous oxide is manufactured by heating ammonium nitrate crystals. Certain by-product impurities of this manufacturing process may be present in commercial or non-hospital-grade  $N_2O$  cylinders, and are deadly. Major impurities are (1) nitrogen, which dilutes the anesthetic; (2) nitric oxide, which can combine with hemoglobin to produce an anemiclike hypoxia; and (3) nitrogen dioxide, which is highly reactive. Nitrogen dioxide together with water vapor can form nitric oxide, nitric acid, or nitrous acid, all of which are poisonous. Once in the tissues, these acids cause pulmonary edema. Inhalation of as little as 0.5% to 2.0% nitric oxide or nitrogen dioxide for 5 to 10 minutes can have serious effects on the patient (5,18). Thus  $N_2O$  and  $O_2$  used for sedation must be of hospital grade.

A stable compound,  $N_2O$  does not react with soda lime, other anesthetic agents, or the metal parts of equipment. It does, however, impregnate and diffuse through rubber. Nitrous oxide itself does not explode, but it is a mild oxidizing agent and therefore supports combustion (5).

Nitrous oxide is 32 times more soluble in blood than nitrogen and 20 times more soluble in tissues and fat. Due to this,  $N_2O$  uptake is about 30 times the nitrogen elimination rate. Nitrous oxide is distributed to all body tissues, and its concentration in any particular tissue group depends on perfusion of that tissue and the length of exposure to  $N_2O$ .

Nitrous oxide is eliminated mainly through the lungs. When the  $N_2O$  flow is discontinued and the process of elimination begins, the greatest volume diffuses out in the first 2-3 minutes; at the end of 5 minutes, the rate of elimination is halved; after 10 minutes,  $N_2O$  is no longer detectable in the blood (5).

A problem related to the outward diffusion of  $N_2O$  is diffusion hypoxia. A patient breathing room air after a  $N_2O$  anesthetic takes up little nitrogen because of its low solubility in the blood. Meanwhile,  $N_2O$  elimination takes place at a rapid rate. The large amount of  $N_2O$  being eliminated (approximately 5 liters) causes dilution of alveolar oxygen and, hence, the hypoxia (5,23).

Because of its high partial pressure and blood gas partition coefficient,  $N_2O$  also diffuses readily from a gas-containing space within the body where the tension of  $N_2O$  is less than the tension of  $N_2O$  in the blood. For example, if  $N_2O$  is removed from a gas space to the blood, the tension of  $N_2O$  within the space will approximate blood  $N_2O$  tension. The  $N_2O$  will then rapidly diffuse out of the space, but at least 32 times as fast as the  $N_2O$  that is removed. The result is an increased number of total gas exchanges, which produces an increase in gas volume of the walls and an increase in the pressure of the walls and the space. This is the mechanism of  $N_2O$  embolism, which is indicated in the peritoneum, pericardium, pleura, and lungs. These spaces, enlarging the preexisting volume of the space, may cause a return.

Nitrous oxide can increase the volume of the space or bullos lung disease as well as in patients with cysts or intestinal obstruction. Nitrous oxide can also cause gas embolism in cavities that normally contain air, such as the middle ear, the eye, and the sinuses. These cavities are closed because of an upper respiratory tract infection and congestion and pain usually follow, secondary to the gas embolism. Such complications as sinus headache, earache, and eye pain may occur. Also, air injected for pneumoencephalography and other procedures in patients who have recently undergone this test should not receive  $N_2O$  (5,12,13).

When  $N_2O$  is administered, the patient usually experiences a sweet taste; later, a feeling of warmth and a numbness of the face. Confusion, exhilaration, and laughing often follow. In concentrations of 50% and 60%, analgesia is usually produced. In concentrations of 65% and 70%,  $N_2O$  may produce unconsciousness; but this (stage 1) unconsciousness results only from concentrations greater than 50%. Mixtures of  $N_2O$  with  $O_2$  definitely produce unconsciousness, and mixtures of  $N_2O$  with  $O_2$  produce untoward effects such as nausea, vomiting, dysphagia, astrophobia, apprehension, and hallucinations. The most common side effects experienced by patients receiving  $N_2O$  in low concentrations are (1) dizziness, (2) tingling in fingers and toes, (3) disorders of taste and smell, and (4) nausea (5,12,13).

For many years  $N_2O$  was commonly believed to have no adverse effects in the absence of hypoxia, but recent studies have shown that  $N_2O$  can have other adverse effects. Nitrous oxide and oxygen exert a mild, direct depressant action on myocardial contractile force. Concentrations of  $N_2O$  as low as 40% can depress cardiovascular function and lower cardiac output, which decreases blood pressure. Simultaneous to the depression of cardiovascular function is the production of alpha stimulation. Alpha stimulation increases peripheral vascular resistance, resulting in an increase in central venous pressure. This opposes the blood pressure effects caused by myocardial depression and returns the blood pressure to normal in the individual without cardiovascular disease. However, patients who have occlusion of the coronary arteries and/or impaired left ventricular function show a decrease in left ventricular

function and increased left end diastolic pressure, which suggests a failing heart and predisposes a patient to develop congestive heart failure. For this reason, patients with compromised cardiovascular systems usually do not tolerate N<sub>2</sub>O sedation well (6-8,18,22).

Depression of renal blood flow is another undesirable effect of N<sub>2</sub>O, only recently seen. Animal studies have shown that this drop in renal blood flow is independent of a drop in the arterial pressure or cardiac output and is completely reversed when N<sub>2</sub>O is discontinued. This finding is new and still under study, but when renal ischemia needs to be avoided, this important and undesirable action of N<sub>2</sub>O must be kept in mind (18).

In 1973 two researchers, Hendrickson and Jogensen, discovered another startling side effect of N<sub>2</sub>O. They found that when N<sub>2</sub>O was administered to patients with intracranial disorders, a marked, uniform rise in intracranial pressure occurred. This pressure rise can lead to tissue distortion, herniation of intracranial membranes, and death. This serious, but rare, complication must be considered before N<sub>2</sub>O is administered (18).

Nitrous oxide sedation should never be considered when a patient is already sedated (this includes the effects of alcohol!). Inhalation of N<sub>2</sub>O by such a patient reduces the respiratory stimulant response to carbon dioxide. Under these circumstances, even low concentrations of N<sub>2</sub>O added to preexisting sedation can produce a general anesthetic and its attendant problems (6,13,18).

When used properly, N<sub>2</sub>O is a safe and proven drug. However, the side effects and hazards associated with its use must be recognized before this sedation can be given safely. To ensure its safe use, adequate instruction in and clinical experience with N<sub>2</sub>O analgesia is absolutely necessary for those who wish to administer N<sub>2</sub>O.



## ABUSE OF NITROUS OXIDE

Because  $N_2O$  causes euphoria, it has the potential for psychological dependence and abuse. Recent evidence suggests that  $N_2O$  is widely used for nonprofessional reasons, although the actual extent of this misuse has not been documented (21). Nitrous oxide is readily available from medical and nonmedical sources. The food industry is the second largest user of  $N_2O$ . It is used as a propellant for many foods (especially whipped cream) because it doesn't add taste. Anyone motivated to use  $N_2O$  for personal amusement can obtain it in food form for the purchase price of the item in which it is contained.

No prescription is needed to obtain  $N_2O$ . Cylinders can be bought without question at surgical supply houses. People without means but with desire and opportunity turn to theft. A surprisingly large amount of  $N_2O$  is stolen from hospital loading docks, storage sites, and trucks. One of the biggest attractions to using  $N_2O$  for amusement is that its use cannot be detected. Unlike other drugs used for amusement, 10 minutes after  $N_2O$  is discontinued, for all practical purposes no traces of it are left in the body.

The degree to which its abuse contributes to the reported health problems associated with prolonged exposure to  $N_2O$  (liver, kidney, and neurological disorders) is unknown. Nevertheless, repeated and/or prolonged exposure to  $N_2O$  (whether from room contamination during its professional use or from abuse) produces any or all of the following symptoms: continuous tingling and numbness of the hands and feet, loss of muscle coordination, memory loss, personality change, and decrease in sexual response. The most serious problem associated with the abuse of  $N_2O$  is death. The deaths of many young people have been attributed to self-administration of  $N_2O$ ; the cause, hypoxia. A recent announcement by The American Dental Association Group Life Co. seems to bear out the belief that  $N_2O$  abuse is widespread. They stated that their policy will not cover any death that occurs due to self-administration of  $N_2O$  (4,18).

## PROS AND CONS OF USING NITROUS OXIDE

A medical evaluation of the patient is fundamental to deciding whether or not to use N<sub>2</sub>O. To properly use any drug, the practitioner must be familiar with any medical problems of the patient and any concurrent drugs being taken.

Overall, N<sub>2</sub>O is a very safe drug, but certain medical conditions could lead to trouble if you are not aware of them before you start a procedure. It is important that you take a careful medical history, paying particular attention to the patient's allergies, cardiovascular and pulmonary systems, and drugs currently taken.

The American Society of Anesthesiology (ASA) has a scale, from I to V, that rates the overall seriousness of a patient's medical condition:

- Class I -- a healthy patient with no medical problems
- Class II -- a patient with a medical problem that represents minimum impairment to that patient's health
- Class III -- a patient with a major medical problem
- Class IV -- a very seriously ill patient, not expected to live 24 hours
- Class V -- a moribund patient; only immediate action can possibly save life.

Fortunately most patients that we see are in ASA Class I; i.e., they are in excellent health. Many patients will be in ASA Class II: patients who have a history of some minor medical problem that is either in remission or being adequately controlled by medication. For example, the hypertensive patient whose blood pressure is controlled by medication, or the patient with a history of a seizure disorder that is controlled by anticonvulsives.

The patient probably at the highest risk of developing complications from N<sub>2</sub>O use is one with severe coronary artery disease or borderline or uncontrolled congestive heart failure. These patients may not tolerate even low concentrations (such as 20-30%) of N<sub>2</sub>O. At the same time, the patient with coronary artery disease may benefit the most from N<sub>2</sub>O sedation! Since an increase in stress or pain increases the heart rate and may precipitate an anginal attack, the patient may do better if you can use N<sub>2</sub>O to reduce pain and apprehension; however, some of these patients are very intolerant of N<sub>2</sub>O. When faced with such a situation, first consult with the patient's physician. If the patient is cleared for N<sub>2</sub>O sedation, take a baseline blood pressure. Then start at a low level of N<sub>2</sub>O, and take a blood pressure every few minutes. If complications are developing, the patient's blood pressure will drop and the patient will become diaphoretic and tachypneic. Should this happen, quickly discontinue the N<sub>2</sub>O and give the patient 100% O<sub>2</sub>. This quick adjustment is one of the advantages N<sub>2</sub>O has when compared to intravenous sedation.

## Advantages and Disadvantages for the Dentist

### Advantages

1. Rapid induction and rapid recovery.
2. Dose quickly titrated to patient's need.
3. Increased inspired-O<sub>2</sub> concentration.
4. Few adverse drug interactions.
5. Patient more receptive to suggestion.

Nitrous oxide is an excellent drug with a good track record, but it has some distinct drawbacks that have kept it from being widely used. The two primary disadvantages are the additional equipment that is required and the additional time needed to use the technique properly.

### Disadvantages

1. Expensive N<sub>2</sub>O equipment.
2. Presence in the room at all times of the dentist and an assistant, preferably of the opposite sex.
3. Attention divided by constant patient monitoring.
4. Chronic exposure to N<sub>2</sub>O.
5. Increased malpractice risk.
6. Additional training required.
7. Increased temptation for abuse.

Because no one can guarantee that a patient will not lose consciousness (go into stage II or III anesthesia), proper equipment must be on hand to maintain an airway and ventilate a patient. Thus, anyone who uses N<sub>2</sub>O must be trained in basic life support and know how to use a mask and Ambu bag. An obstructed or blocked airway is not a major complication if it is quickly recognized and corrected. However, when unrecognized and therefore uncorrected, airway obstruction will lead to death (32).

Aside from the malpractice risk due to the ever-present danger of death or permanent brain injury, malpractice suits can arise from another interesting area. Jastak (14) discussed nine cases of sexual phenomenon occurring with N<sub>2</sub>O-O<sub>2</sub> sedation. With this sedation, patients can have sexual fantasies and/or be amnesic of the period in question, which can result in sexual-assault or child-molestation charges being made against the dentist. Unless an assistant, preferably one of the opposite sex, is in the room during N<sub>2</sub>O-O<sub>2</sub> sedation, proving that the patient only had an erotic or sexually oriented dream and was not sexually assaulted is virtually impossible. To avoid problems with both constant monitoring and amnesic patients, the dentist and the dental assistant must remain in the room from the start of N<sub>2</sub>O administration until the patient has fully recovered from its effects.

## Indications and Contraindications for Patients

Tailoring the treatment regime to individual patient needs is very important. In this regard,  $N_2O-O_2$  sedation can be an excellent adjunct to the present use of local anesthetics. Combining  $N_2O-O_2$  sedation with intravenous sedation is to be avoided. Even in the best of hands, combining IV sedation with  $N_2O$  makes it virtually impossible to prevent the patient from slipping into stage II or even stage III anesthesia.

More and more patients are coming to expect and even demand that the dentist provide sedation. As mentioned before,  $N_2O$  is particularly useful in reducing stress with the fearful and apprehensive patient or for patients undergoing lengthy procedures. In the rare situation where the patient refuses local or general anesthesia or has a history of reactions to either, this patient's procedure might be accomplished under  $N_2O-O_2$  sedation alone. In cases where the patient's physician prohibits the use of vasoconstrictors or when a patient has a clotting disorder,  $N_2O$  may reduce the amount of local anesthetic administered.

### Indications

1. The fearful/apprehensive patient.
2. Patient with exaggerated gag reflex.
3. Long appointments.
4. Patient request for  $N_2O-O_2$  sedation.
5. Patient refusal of local or general anesthesia.
6. Use of vasoconstrictors prohibited by patient's physician.
7. History of allergic reactions to local anesthetics.
8. Clotting disorder such as hemophilia.

Several conditions prohibit the use of  $N_2O-O_2$  sedation. These vary from simple things such as trying to administer  $N_2O$  to a patient with nasal obstruction (a nose hood is inoperable in this situation) to more serious situations such as the danger of administering  $N_2O$  to patients with severe chronic obstructive pulmonary disease. In the latter case, the patient retains carbon dioxide and depends on an  $O_2$  drive (hypoxic) for respiration; when an increased amount of  $O_2$  is administered, this patient loses his respiratory drive and will become apneic. Since  $N_2O$  diffuses into closed spaces approximately 30 times faster than nitrogen diffuses out, patients with closed cavities should not be given  $N_2O$ . An example is the patient with an earache. When the eustachian tube is occluded, pressure in the middle ear can increase tremendously, causing an even more severe earache. Patients with congenital blebs in their lungs, sinus blocks, or bowel obstructions can also develop complications because of the greatly increased volume of these closed spaces when  $N_2O$  is given.

### Contraindications

1. Refusal by patient (be sure to get parent's permission for all pediatric patients).
2. Nasal obstruction.
3. Upper respiratory tract infection.
4. Chronic obstructive pulmonary disease (blue bloater).
5. Patient on narcotics or sedatives.
6. Language barrier.
7. Earache.
8. Sinus block.
9. Bowel obstruction.
10. Postpneumoencephalogram status.
11. Cystic fibrosis.
12. Congenital blebs in lungs.
13. Pneumomediastinum, pneumothorax, pneumoperitoneum, pneumopericardium.
14. Lack of CPR training and/or resuscitation equipment/drugs in DTR.

Some conditions are controversial, and the risk/benefit ratio must be weighed in order to decide whether or not patients should receive N<sub>2</sub>O-O<sub>2</sub> sedation. Nitrous oxide is not normally approved for use with the pregnant patient. In alcoholic patients, N<sub>2</sub>O may be beneficial for relaxation; however, N<sub>2</sub>O, being synergistic with alcohol, may also result in stage II or III anesthesia. This is also true for any patient who may be taking either prescription or illicit drugs. One risk of stage II or III anesthesia is that the patient may vomit and aspirate. Thus the patient who has eaten a large meal prior to the dental appointment is probably not a good candidate for N<sub>2</sub>O-O<sub>2</sub> sedation. Patients with sickle cell disease will benefit from the increased O<sub>2</sub> concentrations inspired during N<sub>2</sub>O-O<sub>2</sub> sedation, but they are particularly at risk of sickle cell crisis should they be exposed to diffusion hypoxia during the emergent phase. Also, since myeloneuropathy is a recognized complication of chronic exposure to N<sub>2</sub>O (10), a patient who has an ongoing neurologic process involving a neuropathy (such as diabetes, multiple sclerosis, or amyotrophic lateral sclerosis) should probably not be exposed to N<sub>2</sub>O.

#### Relative Contraindications

1. Pregnancy.
2. Psychiatric disorder.
3. Alcohol or drug abuse.
4. Asthma or severe bronchitis.
5. Sickle cell disease.
6. Some cardiac conditions.
7. Myoneuropathies.
8. Major medical problem or serious illness (ASA class III or IV).
9. Full stomach.
10. No assistant or chaperone in DTR.

In summary, remember the adage "never treat a stranger." Get to know your patients!

## PATIENT MONITORING

The most important consideration when using N<sub>2</sub>O-O<sub>2</sub> sedation is the close monitoring of the patient's response to the N<sub>2</sub>O. A review of the literature of mishaps occurring during N<sub>2</sub>O sedation disclosed that failure of the dentist to properly monitor the patient during N<sub>2</sub>O use is a common error. When attention is focused on a difficult intraoral procedure, the dentist may be unaware that the patient's airway has become obstructed and that the patient is not breathing. One young boy died during the seating of a crown. The dentist involved in this case was pressing down very hard on the mandible in order to seat the crown, and this obstructed the boy's airway. Oversedation makes a patient unable to fight back or tell you there is a problem.

With the healthy, ASA class I, patient, extensive monitoring such as used in a typical operating room during general anesthesia is not necessary. However, the patient's blood pressure and pulse must be measured prior to starting a procedure and the pulse monitored during the procedure. This can be done by palpating a peripheral artery such as the radial or ulnar artery or by watching the pulsation of the carotid or temporal arteries. Paying close attention to the color of the patient's skin and mucus membranes is also very important. The color should remain from unchanged to possibly a slight pink tinge. An ashen pallor or cyanotic color is indicative of inadequate tissue oxygenation.

Make it a habit to scan the patient and N<sub>2</sub>O equipment frequently. The scanning should include the N<sub>2</sub>O machine which must be placed in a comfortable line-of-sight position. Many practitioners fall into the dangerous habit of placing this machine behind them, so they are totally unaware of its functioning. The scan should go from the machine to the patient, noting the patient's pulse and respiration, and then to the work area. During difficult operative procedures, enlist the help of your dental assistant to make sure that the N<sub>2</sub>O machine and the patient continue to do well if you are unable to scan.

Vomiting and aspiration are serious complications. A patient who aspirates gastric contents into the lungs will develop Mendelson's syndrome--caused by a combination of obstruction of the airway by the particulate matter and a burning of the lungs by the hydrochloric acid present in the stomach contents. If the airway remains obstructed, the patient will rapidly become cyanotic and die. Lung burns caused by hydrochloric acid can be severe and life threatening. A patient who aspirates must be quickly referred to an appropriate medical facility.

As you gain experience with the use of N<sub>2</sub>O, you will become aware of the subjective and objective signs and symptoms of N<sub>2</sub>O-O<sub>2</sub> conscious sedation. While inducing the patient with N<sub>2</sub>O, talk to your patient and ascertain if the following subjective symptoms of N<sub>2</sub>O-O<sub>2</sub> sedation are being experienced:

1. Mental and physical relaxation.
2. Indifference to the surroundings and the passage of time.
3. Euphoria and drowsiness.

4. Elevation in the pain threshold.
5. Feeling of warmth.
6. Tingling sensation.
7. Remoteness of sounds.
8. Sense of spinning or vibration.

These are common symptoms; a patient may experience some or all of them. While talking with the patient to determine the effects that are being felt, also look for the following objective signs of N<sub>2</sub>O-O<sub>2</sub> sedation:

1. An awake patient who responds to commands appropriately.
2. A lessened reaction to painful stimuli.
3. Normal and smooth respiration, without obstruction.
4. Normal pulse and blood pressure.
5. Normal eye reaction and pupil size.

Also watch for the onset of nausea. This is usually associated with hypotension and means that the patient is receiving too much N<sub>2</sub>O. Patients should seldom if ever receive more than 50% concentration.



## EQUIPMENT

The only equipment to purchase is that which meets the American Dental Association, Council on Dental Materials and Devices, guidelines for acceptance of N<sub>2</sub>O-O<sub>2</sub> (1) sedation machines and devices, (2) scavenging equipment, and (3) waste-gas monitoring equipment. The specific brand of equipment chosen for each clinic is the choice of the Base Dental Surgeon. The Dental Investigation Service (DIS), Brooks AFB, Texas, has evaluated many N<sub>2</sub>O-O<sub>2</sub> machines and scavenging systems and will be doing test and evaluations (T&E) on new equipment as it becomes available. For specific, up-to-date recommendations on equipment selection, purchase, or installation, contact DIS (AUTO-VON 240-3502).

### Nitrous Oxide-Oxygen Sedation Equipment

All dental N<sub>2</sub>O-O<sub>2</sub> conscious-sedation machines are the continuous-flow type and may be either portable or fixed. Portable machines have wheels and can be moved between treatment rooms. They may have small cylinders (size E) attached or plug into wall outlets in clinics with centrally plumbed N<sub>2</sub>O and O<sub>2</sub>. (See Figure 1.) Fixed machines are permanently attached to a wall or cabinet and require a central gas supply.

Nitrous oxide-oxygen sedation machines on the market today, portable or fixed, are similar in that they

1. control the flow rates of the N<sub>2</sub>O and O<sub>2</sub>.
2. mix the gases together.
3. have a breathing (reservoir) bag to receive the pure or mixed gases.
4. have a nasal inhaler (mask, hood) to deliver the gases to the patient.
5. require a scavenging system to remove waste gases.

All modern N<sub>2</sub>O-O<sub>2</sub> conscious-sedation machines, whether self-contained (have their own tanks) or dependent on a central gas supply, have a fail-safe feature that prevents the machine from flowing any N<sub>2</sub>O if the O<sub>2</sub> supply fails.

The ADA requires that the minimum flow of O<sub>2</sub> be no less than 30% of the total gas flow. Some machines are set to deliver no less than 50% O<sub>2</sub>. Oxygen is a nonliquified compressed gas, so there is a direct correlation between the pressure recorded on the gauge and the amount of gas remaining in the cylinder. This is not true of N<sub>2</sub>O, which is stored in the cylinder as a liquid. With N<sub>2</sub>O the gauge will indicate about 750 psi until all the liquid has vaporized. Then the pressure gauge will quickly drop to zero.

The ADA also required that N<sub>2</sub>O-O<sub>2</sub> machines with a central delivery system have a resuscitator quick-connect to facilitate connecting the resuscitation equipment to the central O<sub>2</sub> system. Thus the machine serves as a source for positive pressure O<sub>2</sub> if necessary.

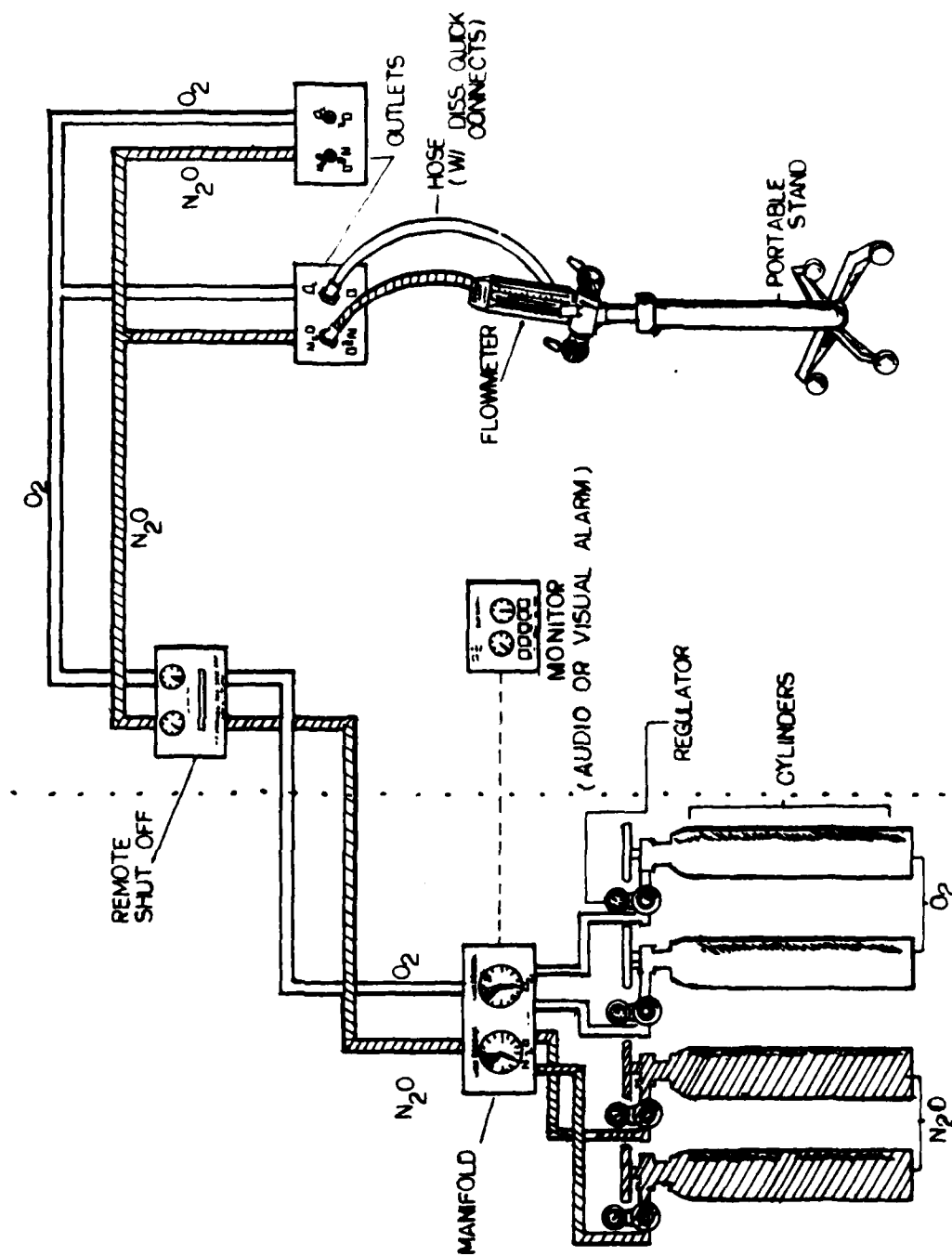


Figure 1. Central gas delivery system.

All N<sub>2</sub>O-O<sub>2</sub> machines have a flowmeter to show the individual rates of N<sub>2</sub>O and O<sub>2</sub> flow (in liters per minute). A flowmeter is simply a device that measures quantities of gas in motion. (See Figure 2.) Some machines have a single dial or lever that determines the percentage concentration of N<sub>2</sub>O or O<sub>2</sub>. In these machines the total flow can be adjusted without affecting concentration, and conversely, the concentration can be changed without affecting the total flow. In machines without this feature, the percentage concentration can only be changed by changing the flow rate of either the N<sub>2</sub>O or O<sub>2</sub>; therefore, any changes in the flow rate will change concentrations. This requires many mathematical recomputations during a procedure.

Installation of N<sub>2</sub>O-O<sub>2</sub> central gas delivery system requires the services of an expert. The ADA requires that the system be installed by a competent supplier of gases and equipment, not by a plumber or anyone untrained in the installation of anesthetic gas equipment. Installation and equipment must meet all ADA guidelines; the National Fire Protection Association (NFPA) standards; and applicable USAF regulations, policies, and standards. After installation, the system must be tested for leaks with dry nitrogen for 24 hours at 150 psi. It also should be tested to confirm that O<sub>2</sub> and N<sub>2</sub>O are coming through their designated tubings.

The management and storage of gas cylinders should comply with the ADA guidelines, the Compressed Gas Association recommendations, and the NFPA standards:

1. Provide a definite location for the cylinders, with no other storage items permitted in that location. Do not store in treatment rooms or corridors. Gas storage areas must be lockable, with access denied to unauthorized personnel. A remote shutoff must be provided if gases are stored in a remote area.
2. Ensure that storage rooms are dry, cool, ventilated, and meet proper fire codes. Lighting fixtures should be shatterproof, and electrical switches approved for hazardous locations.
3. Protect cylinders against (a) excessive rise in temperature; (b) storage near radiators or highly flammable substances such as gasoline and oil; (c) sparks or flames; (d) corrosive chemicals or fumes; and (e) dampness which promotes rust.
4. Separate full and empty cylinders. Small cylinders are satisfactorily stored in bins, but large cylinders should be placed against a wall, preferably with chain fastening to prevent their being knocked over. If a cylinder should fall and the stem break off, the tank will become a high-velocity jet-propelled projectile (much as a balloon will fly about, uncontrolled, if inflated and suddenly released).
5. Keep valves closed. In large cylinders, covering caps must be in place.
6. Be aware of any base regulations affecting compressed gases.

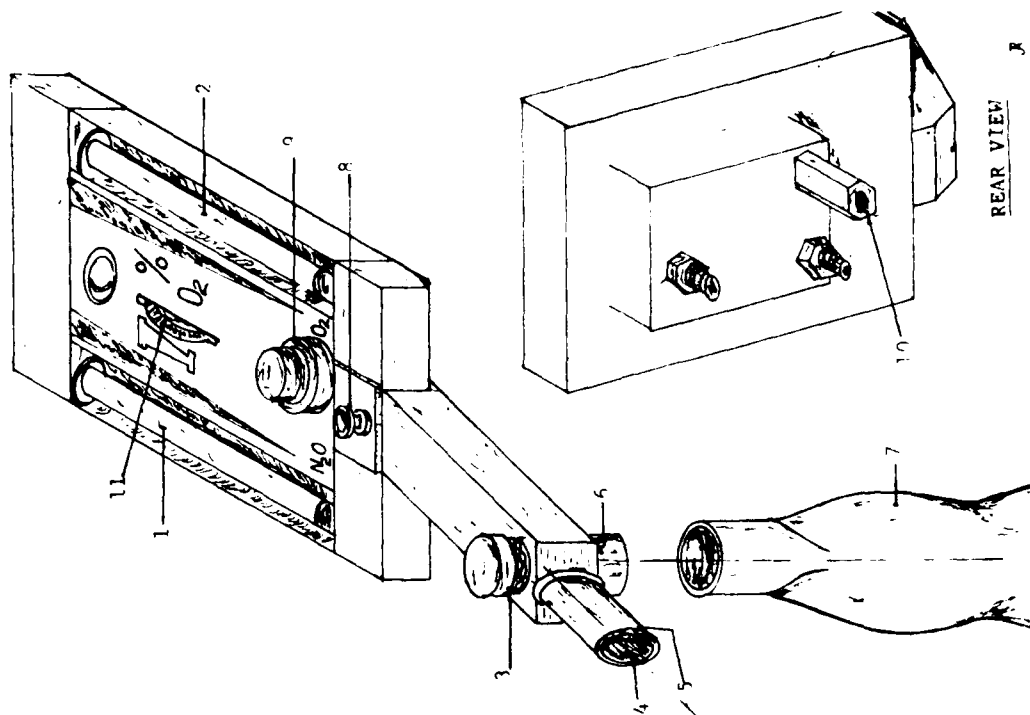
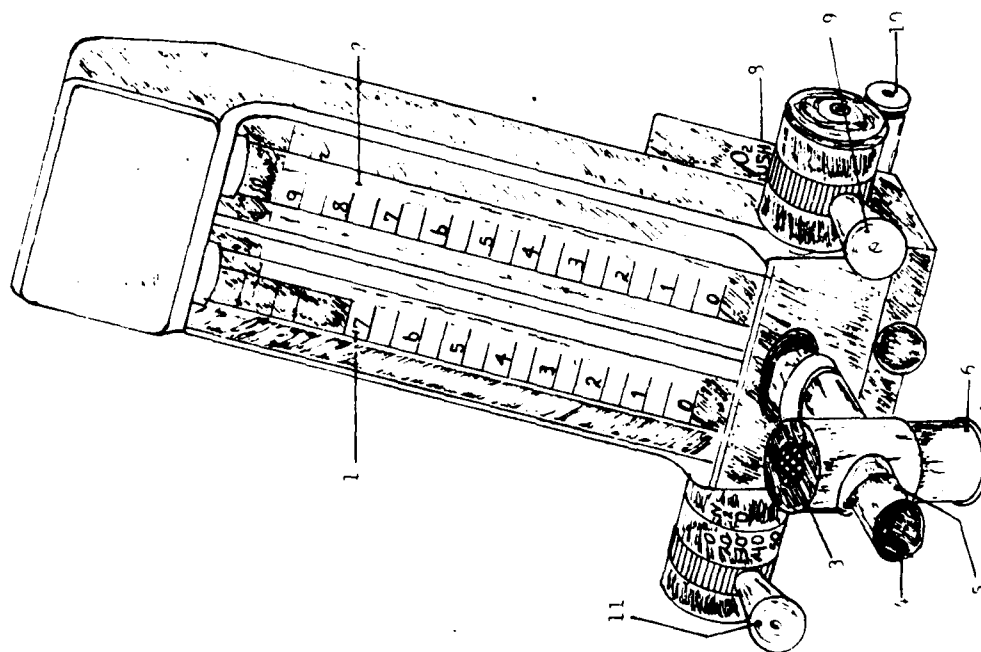


Figure 2. Flowmeters.

- 1 - N<sub>2</sub>O tube
- 2 - O<sub>2</sub> tube
- 3 - emergency air-inlet valve
- 4 - nonbreathing check valve
- 5 - breathing tube connector

- 6 - bag mount
- 7 - breathing bag
- 8 - O<sub>2</sub> flush
- 9 - flow control valve/handle
- 10 - O<sub>2</sub> quick connect
- 11 - mixture dial/handle

The central gas delivery system allows the gas storage tanks (cylinders) to be placed out of the patient's view. It also allows the very large G or H cylinders to be used. These cylinders are much more economical than the smaller E-size cylinders used in the self-contained portable gas machines. The H-type cylinders last about eight times longer than the E-type. Several large cylinders may be attached to a manifold system, eliminating the need for frequent cylinder changes.

Each gas cylinder requires a separate regulator--a mechanism used to reduce the pressure of a gas, as it issues from a compressed-gas cylinder, to a usable and nearly constant pressure. The central gas delivery system requires a line pressure of 50-55 psi. An audible or visual alarm, set at 40 psi low and 60 psi high, is required to monitor this line pressure and must be in a constantly monitored area.

Tubing from remotely placed tanks must be made only of type K or L, pre-cleaned, degreased, capped copper tubing. All connections must be silver soldered with 1000°F (540°C) melting point. Plastic tubing should never be used here.

With quick-coupling wall outlets, the same tanks can supply gases to more than one room. This allows a portable N<sub>2</sub>O-O<sub>2</sub> machine to be moved from room to room. The quick-connects for N<sub>2</sub>O and O<sub>2</sub> are different-sized, threaded couplings and therefore are not interchangeable. This safety feature is standardized and is known as the diameter-index safety system (DISS).

Standard color coding of the gas cylinders is an important safety feature. Oxygen may be color-coded green (United States) or white (international). Blue is the universally accepted color for N<sub>2</sub>O. In this country the green for O<sub>2</sub> and the blue for N<sub>2</sub>O are also used for coding pressure gauges, flowmeters, DISS hoses, and even the knobs under the flowmeters.

A yoke is a device used to attach a gas cylinder to the self-contained portable gas machine. The yoke may be single or double; the double is preferred for dental use. It consists of a metal "O" clamp with an adjustable screw. The inside of the clamp has a nipple that fits snugly into the port of the cylinder valve. The pin-index safety system specifies that two small pins be located at designated positions (different for each gas) below the nipple. These pins must fit into standard sized and positioned holes in the gas cylinders to prevent mistaken interchanging of the cylinders. A nonflammable O-ring type washer is placed around the nipple to provide a leakproof seal between the cylinder and the gas machine.

Before a cylinder is connected to any anesthetic equipment, the cylinder's valve must be carefully opened, very slightly, allowing a momentary flow of gas out of the cylinder. This will blow away any small particles of dust or foreign material that may be obstructing the valve outlet. This is called "cracking" the cylinder.

A valve is defined as a movable mechanism for opening or closing a passage. It is used to start or stop the flow of gas and to regulate the flow, but not the pressure (reduction of gas pressure is achieved by a regulator).

Cylinder valves should be opened and closed slowly to avoid accidental explosion. When the pressure in the tubing has equalized with that of the cylinder, the valve should be opened all the way. If the valves are not fully opened, they may leak.

At very high pressures, when their oxidizing properties are enhanced, O<sub>2</sub> and N<sub>2</sub>O can form an explosive mixture in presence of grease or oil. Therefore, grease and oil should never be used on valves, gauges, or other compressed-gas measuring or storing equipment.

Following is "Revision of Guidelines for the Acceptance Program for Nitrous Oxide-Oxygen Sedation Machines and Devices," 1980, distributed by the ADA Council on Dental Materials and Devices:

*The Acceptance Program for dental materials and devices and the general guidelines, adopted by the Council, for submission of any product have been reported (JADA 88:615 March 1974).*

*At its May 1974 meeting, the Council included nitrous oxide-oxygen sedation machines and devices in the Acceptance Program. This was done on the basis that these devices are useful and effective in providing nitrous oxide-oxygen inhalation sedation in dentistry.*

*The original guidelines were published in The Journal in August, 1974. A number of devices have been classified under those guidelines. Recently, the Council decided to make certain modifications in the guidelines. The modifications consist of i) Requiring that the pin index safety system be made fail-safe by means of elimination of press fitting and adoption of a positive fastening such as welding the pins to the block or machining them from the block for fixing by means of screws; ii) Substituting the term "flow measuring devices" for the more specific term "flow tubes"; iii) Incorporating the requirement that the audible alarm be a part of the analgesia head.*

*A company seeking qualification of its product under the classification system is required to comply with the general guidelines for submission of a product, as well as with the specific guidelines for the device:*

*A. Installation: The manufacturer, in submitting his product for Acceptance, shall agree that the following will be done:*

*1. The installation of the gas delivery system and the gas storage will be in accordance with the National Fire Protection Association Standards.*

*2. The complete installation will be supervised by a competent supplier of gases and equipment.*

*3. The gas cylinders will be stored in locked containers.*

The above instructions should be incorporated in the product literature.

B. Fittings:

1. The gas cylinders, hoses, and flow measuring devices shall be color-coded in accordance with US Standards: green for oxygen and blue for nitrous oxide.

2. Both pin index safety systems and diameter index safety systems are to be used.

The pins shall not be press fitted but shall be attached to the block by a positive means such as welding, screws, or machining out of the block to minimize chances of accidental malfunction of the pin index system.

C. Machine:

1. A fail-safe device shall be installed to close off nitrous oxide supply and sound an audible alarm if oxygen supply fails. The audible alarm shall be on the analgesia head.

2. A minimal flow of 2.5 liters of oxygen shall be provided with activation of the machine. If a mixing dial is used, the maximum percentage of nitrous oxide that can be given will be 70%.

3. Quick connectors of standard size shall be provided to allow for fitting of resuscitation equipment when gases are supplied centrally.

4. A protective housing shall completely enclose the flow measuring devices and will be fronted by a transparent safety shield.

5. A reservoir bag shall be provided for delivery of nitrous oxide and oxygen.

6. Flow measuring devices should be accurate to  $\pm 5\%$ . The oxygen flow measuring device should be located on the right side of the machine as viewed from the front. The flow measuring devices should provide visual monitor of the gas flow.

7. The reservoir bag shall be mounted high enough to allow unrestricted visual monitoring.

8. An on-demand valve shall be available to allow the automatic admission of room air to the system if gas flows are inadequate for the patient's needs.

9. A nonrebreathing valve shall be an integral part of the normal-mode operating system, with the option of being manually disengaged in the event of an emergency.

D. Instructions:

1. Attached to the machine shall be the caution that the equipment is to be used only under the direct supervision of a physician or dentist.

The Council has established the effective date for classification products under these guidelines as one year from the date of this announcement. After that date classification of a product will be required before promotion or exhibiting through Association media. Products currently on the List of Classified Dental Materials and Devices as Acceptable or Provisionally Acceptable must show compliance at the time of scheduled renewal of classification.

Scavenging Equipment

The potential hazards associated with trace N<sub>2</sub>O in dental treatment rooms requires strict adherence to the ADA guidelines for N<sub>2</sub>O-O<sub>2</sub> scavenging equipment. Particularly important is the scavenging equipment's ability to attain, within the breathing zone of the dentist, the lowest reasonably achievable level of N<sub>2</sub>O. This is defined as meeting exposure levels reflected in the current National Institute for Occupational Safety and Health (NIOSH) criteria document and applicable Occupational Safety and Health Administration (OSHA) regulations.

Following are "Guidelines for Acceptance of Nitrous-Oxide/Oxygen Scavenging Equipment," 1977, distributed by the ADA Council on Dental Materials and Devices:

The following guidelines are intended to outline the important and desirable characteristics of scavenging equipment used in conjunction with inhalation sedation devices to reduce the occupational exposure to waste nitrous oxide.

The submission must show that the equipment meets the following product characteristics. In addition, the submission must comply with the Council's "Directions for Submission of Products" (May 1973).

SCAVENGING EQUIPMENT MUST BE:

1. adaptable to most existing sedation, anesthesia, and exhaust systems.
2. constructed so that it does not significantly interfere with normal breathing system and delivery of selected gas concentrations (e.g., resistance, dead space, gas concentrations, and pressure).



3. capable of attaining the lowest reasonably achievable level\* of  $N_2O$  within the breathing zone of the dentist.

4. effective regardless of the heating and air conditioning system in use.

5. constructed to permit safe and efficient disposal of the gases: (a) the waste gas must not contaminate air intakes and personnel areas; (b) NFPA standards for disposal of oxidizing agents must be met; (c) the exhaust system must have sufficient capacity to remove the waste gases.

\*Defined as meeting exposure levels reflected in the current NIOSH criteria document and applicable OSHA regulations.

Instructions for Use accompanying the scavenging device must include the following points:

1. The need for equipment maintenance (if there are high pressure or low pressure leaks, scavenging will not be effective).

2. Commentary regarding technique of inhalation anesthetic agent administration (i.e.,  $N_2O$  should not be administered until such time as the mask is properly in place. Direct spillage of inhalation anesthetics into the atmosphere is to be avoided).

3. Instructions for proper and safe installation of scavenging equipment and disposal of the waste gases (e.g., waste gases must not contaminate air intakes and personnel areas, NFPA standards for disposal of oxidizing agents met; exhaust system must have sufficient capacity to remove the waste gases).

NOTE: It is not necessary to submit a sample device with the submission unless specifically asked for by the Council. Please prepare submissions in triplicate.

#### Waste-Gas Monitoring Equipment

The room air in dental treatment rooms should be monitored for the presence of trace  $N_2O$ . Active monitoring requires the assistance of bioenvironmental engineers. Passive monitors are available from several companies. Occasionally the air in other parts of the clinic should be monitored, as air circulation may carry trace amounts of  $N_2O$  into halls and other rooms.

Following are "Guidelines for Acceptance of Nitrous-Oxide/Oxygen Waste Gas Monitoring Equipment," 1977, distributed by the ADA Council on Dental Materials and Devices:

The following guidelines are intended to outline the important and desirable characteristics of gas monitoring equipment used in conjunction with inhalation sedation devices to monitor the occupational exposure to waste nitrous oxide.

The submission must show that the equipment meets the following product characteristics. In addition, the submission must comply with the Council's "Direction for Submission of Products" (May 1973).

MONITORING EQUIPMENT MUST PERMIT THE COLLECTION OF A TIME WEIGHTED AIR SAMPLE, COLLECTED AT A CONSTANT RATE OVER A SPECIFIED PERIOD OF TIME, OBTAINED WITHIN THE BREATHING ZONE OF THE DENTIST DURING ADMINISTRATION OF INHALATION ANESTHETIC AGENTS.

The equipment characteristics must include at least the following capabilities:

1. be simple and easy to operate.
2. permit collection of at least a two-hour time weighted sample.
3. be adjustable to permit more rapid collection of a time weighted sample (around 15 minutes).
4. provide for convenient collection of a sample from the breathing zone of the dentist.
5. the sampler must be properly sealable to maintain sample integrity and avoid leakage of the sample in shipment and storage.
6. be small enough to permit mailing of the collected sample for analysis (except for samplers intended for use at institutions which have in-house analysis capability).

NOTE: It is not necessary to submit a sample device with the submission unless specifically asked for by the Council. Please prepare all submissions in triplicate.

## HEALTH HAZARDS AND PROTECTION FOR THE DENTAL STAFF

It is estimated that 30,000 to 40,000 dentists currently use N<sub>2</sub>O and that over 100,000 individuals--dentists, assistants, and office personnel--are chronically exposed to trace concentrations of N<sub>2</sub>O (9).

In July 1980, the Journal of the American Dental Association published a retrospective epidemiologic health survey involving 30,650 dentists and 30,547 chairside assistants. Approximately half of these dentists and assistants used inhalation anesthetics. The results, comparing the percentage increase of health problems in the "user" versus the "nonuser" groups, suggest that long-term exposure to trace gases, such as N<sub>2</sub>O, in dental treatment rooms may lead to an increased incidence of spontaneous abortion, congenital abnormalities in offspring, cancer, liver disease, and kidney disease (4). Occasional exposure of a patient to properly administered N<sub>2</sub>O has not been shown to be hazardous (1).

The fact that chronic exposure to N<sub>2</sub>O may be hazardous should not limit its clinical use. Nitrous oxide, like dental x-rays, can be used confidently when proper safety precautions are taken. Before such precautions can be taken, hazardous conditions must be recognized.

### Area Contamination

Sources of contamination are--

1. Scavenging equipment not used.

2. Leakage from the N<sub>2</sub>O machine. Sources of leakage include:

(a) Faulty wall connector fittings in central systems.

(b) Defective manifold "O" ring in portable units.

(c) Faulty pressure hose fittings.

(d) Defective flowmeters, breathing bags, tubes leading to and from scavenging nasal inhaler, and the scavenging nasal inhaler itself (particularly if it has a relief valve, as this valve exhausts the entire flow of gas into the operator's breathing zone).

(e) Loose or defective connections between any of the parts mentioned in d.

(f) Defective seals and gaskets.

3. Technique errors:

(a) Turning on the N<sub>2</sub>O before the nasal inhaler has been placed and fitted on the patient.

(b) Allowing the nasal inhaler to become displaced during the procedure.

(c) Allowing the patient to mouth breathe or talk excessively.

(d) Removing the nasal inhaler without oxygenating the patient after treatment. This oxygenation prevents diffusion hypoxia and also allows the  $N_2O$  that is "blown off" by the patient during this posttreatment oxygenation to be scavenged.

4. Masks with pop-off valves.

5. Nonrecirculating air conditioning.

6. Scavenging equipment connected to a central vacuum system but not vented to the outside or with insufficient flow rate (1.5 cfm is minimum).

7. Air venturi systems (AVS) (not used for  $N_2O$  scavenging because they return exhausted air into the treatment room).

8. Improper flow levels.

In the past, most nasal masks, inhalers, or hoods exhausted air and  $N_2O$  into the treatment room. One study (17) found that  $N_2O$  in these rooms ranged from 500 to 6,700 ppm as opposed to the NIOSH recommended standard of 50 ppm (19).

To reduce the amount of waste  $N_2O$  in dental treatment rooms, scavenging systems recently have been designed into the nasal mask. Scavenging is divided into two basic types, internal and external. Internal refers to the masks and suction equipment that remove excess  $N_2O$  from within the mask to the outside, without allowing it to escape into the treatment room. External refers to removing  $N_2O$  from the air in the breathing zone of the operator and the assistant. A simple fan directed at the treatment team's breathing zone will dilute the  $N_2O$  in that area.

The room air in dental treatment rooms should occasionally be monitored for  $N_2O$ . The bioenvironmental engineers can sample the air in the breathing zone of the treatment team, using a MIRAN-1A infrared analyzer and a strip-chart recorder. The strip-chart recorder plots absorbance versus time: the absorbance is averaged over the period of  $N_2O$  application and then converted to ppm. A less elaborate, and unfortunately less reliable, method for monitoring  $N_2O$  has recently been introduced: a lapel monitor can be used to obtain an 8-hour time-weighted average of  $N_2O$ . The monitor is simply a container that is opened and worn, then resealed and mailed to the company for analysis.

No single measure is sufficient to control contamination from  $N_2O$ . An understanding of all the sources of contamination is necessary before steps can be taken to eliminate them.

### Self-Administration

Chronic abuse of N<sub>2</sub>O by self-administration may result in serious myelopathy or neuropathy. Symptoms include early sensory complaints, loss of balance, leg weakness, gait ataxia, impotence, and sphincter disturbances. The neurological picture is similar to that of subacute combined degeneration of the spinal cord. The symptoms are not always reversible if the abuse is discontinued (15,21).

Security is of the utmost importance in preventing mischievous abuse of N<sub>2</sub>O. Each clinic must insure that all N<sub>2</sub>O delivery systems are secured at the end of the working day. How this is accomplished will vary from clinic to clinic, but it is absolutely vital that N<sub>2</sub>O security be outlined in the Dental Operating Instructions and that all dental personnel are familiar with these instructions.

## TECHNIQUE

### Fundamentals

As in all dental treatment, there is more than one way to administer N<sub>2</sub>O. But whatever way you choose, the following basic fundamentals apply:

1. Never administer N<sub>2</sub>O to an unwilling patient.
2. Never give more than 70% N<sub>2</sub>O; in fact, concentrations of more than 50% are seldom necessary. If more than 50% N<sub>2</sub>O is needed, another form of sedation may be indicated.
3. Insure that the patient has a patent airway and is receiving an adequate flow of gas. The ideal flow is the amount required to keep the breathing bag approximately 3/4 full.
4. Continuously monitor the patient during the procedure; patient response is directly related to depth of sedation. Elaborate monitoring equipment is not necessary and may in fact be counterproductive (due to increased patient apprehension).
5. The patient must be accompanied by a responsible adult who can take responsibility for seeing the patient safely home.
6. Neither dentist nor assistant should leave the dental treatment room while the patient is receiving N<sub>2</sub>O.
7. Keep accurate records.

### Administration

The following is a step-by-step technique describing "one way" to administer N<sub>2</sub>O-O<sub>2</sub> conscious sedation:

1. Seat the patient comfortably in a supine or semisupine position. The semisupine position decreases the risk of vomiting.
2. Provide the patient with a quiet, relaxed atmosphere as free as possible from distracting sights and sounds.
3. Establish rapport: patient confidence is essential for success.
4. Recheck the medical history and get a baseline blood pressure and pulse.
5. Activate the scavenging system.
6. Turn on 100% O<sub>2</sub> with a 6-8-liter flow. The breathing bag should be partially filled with O<sub>2</sub>.

7. Place the scavenging nasal inhaler over the patient's nose; adjust for a close but comfortable fit. Always place the nasal inhaler after the 100% O<sub>2</sub> and scavenging system have been initiated.

8. Check the equipment for leaks. Check the breathing bag and adjust the flow to insure the bag is maintained at 3/4 full.

9. Reassure the patient with physical and/or verbal contact.

10. Introduce the N<sub>2</sub>O gradually (staging). If it is the first time the patient has had N<sub>2</sub>O, start with 25%. (If a patient has had N<sub>2</sub>O before without problems, go directly to the proper working mixture.)

11. Use the power of suggestion to reassure the patient as induction is taking place.

12. After a few minutes of 25% N<sub>2</sub>O and 75% O<sub>2</sub>, increase the N<sub>2</sub>O concentration, in stages, to a maximum of 50% (first induction, 40%). A few patients may tolerate higher percentages, but generally don't exceed 50%.

13. Usually 5 or 6 minutes after the N<sub>2</sub>O has been started, the patient will be ready for dental treatment. Patient reaction, not an absolute administration time or dosage, determines when treatment may be initiated. The patient who is ready for treatment (stage 1--plane 2) experiences sensations of drifting, floating, daydreaming, alterations of time dimension, euphoria, tingling or warmth of extremities, and voice change (lower), and follows verbal commands slowly. This determination requires careful observation and questioning of the patient.

14. Check the flow rate. After the patient has been induced, the flow rate can often be reduced. Insure that the breathing bag remains 3/4 full.

15. Proceed with the dental procedure. Continue to carefully monitor the patient and the machine. Maintain the patient on the lowest concentration of N<sub>2</sub>O required to keep him comfortable.

16. Near the end of the dental procedure, discontinue the N<sub>2</sub>O and administer 100% O<sub>2</sub>.

17. Oxygenate for 5-10 minutes to avoid diffusion hypoxia.

18. Elevate the patient's head slowly, then remove the scavenging nasal inhaler. Allow the patient to breathe room air for a few minutes.

19. Obtain a postoperative blood pressure and pulse.

20. Compliment the patient for cooperating. Discuss procedures accomplished, treatment remaining, and next appointment.

21. Allow patient to get up and leave the treatment room but not the clinic until 15 minutes after posttreatment oxygenation. Check to see if escort is there to see patient safely home.

## Records

Keep accurate records of each N<sub>2</sub>O administration. The following information should be recorded on the SF 603 and be available in the dental health folder:

1. Date of administration.
2. Starting blood pressure and pulse.
3. Time administration started (O<sub>2</sub> on).
4. Induction percentage and flow.
5. Time administration stopped (oxygenation completed).
6. Ending blood pressure and pulse.
7. Any notable events during administration.
8. Time the patient left the dental clinic (escorted by whom).

This information is extremely valuable for future administration of N<sub>2</sub>O as it gives the operator an indication of the probable working mixture for that patient.



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