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Nitrous Oxide Sedation: Clinical Review & Workplace Safety

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4 credit hours (4 CEs)

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LEARNING OBJECTIVES

Upon completion of this course, the student will be able to:

- Understand the history and background for Nitrous Oxide as an anesthetic agent.
- Identify indications for use in clinical dentistry.
- Identify contraindications for use in clinical dentistry.
- Evaluate patients suitable for nitrous oxide sedation.
- Know the basic equipment and its use in the dental operatory.
- Understand best clinical practices for nitrous oxide sedation.
- Implement workplace monitoring and safety guidelines per OSHA guidelines.
- Identify signs and symptoms of exposure.
- Understand nitrous monitoring systems, i.e. Laudauer Monitoring Badge.
- Maintain absolute safety for patients in the clinical setting.

INTRODUCTION

Patient anxiety has always been a major issue in dental offices. This course reviews guidelines for use of nitrous oxide for the dental practitioner and dental staff to manage anxiety and pain. Nitrous Oxide (N_2O), when administered properly, is safe, effective, and tends to increase patient satisfaction during some dental procedures. Since clinical dentistry often needs chemical agents to maintain patient comfort and to allay anxiety (anxiolytic properties), the ideal agent would have a fairly rapid onset of action, good therapeutic effectiveness, a wide safety margin, quick recovery time, no "hangover" effect or excessive sedative effects, and which does not require the presence of an anesthesiologist.

An anesthetic which is ideally suited to clinical dentistry is nitrous oxide or N_2O as nitrous oxide is commonly abbreviated. Nitrous oxide produces analgesic and anxiolytic effects when used correctly in a clinical setting. Nitrous oxide (N_2O on many forms or chemical symbol N_2O) gas has been available to the medical and dental community for over 150 years. The use of nitrous oxide as an anesthetic is common for anesthesiologists and dental practitioners as an adjunct to local anesthetic agents, and fulfills almost all of the criteria listed above.

Benefits of Nitrous Oxide Sedation

1. Increase patient comfort during procedures
2. Safe and effective
3. Potential practice building tool
4. Short recovery time
5. Easy to administer

After a discussion of nitrous oxide's chemical and physical properties, the course emphasizes best clinical practices to support absolute patient safety and to assure that clinicians minimize exposure to themselves in the workplace. OSHA sets forth specific guidelines for clinical and workplace safety which will be discussed in detail. Also a review of common terms is provided as an appendix, as well as information about workplace safety and monitoring systems for exposure management in the dental clinical setting. Ironically, nitrous oxide exposure issues for the patient are relatively minimal. Of more concern are the long-term health issues for clinicians, particularly child bearing age women, who may be exposed on a daily basis and therefore subject to more cumulative effects based on the frequency of exposure.

HISTORY OF NITROUS OXIDE AND USE IN DENTISTRY


Joseph Priestly

Nitrous oxide, one of the first modern anesthetics, was first manufactured in 1772 by English chemist, Joseph Priestly. About 1800, Sir Humphrey Davy experimented with the physiological properties of the gas and stated: "As nitrous oxide in its extensive operation appears capable of destroying physical pain, it may probably be used with advantage during surgical operation". The surgical world ignored his suggestion, and interest in the surgical use of nitrous oxide would have to wait another half century. After Sir Davy observed the amusing effects on people who inhaled nitrous oxide, he coined the term "laughing gas" which is also commonly used today.

Nitrous oxide was used for the first time as a dental anesthetic drug in 1844. Dr. Horace Wells, with assistance by Gardner Quincy Colton and John Mankey Riggs, collaborated successfully to use nitrous oxide on a patient for an extraction. In the following weeks, Wells treated the first 12-15 patients with nitrous oxide, and according to his own record only failed in two cases. In spite of these convincing results reported by Wells to the medical society in Boston, this new method of pain management was not immediately adopted by other dentists.

In early 1845, Wells' first public demonstration of nitrous oxide anesthesia for the medical faculty in Boston was only partly unsuccessful, leaving his colleagues doubtful regarding its efficacy and safety. Wells was booed off the stage and in the aftermath, he lost his reputation and eventually committed suicide. However, to this day, Dr. Wells is considered the "discoverer of anesthesia".

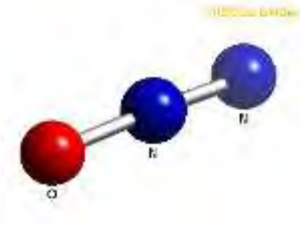
In 1863 nitrous oxide anesthesia came into general use, when Gardner Quincy Colton successfully began to use nitrous oxide in all his "Colton Dental Association" clinics. Up to the 1860's nitrous oxide was used alone as an inhalational anesthetic with 100% concentration of the gas administered to patients. Oxygen was added to the gas mix, and soon Colton and his associates successfully administered nitrous oxide to more than 25,000 patients, with over 75,000 extractions completed with the use of N_2O as an anesthetic. Now with the efficacy and safety demonstrated by large numbers of successful procedures, the use of nitrous oxide rapidly became the preferred anesthetic method in dentistry. The gas is mild enough to keep a patient in a conscious and conversational state, and in most cases is strong enough to suppress the pain caused by dental procedures. Therefore, nitrous oxide remains today as the preferred anesthetic gas used in dentistry.

Every year approximately 45 million dental patients undergo anesthesia in North America, with nitrous oxide constituting a major component in about half of these procedures. A significant percentage of general dentists use nitrous oxide sedation in their practices to manage pain, anxiety, and excessive gag reflex. Nitrous is the most used gaseous anesthetic in the world, commonly administered for the purpose of decreasing the amount of more potent and usually more toxic agents during general anesthesia cases.

CHEMICAL AND PHYSICAL PROPERTIES

Formula

N(2)O



Synonyms

- Synonyms for Nitrous Oxide include:
- Dinitrogen monoxide
- factitious air
- hyponitrous acid anhydride
- laughing gas
- nitrogen oxide

Identifiers

1. CAS No.: 10024-97-2
2. RTECS No.: QX1350000
3. DOT UN: 1070 14 (compressed); 2201 23 (refrigerated liquid)
4. DOT label: Nonflammable gas, oxidizer (nitrous oxide, compressed); nonflammable gas (nitrous oxide, refrigerated liquid)

Appearance and Odor

Nitrous oxide is a colorless gas at room temperature with a slightly sweet odor and taste.

Physical Data

1. Molecular weight: 44.02
2. Boiling point (at 760 mm Hg): -88.5 degrees C (-127.3 degrees F)
3. Specific gravity (air = 1): 1.97 at 25 degrees C (77 degrees F)

4. Vapor density: 1.53
5. Melting point: -91 degrees C (-132 degrees F)
6. Vapor pressure: 760 mm Hg at 88.5 degrees C (191.3 degrees F)
7. Solubility: Slightly soluble in water; soluble in alcohol, ether, oils, and sulfuric acid .
8. Evaporation rate: Data not available.

Reactivity

1. Conditions contributing to instability: Nitrous oxide can form an explosive mixture with air.
2. Incompatibilities: Contact of nitrous oxide with aluminum, boron, hydrazine, lithium hydride, phenyllithium, phosphine, sodium, tungsten carbide, hydrogen, hydrogen sulfide, organic peroxides, ammonia, or carbon monoxide may cause violent reactions to occur.
3. Hazardous decomposition products: Toxic gases (such as carbon monoxide and oxides of nitrogen) may be released in a fire involving nitrous oxide.
4. Special precautions: None reported.

Flammability

Nitrous oxide is a non-flammable gas at room temperature. The National Fire Protection Association has not assigned a flammability rating to nitrous oxide.

1. Flash point: Not applicable.
2. Auto-ignition temperature: Not applicable.
3. Flammable limits in air: Not applicable.
4. Extinguishant: For small fires use dry chemical or carbon dioxide. Use water spray, fog, or standard foam to fight large fires involving nitrous oxide.

Fires involving nitrous oxide should be fought upwind from the maximum distance possible. Keep unnecessary people away; isolate the hazard area and deny entry. Isolate the area for 1/2 mile in all directions if a tank, rail car, or tank truck is involved in the fire. For a massive fire in a cargo area, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from the area and let the fire burn. Emergency personnel should stay out of low areas and ventilate closed spaces before entering. Vapors are an explosion hazard indoors, outdoors, or in sewers. Containers of nitrous oxide may explode in the heat of the fire and should be moved from the fire area if it is possible to do so safely. If this is not possible, cool the fire-exposed containers from the sides with water until well after the fire is out. Stay away from the ends of containers. Firefighters should wear a full set of protective clothing and self-contained breathing apparatus when fighting fires involving nitrous oxide.

EXPOSURE LIMITS

OSHA

The Occupational Safety and Health Administration (OSHA) does not currently regulate exposure limits of nitrous oxide.

NIOSH REL

The National Institute for Occupational Safety and Health (NIOSH) has established a recommended exposure limit (REL) for nitrous oxide of 25 parts per million (ppm) parts of air (45 milligrams per cubic meter (mg/m(3)) as a time-weighted average (TWA) for the duration of the exposure.

Rationale for Limits

The NIOSH limit is based on the risk of reproductive system effects and decreases in audiovisual performance.

The ACGIH limit is based on the risk of reproductive, hematological, and nervous system effects.

HEALTH HAZARD INFORMATION

Routes of Exposure

Exposure to nitrous oxide occurs through inhalation.

Summary of Toxicology

Effects on Animals

Nitrous oxide has central nervous system, teratogenic, bone marrow, and liver effects in animals [ACGIH 1991]. Rats exposed to an 80 percent concentration for 2 or more days showed signs of bone marrow toxicity [ACGIH 1991]. However, rats exposed to a 1 percent concentration of nitrous oxide for periods ranging from 7 days to 6 months showed no bone marrow effects [ACGIH 1991]. Exposure to nitrous oxide also causes neurotoxic (spinal cord lesions, demyelination, peripheral neuropathy) and hepatotoxic (focal inflammatory lesions) effects in experimental animals [ACGIH 1991]. In one study, pregnant rats were exposed to 50 percent nitrous oxide for 24 hours/day starting on day 8 of gestation and continuing for 1, 2, 4, or 6 days; dose-related embryolethal and teratogenic effects occurred among the offspring. The most common effects were embryonic death, resorption, and abnormalities of the ribs and vertebrae [Rom 1992]. Nitrous oxide was negative in three carcinogenicity assays in mice and rats exposed to concentrations as high as 400,000 ppm for 4 hours/day, 5 days/week for 78 weeks [ACGIH 1991]. The results of mutagenicity assays involving nitrous oxide were negative [ACGIH 1991].

Effects on Humans

Nitrous oxide is an asphyxiant at high concentrations. At lower concentrations, exposure causes central nervous system, cardiovascular, hepatic, hematopoietic, and reproductive effects in humans. At a concentration of 50 to 67 percent (500,000 to 670,000 ppm) nitrous oxide is used to induce anesthesia in humans [Rom 1992]. Patients exposed to a 50:50 mixture of nitrous oxide:oxygen for prolonged periods to induce continuous sedation developed bone marrow depression and granulocytopenia. Although most patients recover, several deaths from aplastic anemia have been reported. Neurotoxic effects occur after acute exposure to concentrations of 80,000 to 200,000 ppm and above; effects include slowed reaction times and performance decrements [Hathaway et al. 1991]. Long-term occupational exposure (dentists, dental assistants) has been associated with numbness, difficulty in concentrating, paresthesias, and impairment of equilibrium [ACGIH 1991]. In one study, exposure to 50 ppm nitrous oxide was associated with a decrement in audiovisual performance, but this result has not been duplicated in other studies Epidemiological studies, primarily of operating room personnel, have shown increased risks of spontaneous abortion, premature delivery, and involuntary infertility among these occupationally exposed populations [ACGIH 1991; Hathaway et al. 1991].

SIGNS AND SYPTOMS OF EXPOSURE

Acute Exposure

The signs and symptoms of acute exposure to nitrous oxide include dizziness, difficult breathing, headache, nausea, fatigue, and irritability. Acute exposure to nitrous oxide concentrations of 400,000 to 800,000 ppm may cause loss of consciousness.

Chronic Exposure

The signs or symptoms of chronic overexposure to nitrous oxide may include tingling, numbness, difficulty in concentrating, interference with gait, and reproductive effects.

OSHA EXPOSURE SOURCES AND CONTROL METHODS

(per OSHA Guidelines 2013)

The following operations may involve nitrous oxide and lead to worker exposures to this substance:

- The manufacture and transportation of nitrous oxide
- Use as an anesthetic gas
- Use as a propellant (foaming agent) in whipped creams
- Use as a leak detecting agent on natural gas pipelines
- Use as an oxidant for the production of organic compounds
- Use in rocket fuel formulations
- Use in the manufacture of nitrates from alkali metals

Methods that are effective in controlling worker exposures to nitrous oxide, depending on the feasibility of implementation, are as follows:

- Process enclosure
- Local exhaust ventilation
- General dilution ventilation
- Personal protective equipment

Workers responding to a release or potential release of a hazardous substance must be protected as required by paragraph (q) of OSHA's Hazardous Waste Operations and Emergency Response Standard.

Emergency Medical Procedures with Exposure

Remove an incapacitated worker from further exposure and implement appropriate emergency procedures e.g., those listed on the Material Safety Data Sheet required by OSHA's Hazard Communication Standard. All workers should be familiar with emergency procedures, the location and proper use of emergency equipment, and methods of protecting themselves during rescue operations.

Good sources per OSHA of information about control methods are as follows:

1. ACGIH [1992]. Industrial ventilation--a manual of recommended practice. 21st ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

2. Burton DJ [1986]. Industrial ventilation--a self-study companion. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

3. Alden JL, Kane JM [1982]. Design of industrial ventilation systems. New York, NY: Industrial Press, Inc.

4. Wadden RA, Scheff PA [1987]. Engineering design for control of workplace hazards. New York, NY: McGraw-Hill.

5. Plog BA [1988]. Fundamentals of industrial hygiene. Chicago, IL: National Safety Council.

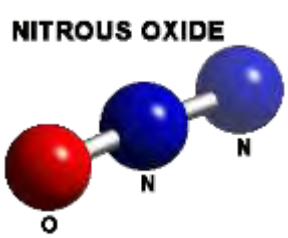
WORKPLACE MONITORING AND MEASUREMENT

Determination of a worker's exposure to airborne nitrous oxide can be made using one of the following techniques:

1. Use of a Landauer Passive Dosimeter badge, which can be used for a minimum sampling duration of 1 hour (maximum duration 40 hours). Analysis is performed by the manufacturer of the badge as described in the OSHA Computerized Information System.

2. An ambient air or bag sample with a minimum collection volume of two spectrophotometer cell volumes. Analysis is conducted using a long-path length portable infrared spectrophotometer as described in NIOSH Method No. 6600.

PROPERTIES AND MECHANISM OF ACTION



Nitrous oxide produces analgesic (pain killing) and anxiolytic (anxiety reduction) effects. Nitrous oxide is the weakest of the inhalant anesthetics used for patient sedation in dentistry or medicine. The chemical formula is N_2O. The gas is colorless, nonflammable, with a slightly sweet odor.

Nitrous oxide has low solubility in blood, diffuses rapidly across the alveolar-arterial membrane and is excreted unchanged through the lungs. As a result, nitrous takes effect rapidly and is quickly reversible on discontinuation. Nitrous oxide can induce loss of consciousness at high concentrations, typically 70% or higher. Nitrous oxide produces either no change, or a slight increase in blood pressure, while all other volatile anesthetics reduce blood pressure. There is no effect on heart rate, but high doses may cause myocardial depression.

The exact mechanism of action is unknown. However, the most widely accepted theory is that the analgesic effect is occurs by interaction with the opioid receptors. These are the same receptors activated by morphine and heroin. This stimulation occurs in the mid-brain leading to activation of the descending inhibitory pathways, which alters pain processing in the spinal cord. The anxiolytic effect is

mediated by interaction with the GABA-A receptors. The mechanism of action closely resembles that of ethanol. GABA is an inhibitory neurotransmitter that inhibits the pre-synaptic cells from transmitting thus decreasing nervous system activity.

Nitrous oxide gas is used in both the medical and dental professions to ensure patient comfort during procedures. A 40%-70% N_2O mixture (the remainder consisting of oxygen) is used as an adjunct to inhalation and IV general anesthesia. The gaseous mixture is administered using either a mask, nasal canula, or an endotracheal tube. The onset of action for N_2O is between 2-5 minutes. However, since the mean alveolar concentration (MAC) of N_2O considered the ED50 for general anesthesia (the dose at which 50% of patients will experience anesthesia) is 105%, nitrous cannot be used alone as a general anesthetic. Typically, nitrous oxide is only used to start the anesthesia process.

In dentistry, nitrous oxide is typically used as an anxiolytic or as an anxiety reducing agent. N_2O is given as a 25%-50% mixture with oxygen. Most often it is administered through a nasal mask or nasal canula.

The patient should be started out breathing 100% oxygen and then slowly allowed to breathe increasing amounts of N_2O until the desired effect is achieved. It is important that the patient be reminded to breathe through the nose in order for the gas to work. The patient should be questioned as to how they are feeling to ensure an optimal level of nitrous is being administered. Therapeutic levels will vary from patient to patient. If the nitrous level being administered is too low, the patient will not be receiving an effective anxiolytic dose. If the nitrous level is too high, unwanted side effects may occur. After the procedure is finished, allow the patient to breathe 100% oxygen again for 2-5 minutes in order to clear the nitrous from the lungs and return the patient to a pre-anesthetic state or normal feeling.

Disinfection

Disposable nose masks are available and widely used due to their convenience. However, if a reusable nosepiece is used, it is important to disinfect it between each patient. Nosocomial infections have occasionally been linked with the use of unsterile inhalation devices due to cross contamination. The recommended technique for disinfection of these masks is the use of an alkaline glutaraldehyde solution.

USES IN CLINICAL DENTISTRY

Indications

- A fearful, anxious, or obstreperous patient
- Certain patients with special health care needs
- A patient whose gag reflex interferes with dental care
- A patient for whom profound local anesthesia cannot be obtained
- A cooperative child undergoing a lengthy dental procedure

Contraindications

- Some chronic obstructive pulmonary diseases
- Severe emotional disturbances or drug-related dependencies (see abuse)
- First trimester of pregnancy
- Treatment with bleomycin sulfate
- Methylenetetrahydrofolate reductase deficiency (B12)

The contraindications for use of nitrous are important especially when considering that nitrous oxide is the only inhaled anesthetic proven to be teratogenic (causing birth defects) in animals, so is to be avoided in the first trimester of pregnancy. Patients with pulmonary hypertension or major cardiac disease should be evaluated carefully and in consultation with the medical doctor before using nitrous. Patients with severely compromised cardiac function are not candidates for nitrous oxide sedation because of the slight myocardial depressant action of the gas on the circulatory system. And patients who are claustrophobic may be unable to tolerate a nasal mask although use of a nasal canula may solve the issue. Some patients may fear “losing control” of themselves and adamantly refuse N_2O

sedation. Patients with persistent nasal congestion or obstruction or who unable to breathe comfortably through the nose, may not be candidates for nitrous oxide sedation.

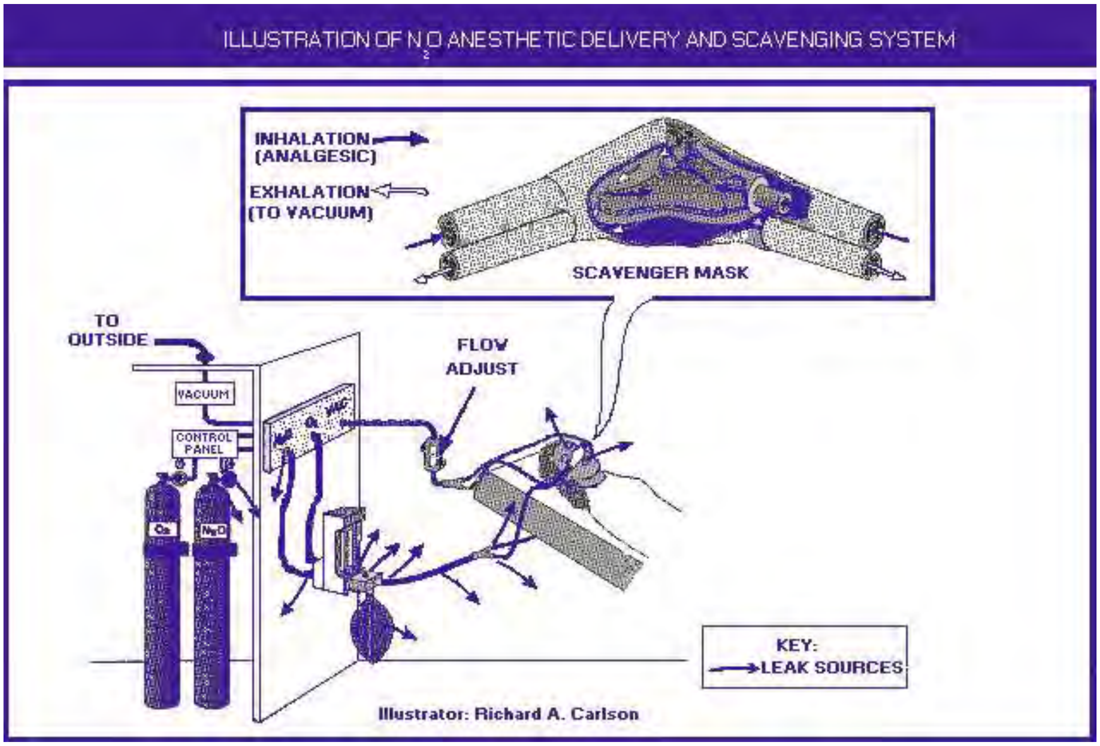
Review of patient's current medical history is critical prior to the decision to use nitrous oxide sedation and a medical consultation with the patient's physician may be necessary. This assessment should include:

- Allergies and previous allergic or adverse drug reactions
- Current medications including dose, time, route, and site of administration
- Diseases, disorders, or physical abnormalities and pregnancy status
- Previous hospitalization to include the date and purpose
- Obtain written consent from patient or the guardian of a minor patient.

EQUIPMENT

Mixtures of N_2O and oxygen have been used in dentistry as general anesthetic agents, analgesics, and sedatives for more than 100 years. The usual analgesia equipment used by dentists includes a N_2O and O_2 delivery system, a gas mixing bag, and a nasal mask or nasal canula with a positive pressure relief valve.

The illustration below shows basic N_20 equipment set up and arrows represent possible leakage areas, discussed below.



Engineering Controls / Maintenance Procedures

The following engineering controls and maintenance procedures have been shown to be feasible and effective in reducing workplace exposure to N_2O during anesthetic administration.

Anesthetic delivery

Excessive exposure to N_2O may occur as a result of leaks from the anesthetic delivery system during administration. The rubber and plastic components of the anesthetic equipment are potential sources of N_2O leakage because they may be degraded by the N_2O and the oxygen as well as by repeated sterilization.

These sources include leaks from the high-pressure connections present in the gas delivery tanks, the wall connectors, the hoses connected to the anesthetic machine, and the anesthetic machine (especially the on-demand valve). Low-pressure leaks occur from the connections between the anesthetic flowmeter and the scavenging mask. This leakage is due to loose-fitting connections, loosely assembled or deformed slip joints and threaded connections, and defective or worn seals, gaskets, breathing bags, and hoses.

All newly installed dental facilities that deliver nitrous oxide/oxygen must be checked for proper gas delivery and fail-safe function prior to use. Inhalation equipment must have the capacity for delivering 100%, and never less than 30%, oxygen concentration at a flow rate appropriate to the child's or adult's size. Additionally, inhalation equipment must have a fail-safe system that is checked and calibrated regularly according to the dental practitioner's state laws and regulations. All nitrous oxide delivery system equipment must have an appropriate scavenging system.

The dental clinician, who utilizes nitrous oxide/oxygen analgesia for a pediatric or general practice dental patient, shall possess appropriate training and skills and have available the proper facilities, personnel, and equipment to manage any reasonably foreseeable emergency. Training and certification in basic life support are required for all clinical personnel and per state regulation. These individuals should participate in periodic review of the office's emergency protocol, the emergency drug cart, and simulated exercises to assure proper emergency management response. Ideally the dental team meets regularly to review clinical emergency management protocols. All dental personnel need current CPR and basic life support training.

An emergency cart (kit) must be readily accessible. Emergency equipment must be able to accommodate adults and children of all ages and sizes. It should include equipment to resuscitate a non-breathing, unconscious patient and provide continuous support until trained emergency personnel arrive.

A positive pressure oxygen delivery system capable of administering >90% oxygen at a 10 liters/minute flow for at least 60 minutes (650 liters, "E" cylinder) must be available. When a self-inflating bag valve mask device is used for delivering positive pressure oxygen, a 15 liters/minute flow is recommended. There should be documentation that all emergency equipment and drugs are checked and maintained on a regularly scheduled basis. Where state law mandates equipment and facilities, such statutes should supersede this guideline.

Analgesia machines for dentistry are designed to deliver up to 70 percent (700,000 ppm) N_2O to a patient during dental treatment. The machine restricts higher concentrations of N_2O from being administered to protect the patient from hypoxia (lack of oxygen). In most cases, patients receive between 30 and 50 percent N_2O during a procedure. The amount of time N_2O is administered to a patient depends on the dentist's judgment of an individual patient needs and the complexity of the case.


Single-use mask

A newer type of mask is a frequent choice in dental practice: a single patient use nasal hood or single use nasal canula. This single use mask or canula does not require sterilization after surgery because it is used once and is disposable.

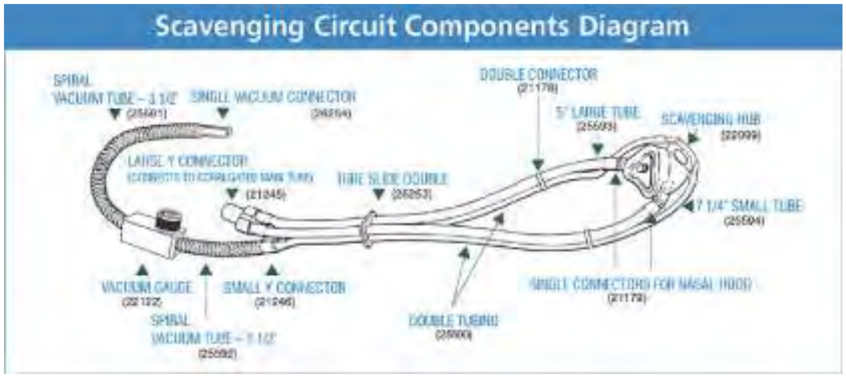
In a dental operatory, a scavenging system is part of a high-volume evacuation system used with a dental unit. The vacuum system may dispose of a combination of waste gases, oral fluid, and debris, and is not limited to waste gas removal. The exhaust air of the evacuation system should be vented outside the building and away from fresh-air inlets and open windows to prevent re-entry of gas into the operatory.

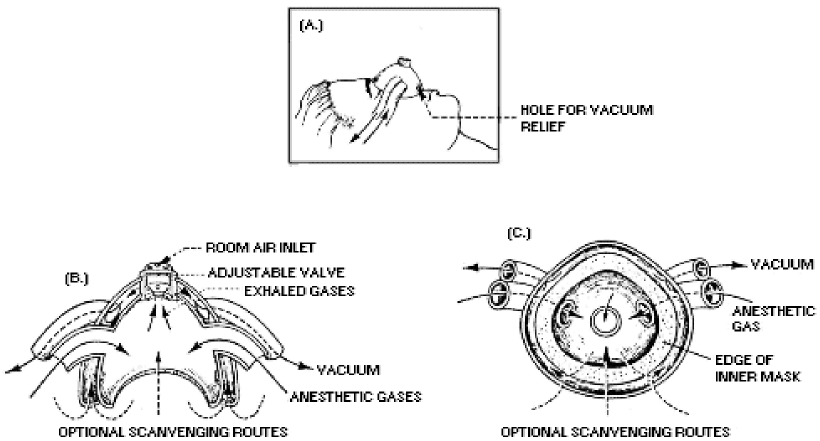
Scavenging System

A scavenging system designed to pick up excess gases consists of five basic components:

1. Gas collection assembly which captures excess anesthetic gases at the site of emission, and delivers it to the transfer tubing.
2. Transfer tubing: conveys the excess anesthetic gases to the interface.
3. The interface: provides positive (and sometimes negative) pressure relief and may provide reservoir capacity. It is designed to protect the patient's lungs from excessive positive or negative scavenging system pressure.
4. Gas disposal assembly tubing: conducts the excess anesthetic gases from the interface to the gas disposal assembly.

5. Gas disposal assembly: conveys the excess gases to a point where they can be discharged safely into the atmosphere. Several methods in use include a non-recirculating or recirculating ventilation system, a central vacuum system, a dedicated (single-purpose) waste gas exhaust system, or a passive duct system.





Circle breathing system connected to a closed reservoir scavenging interface.

The general ventilation should provide good room / air mixing. In addition, auxiliary (local) exhaust ventilation should be used in conjunction with a scavenging system and has been shown to be effective in reducing excess N_2O in the breathing zone of the dentist and dental assistant, from nasal mask leakage and patient mouth breathing. This type of ventilation captures the waste anesthetic gases at their source. However, there are practical limitations in using it in the dental operatory. These include proximity to the patient, interference with dental practices, noise, installation and maintenance costs. It is most important that the dentist not work between the patient and a free-standing local exhaust hood. Doing so will cause the contaminated air to be drawn through the dentist’s breathing zone.

SAFETY IN THE DIGITAL AGE

(per ADA Guide to Dental Therapeutics, 2008)

Significant and recent changes in safety protocols relates to the technology used to control the precise flow of gasses delivered through the inhalation sedation unit. Although the old flow tube flowmeter technology is still available, it is being replaced by the state-of-the-art digital electronic flow control devices, such as the Centurion Mixer and Digital MDM. Both of these devices are percentage devices and overcome the limitations of the older flow tube technology. The devices have resolution of the gas flow in increments of 0.1 liter per minute, and the total flow and percent of oxygen are displayed digitally, eliminating the guesswork or calculations required with simple flow tube devices. The ability to clean the front panel with a disinfection wipe reduces the potential of cross patient infection, an issue associated with the crevices created by knobs and levers. Patient safety is ensured with built-in alarms for all gas depletion conditions along with servo control of the gas delivery. Continuous internal self-monitoring of all operational parameters by the device frees the practitioner to concentrate on the patient's needs. The device alerts the practitioner or staff to unusual parameters requiring attention, similar to those seen in larger hospital-based systems.

The digital units deliver pure oxygen during the "flush" function by electronically shutting off the nitrous oxide flow, as opposed to the flow tube units, which only dilute the nitrous oxide delivered. Again, the removal of extra steps in shutting down the nitrous oxide supply before pressing the "flush" button is removed and greatly simplifies the practitioner's tasks.

The units contain flashing LEDs to afford the practitioner a simple method of ensuring that the individual component gas is flowing and that the relative ratio and amount of flow is correct. Additionally, the digital unit provides the capability of displaying the flow rate of either of the constituent gasses. The non-silenceable alarm function for oxygen depletion ensures patient safety. The air intake valve located on the bag tee provides room air to the patient whenever the patient's breathing demand is greater than the combined output of the mixer head's settings and reservoir bag volume.

Various models of the electronic gas mixing head allow mounting as a wall unit, portable unit, countertop unit, or as a flush-mount unit in modern cabinetry. Digital heads have the most flexibility, especially when combined with various remote bag tee options provided by the manufacturer. The units are fully compatible with central gas supply systems such as the popular Flo-Safe Manifold, Centurion Gas Manifold, and all existing scavenging systems.

Electronic digital administration heads for delivery of conscious sedation advance the art of dentistry. The digital heads once considered the wave of the future are the standard today. The digital accuracy and exacting control is highly recommended for patient comfort and safety (Malamed, 2008, for the ADA Dental Therapeutics).

Safety Features Incorporated into Modern Inhalation Sedation Units

- Alarm
- Color coding
- Diameter index safety system
- Emergency air inlet
- Lock
- Minimum oxygen liter flow
- Minimum oxygen percentage
- Oxygen fail-safe
- Oxygen flush button
- Pin index safety system
- Quick-connect for positive-pressure oxygen
- Reservoir bag

CLINICAL WORK PRACTICES

- Prior to first use each day of the N_2O machine and every time a gas cylinder is changed, the low-pressure connections should be tested for leaks. High-pressure line connections should be tested for leaks quarterly. A soap solution may be used to test for leaks at connections. Alternatively, a portable infrared spectrophotometer can be used to detect an insidious leak.
- Prior to first use each day, inspect all N_2O equipment (e.g., reservoir bag, tubing, mask, connectors) for worn parts, cracks, holes, or tears. Replace as necessary. Connect mask to the tubing and turn on vacuum pump. Verify appropriate flow rate (i.e., up to 45 L/min or manufacturer's recommendations).

- A properly sized mask should be selected and placed on the patient. A good, comfortable fit should be ensured. The reservoir (breathing) bag should not be over or under-inflated while the patient is breathing oxygen (before administering N_2O).
- Encourage the patient to minimize talking, mouth breathing, and facial movement while the mask is in place.

- During N_2O administration, the reservoir bag should be periodically inspected for changes in tidal volume, and the vacuum flow rate should be verified.
- On completing anesthetic administration and before removing the mask, non-anesthetic gases/agents should be delivered to the patient for a sufficient time based on clinical assessment that may vary from patient to patient. In this way, both the patient and the system will be purged of residual N_2O. Do not use an oxygen flush.

CLINICAL ADMINISTRATION PROTOCOLS

Some dentists administer N_2O at higher concentrations at the beginning of the procedure, and then decrease the amount as the procedure progresses. Others administer the same amount of N_2O throughout the procedure. When the procedure is completed, the N_2O is turned off. Some dentists turn the N_2O on only at the beginning of the operation, using N_2O as a sedative during the administration of local anesthesia, and turn it off before operating procedures. Based on variations in dental practices and other factors in room air, N_2O concentrations can vary considerably for each operation and also vary over the course of the dental procedure.

In the typical dental office procedure, the nasal mask or nasal canula is placed on the patient, fitted, and adjusted prior to administration of the nitrous oxide/ oxygen gases. The mask or canula is designed for the nose of the patient since access to the patient's mouth is essential for dental procedures.

Ideal sedation has been achieved when the patient states that he or she is experiencing some or all of the following:

- feeling of warmth throughout his or her body
- numbness of the hands and feet
- numbness of the soft tissues of the oral cavity
- a feeling of euphoria, and a feeling of lightness or of heaviness of the extremities.

***Note that not all patients will experience the same symptoms.**

.A local anesthetic, if needed, is typically administered after the N_2O takes effect. The patient's mouth is opened and the local anesthetic is injected. The dental procedure begins after the local anesthetic takes effect. The patient opens his/her mouth but is instructed to breathe through the nose. Nonetheless, a certain amount of mouth breathing frequently occurs. The dentist may periodically stop the dental procedure for a moment to allow the patient to close the mouth and breathe deeply to re-establish an appropriate concentration of N_2O in the patient's body before resuming the procedure. Depending on the nature of the procedure, high velocity suction is regularly used to remove intra-oral debris and, when used, creates a negative air flow and captures some of the gas exhaled by the patient.

At the end of the procedure, the nosepiece is left on the patient while the N_2O is turned off and the oxygen flow is increased. The anesthetic mixture diffuses from the circulating blood into the lungs and is exhaled. Scavenging is continued while the patient is eliminating the N_2O.

Monitoring the Patient

The response of patients to commands during procedures performed during nitrous oxide anesthesia serves as a guide to their level of consciousness. Clinical observation of the patient must be done during any dental procedure. During nitrous oxide/oxygen analgesia, continual clinical observation of the patient's responsiveness, color, and respiratory rate and rhythm must be performed. Spoken responses provide an indication that the patient is breathing. If any other pharmacologic agent is used in addition to nitrous oxide/oxygen and a local anesthetic, monitoring guidelines for the appropriate level of sedation must be followed.

The use of a pulse oximeter is also indicated. The oximeter measures the amount of oxygen saturation in the bloodstream via a sensor device placed on a finger or in the case of an infant, on a foot. If the reading falls below 90%, the attending dental personnel need to increase oxygen by increasing flow by making sure the airway is unobstructed and that the patient is breathing deeply enough to maintain appropriate levels. Pulse oximeters are relatively inexpensive and are extremely helpful in monitoring the patient during nitrous oxide administration. Most pulse oximeters have a sound notification if the oxygen saturation in the blood falls below 90%.

Examples of Pulse Oximeter Devices

Side Effects of Nitrous Oxide / Oxygen Inhalation

The side effects of N_2O take three main forms:

1. Metabolic inhibition
2. Pressure/volume problems
3. Problems related to the administration of oxygen.

Metabolism of Nitrous Oxide

Nitrous oxide irreversibly oxidizes the cobalt atom of vitamin B12, inhibiting the activity of the cobalamine-dependent enzyme methionine synthase. Synthesis of the enzyme is required to restore activity and takes several days. A 50% decrease in methionine synthase activity is seen after only 2 hours of exposure. Loss of this enzyme shuts off the synthesis of methionine, a principle substrate for assembly of myelin sheaths and DNA synthesis, and leads to an accumulation of its precursor homocysteine. In adults with untreated B12 deficiency exposed to nitrous or those who chronically abuse N_2O leading to depletion of body stores of cobalamine, a myeloneuropathy is seen which is identical to subacute combined degeneration of the spinal column as seen in pernicious anemia. A high degree of suspicion is necessary for any patient who develops neurologic symptoms after nitrous anesthesia. For these reasons, patients with suspected B12 deficiency (history of B12 supplementation, post gastrectomy, ileal malabsorption) or anemia should not receive nitrous.

Pressure/Volume Toxicity

The other major cause of adverse events from nitrous oxide is due to pressure/volume complications. Compared to nitrogen, nitrous oxide is 34 times more soluble in blood. It will thus diffuse from the blood into any closed air-filled cavity in the body faster than the nitrogen can diffuse out. In a cavity with thick or noncompliant walls, the pressure inside such a cavity will immediately begin to increase. On the other hand, if the nitrous diffuses into a compliant, thin-walled air-filled space such as a pulmonary cyst or a loop of incarcerated bowel, the elevation in pressure will lead to distention of the structure. The major example of nitrous diffusing into a poorly compliant cavity is the eyeball.

Opthalmologists frequently inject inert gases, e.g., sulfur hexafluoride or perflouropropane, into the eye to treat retinal detachments. These injections are administered during retinal surgery but may also be done in an office setting. These gas bubbles can remain in the eyeball for weeks before they are reabsorbed. If a patient with an intraocular gas bubble receives nitrous oxide anesthesia, the nitrous will diffuse into the gas bubble and lead to an immediate and dangerous elevation of intraocular pressure. The elevated pressure leads to central retinal artery occlusion and irreversible vision loss. Cases of total vision loss have been reported in patients with diabetic retinopathy followed by nitrous anesthesia. Therefore, the first question to be asked of any patient before nitrous oxide anesthesia is given should ascertain whether the patient has had any ocular procedures, injections, or surgery in the previous 3 months prior to the contemplated use of nitrous oxide.

Ideally, such a patient will still be wearing their green plastic wristband, issued by the opthamologist warning against the use of nitrous oxide.

Oxygen Toxicity

Nitrous oxide administration should be avoided in patients who have received therapy with Bleomycin, an anti-neoplastic antibiotic, which is known to cause pulmonary toxicity. Acute respiratory distress syndrome has occurred in patients who have received bleomycin and is felt to be due to fluid overload and high inspired oxygen concentrations given during the surgical procedure.

Post-inhalation Hypoxia (lack of oxygen)

In 1955, Dr. Raymond Fink published a paper documenting oxygen desaturation of up to 10% occurring after patients given N_2O /O_2 anesthesia were placed on room air, with the effect lasting up to 10 minutes. For this reason, the standard of care is to administer 100% oxygen for at least 5 minutes to all patients at the conclusion of inhalation anesthesia with N_2O /O_2. This has been shown to completely prevent this so-called post-inhalation hypoxia.

Acute and chronic adverse effects of nitrous oxide on the patient are rare. Nausea and vomiting are the most common adverse effects, occurring in 0.5% of patients. A higher incidence is noted with longer administration of nitrous oxide/oxygen, fluctuations in nitrous oxide levels, and increased concentrations of nitrous oxide. Fasting is not required for patients undergoing nitrous oxide analgesia. The practitioner, however, may recommend that only a light meal be consumed in the 2 hours prior to the administration of nitrous oxide to avoid any possibility of aspiration of vomit during a procedure.

DOCUMENTATION

Informed consent must be obtained from the parent and documented in the patient's record prior to administration of nitrous oxide/oxygen. The practitioner should provide instructions to the parent regarding pre-treatment dietary precautions, if indicated. In addition, the patient's record should include indication for use of nitrous oxide/oxygen inhalation, nitrous oxide dosage (i.e., percent nitrous oxide/oxygen and/or flow rate), duration of the procedure, and post treatment oxygenation procedure.

Documentation is critical to protect a dentist in the case of a lawsuit. All aspects of a procedure must include the percentage of N_2O administered, the length of time the patient was sedated, and the flow of gas during administration.

An acceptable example of documentation for the procedure:

> **"Pt. given 25% N20/75%O2 for 45 minutes @ 7L/min. Pt. initially given 35% N20/65% O2 and reported "slight uneasy feeling' – N2O was subsequently adjusted and comfortable level of sedation achieved". In 10:45am – Out 11:30am".**

Documentation must be consistent and accurate. If in doubt more documentation is better than less.

ADDITIONAL WORKPLACE SAFETY INFORMATION

(per OSHA & NIOSH)

Health Effects

Animal studies have shown adverse reproductive effects in female rats exposed to airborne concentrations of N_2O. Data from these studies indicate that exposure to N_2O during gestation can produce adverse health effects in the offspring.

Several studies of workers have shown that occupational exposure to N_2O causes adverse effects such as reduced fertility, spontaneous abortions, and neurologic, renal, and liver disease. A recent study reported that female dental assistants exposed to unscavenged N_2O for 5 or more hours per week had a significant risk of reduced fertility compared with unexposed female dental assistants. The exposed assistants had a 59% decrease in probability of conception for any given menstrual cycle compared with the unexposed assistants. For dental assistants who used scavenging systems during N_2O administration, the probability of conception was not significantly different from that of the unexposed assistants. Since environmental exposures were not measured during these epidemiologic studies, no dose-effect relationship could be established.

Workers Exposed

More than 600,000 workers (i.e., dentists, dental assistants, and dental hygienists) practice dentistry in the United States. In 2010, the American Dental Association (ADA) reported that 35% of all dentists used N_2O to control pain and anxiety in their patients. The ADA Survey of Dental Practice indicated that 58% of dentists reported having N_2O anesthetic equipment, and 64% of those practitioners also reported having a scavenging system.

General Workplace Controls

Occupational exposure for dental clinicians can be controlled by the application of a number of well-known principles including engineering and work practice controls, administrative controls, personal protective equipment, and monitoring.

Exposure may be controlled by some or all of the following:

- Effective anesthetic gas scavenging systems that remove excess anesthetic gas at the point of origin.
- Effective general or dilution ventilation.
- Good work practices on the part of the health-care workers, including the proper use of controls.
- Proper maintenance of equipment to prevent leaks.

- Periodic personnel exposure and environmental monitoring to determine the effectiveness of the overall waste anesthetic gas control program.

Occupational Exposure Limits

The Occupational Safety and Health Administration (OSHA) does not currently have an exposure limit standard for N_2O.

The NIOSH recommended exposure limit (REL) for N_2O is 25 ppm as a time-weighted average (TWA) during the period of anesthetic administration [NIOSH 1977b]. This REL is intended to prevent decreases in mental performance, audiovisual ability, and manual dexterity during exposures to N_2O. An REL to prevent adverse reproductive effects cannot be established until more data are available.

The American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit value (TLV) for N_2O is 50 ppm as an 8-hour TWA.

Guidelines for Minimizing Exposure

Exposure monitoring should be the first step in developing work practices and worker education programs, since measurements of N_2O are needed to determine the type and extent of controls that are necessary. Guidelines for this section are provided from OSHA and NIOSH websites.

http://www.osha.gov/SLTC/healthguidelines/nitrousoxide/recognition.html

Determination of a worker's exposure to airborne nitrous oxide can be made using one of the following techniques:

- Landauer Passive Dosimeter badge, which can be used for a minimum sampling duration of 1 hour (maximum duration 40 hours). Analysis is performed by the manufacturer of the badge as described in the OSHA Computerized Information System.

- Use of an ambient air or bag sample with a minimum collection volume of two spectrophotometer cell volumes. Analysis is conducted using a long-path length portable infrared spectrophotometer as described in NIOSH Method No. 6600.

- ADA (American Dental Association) approved manufacturer of various dosimeter badges for nitrous oxide exposure measurement.

NITROUS OXIDE BADGE MONITORS

The United States Department of Labor recommends healthcare workers and dental clinicians monitor exposure to N_20 by use of badges. Several manufacturers make monitoring badges. Landauer is specifically mentioned by the Labor Department and offers the information below from their website:

The Landauer nitrous oxide monitor (NITROX®) is a diffusion type air monitoring badge assembly worn in the breathing zone of personnel to evaluate potential exposure to N_2O gas. Nitrous oxide gas is adsorbed on the selected adsorbent material (molecular sieve), sent to the laboratory and thermally desorbed and analyzed by the manufacturer using IR. Both an active cartridge sample collected by drawing air through the cartridge with a calibrated sampling pump, (referred to as "active samples" in this report), and a passive monitor sample which requires no sampling pump to collect the sample (referred to as "passive samples" in this report) were taken. Both use the same proprietary adsorbent material.

Advantages and Disadvantages

(per Dept. of Labor)

This badge monitor method, such as Landauer has adequate sensitivity for measuring workplace atmosphere concentrations of N_2O.

The sampling procedure for this method involves no liquid and mechanical pumps. A somewhat bulky direct-reading instrument is not used and pre- and post-calibration is not necessary.

One disadvantage is the requirement that the monitor is analyzed at the manufacturer's laboratory, which does not allow for immediate results as given by a direct-reading instrument. Quality control is dependent mainly on the manufacturer; this makes it difficult for those laboratories which prefer to conduct their own quality control program. It is recommended that users occasionally prepare spiked samples to assure adequate quality control.

Signs and Symptoms of Exposure

Acute exposure: The signs and symptoms of acute exposure to nitrous oxide include dizziness, difficult breathing, headache, nausea, fatigue, and irritability. Acute exposure to nitrous oxide concentrations of 400,000 to 800,000 ppm may cause loss of consciousness.

Chronic exposure: The signs or symptoms of chronic overexposure to nitrous oxide may include tingling, numbness.

ABUSE OF NITROUS OXIDE

- The substance disrupts learning ability. In a typical experiment volunteers who inhaled a low dose of the drug showed worsened reaction time, worsened ability to do arithmetic, and general sedation accompanied by nervous system depression (as opposed to stimulation).
- Interference with driving ability has been noted one-half hour after a dose.
- Short-term exposure can cause dizziness, nausea, vomiting, and breathing difficulty.

- Some recreational users quickly inhale as much nitrous oxide as possible and hold their breath. This technique causes a sudden change of pressure inside the lungs and can rupture small interior structures needed for breathing.
- Blood pressure can go up or down, depending on dosage. Users can lose consciousness, which may be hazardous in a recreational context due to falls or inability to shut off the gas source.
- The substance deactivates vitamin B12, an effect that can cause numbness and difficulty in moving arms and legs.
- Other results can be impotence and involuntary discharge of urine and feces.
- Nitrous oxide interferes with blood clotting, and long-term exposure has caused blood abnormalities.
- Persons with chronic industrial exposure have more kidney and liver disease than usual.
- Nitrous oxide can become very cold when released as a gas from a pressurized container, cold enough to cause frostbite upon meeting skin or throat.
- Breathing nitrous oxide without an adequate supply of oxygen can be fatal; a little in a closed space or a lot from a face mask can suffocate a user.
- Although nitrous oxide is called nonflammable, when inhaled it can seep into the abdominal cavity and bowels, mixing with body gases to create a flammable combination. If ignited the result would be like setting off an explosive inside the body; the danger is real enough that surgical personnel administering nitrous oxide as an anesthetic have been warned about it.

CONCLUSION

Nitrous oxide / oxygen anesthesia is used in a standard way in dentistry and medicine. And review of the standards on a regular basis is invaluable to maintain the highest standard of care. Professional use and administration of nitrous oxide is a tried and true method to manage patients' anxiety for dental procedures. The overall patient experience is enhanced by careful and professional use of this practice-building anesthetic gas. Dental team members must adhere to the best clinical protocols and know the standard of care to ensure absolute safety for the patient and to minimize exposure to themselves. Nitrous oxide is safe and effective for use by qualified dental professionals in a wide variety of situations requiring pain and anxiety management in the dental office setting.

EXAM – NITROUS OXIDE CLINICAL REVIEW

Click here to take the online test.

1. The benefits of Nitrous Oxide sedation include:
   a. Increases patient comfort
   b. Safe and effective
   c. Short recovery time
   d. Easy to administer
   e. All of the above

2. The first dentist to successfully use N_2O for an extraction was Dr. Horace Well.
   a. True
   b. False

3. Synonyms for N_2O include all of the following, EXCEPT:
   a. Dinitrogen monoxide
   b. Hyponitrous acid anhydride
   c. Nitric monoxide
   d. Laughing gas

4. OSHA currently regulates exposure limits of nitrous oxide in clinical practice.
   a. True
   b. False

5. Nitrous oxide is an asphyxiant at high concentrations.
   a. True
   b. False

6. Tingling, numbness, difficulty in concentrating and interference in gait represent:
   a. Acute exposure
   b. Chronic exposure

7. Methods that are effective in controlling worker exposure to N_2O, include:
   a. Process enclosure
   b. Local exhaust ventilation
   c. General dilution ventilation
   d. Personal protection equipment
   e. All of the above

8. The use of a Landauer Dosimeter badge is an active method of collecting a sampling to determine nitrous oxide exposure for a clinician.
   a. True
   b. False

9. The anxiolytic effect of N_2O is mediated by interaction with GABA-A receptors and closely resembles that of ethanol.
   a. True
   b. False

10. A __________ N_2O to oxygen mixture is used as an adjunct to inhalation and IV general anesthesia.
   a. 20%-80%
   b. 30%-70%
   c. 40%-70%
   d. None of the above

11. In dentistry, N_2O is typically used as a 25%-50% mixture with oxygen.
   a. True
   b. False

12. Indications for use of N_2O in clinical dentistry include the following, EXCEPT:
   a. A fearful, anxious, or obstreperous patient
   b. Patients in the first trimester of pregnancy.
   c. A patient with a gag reflex that interferes with care.
   d. A cooperative child undergoing a lengthy procedure.

13. Contraindications for use of N_2O in patients include the following, EXCEPT:
   a. Chronic obstructive pulmonary diseases.
   b. Severe emotional disturbances
   c. Treatment with bleomycin sulfate
   d. Methylenetetrahydrofolate reductase deficiency (B12)
   e. None of the above

14. Excessive exposure to N_2O may occur as a result of leaks from the anesthetic delivery system during administration.
   a. True
   b. False

15. A positive pressure oxygen delivery system capable of administering ________ oxygen at 10 liters/ minute flow for at least _______ minutes must be available.
   a. > 70% - 30 mins
   b. > 80% - 30 mins
   c. > 90% - 30 mins
   d. > 90% - 60 mins
   e. > 100% - 60 mins

16. Use of a scavenging system is optional in an operatory with optimized room ventilation which is also digitally monitored.
    a. True
    b. False

17. Digital administration units deliver pure oxygen during the “flush” function by shutting off the nitrous oxide flow, as opposed to flow tube units, which only dilute the N_2O delivered.
    a. True
    b. False

18. The _______ alarm function for oxygen depletion ensures patient safety.
    a. Oximeter
    b. Silenceable
    c. Non-silenceable
    d. Oxygen intake monitoring

19. Ideal sedation has been achieved when the patient states that he/she are feeling:
    a. feeling of warmth throughout the body.
    b. numbness of the hands or feet.
    c. numbness of the soft tissues of the oral cavity.
    d. a feeling of euphoria or heaviness in the extremities.
    e. all of the above.

20. The response of patients to commands during procedures during N_2O anesthesia serves as a guide to their level of consciousness.
    a. True
    b. False

21. A reading on a pulse oximeters should not fall below:
    a. 70%
    b. 80%
    c. 90%
    d. 100%

22. Pressure / Volume toxicity is of concern with procedures prior to dental treatment by:
    a. Cardiologists
    b. Ophthalmologists
    c. Dermatologists
    d. Gastroenterologists

23. If a patient noted on their medical history the use of the antibiotic ___________, N_2O should not be administered.
    a. Bleomycin
    b. Erythromycin
    c. Amoxicillin
    d. Bi-cillin K

24. Documentation of the patient's N_2O administration should include:
    a. percentage of N_2O administered
    b. length of time the patient was sedated
    c. flow of gas during administration
    d. all of the above

25. Nitrous oxide exposure is risky for:

a. Female dental assistants of reproduction age
b. Patients in the first trimester of pregnancy
c. Drug impaired patients
d. All of the above

FAX ANSWER SHEET (703) 935-2190
Nitrous Oxide Sedation Review

Please complete and **fax this form only** to (703) 935-2190. Be sure to include the name of the course you are submitting answers for. Please print your answers clearly.

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Please print the corresponding letter for each answer below:

1.	______	**6.**	______	**11.**	______	**16.**	______	**21.**	______
2.	______	**7.**	______	**12.**	______	**17.**	______	**22.**	______
3.	______	**8.**	______	**13.**	______	**18.**	______	**23.**	______
4.	______	**9.**	______	**14.**	______	**19.**	______	**24.**	______
5.	______	**10.**	______	**15.**	______	**20.**	______	**25.**	______

Please help us improve by circling the appropriate answer.

Ordering experience was convenient.	Yes	No
I received my workbook or file in a timely manner.	Yes	No
Course text and test is clear and understandable.	Yes	No
I will use the course information in my daily practice.	Yes	No

Overall, I would give this course a grade of _________.

Comments:

____

____

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GLOSSARY OF TERMS

The following glossary of terms relates to use of N_20 sedation. This list is abbreviated from the OSHA list. The full glossary is available by searching the OSHA website: http://www.osha.gov/dts/osta/anestheticgases/index.html

Air is the elastic, invisible mixture of gases (chiefly nitrogen and oxygen) that may be used with medical equipment; also called medical air.

Anesthesia machine is equipment intended for dispensing and delivering anesthetic gases and vapors into a breathing system.

Anesthetic agent is a drug that is used to reduce or abolish the sensation of pain, e.g., halothane, enflurane, isoflurane, desflurane, sevoflurane, and methoxyflurane.

Anesthetic gas is any gaseous substance, e.g., nitrous oxide, used in producing a state of anesthesia.

Anesthetizing location is any area in a facility where an anesthetic agent or drug is administered in the course of examination or treatment. This includes operating rooms, delivery rooms, emergency rooms, induction rooms, and other areas.

Area sample is a sample collected at a fixed point in the workplace.

Breathing system is a gas pathway in direct connection with the patient's lungs, through which gas flow occurs at respiratory pressures, and into which a gas mixture of controlled composition may be dispensed. The function of the breathing system is to convey oxygen and anesthetic gases to the patient's lungs and remove waste and anesthetic gases from the patient's lungs. Scavenging equipment is not considered part of the breathing system. The system is also referred to as breathing or patient circuit, respiratory circuit or system.

Breathing zone is defined as the area immediately adjacent to the employee's nose and mouth; a hemisphere forward of the worker's shoulders with a radius of approximately 6 to 9 inches.

Carbon dioxide (CO_2) is a colorless, odorless gas, and is a normal end product of human metabolism. It is formed in the tissues and eliminated by the lungs.

Carcinogenicity is the ability of a substance to cause cancer.

Check valves are also known as unidirectional valves, one-way valves, and inspiratory and expiratory valves (refer to definition of unidirectional valve).

Compressed gas is defined as any material or mixture having in the container an absolute pressure exceeding 40 psig at 70°F or having an absolute pressure exceeding 104 psig at 130°F.

Congenital anomaly is a structural or functional abnormality of the human body that develops before birth but is not inherited. One type of birth defect.

Cylinder supply source is a cylindrical-shaped tank that is color-coded and pin-indexed or Compressed Gas Association (CGA)valve-specific and used to contain a specified medical gas.

Cylinder pressure gauge monitors the pressure of gas within a cylinder.

Epidemiology is the study of health and illness in human populations.

Excess gases are those gases and anesthetic vapors that are delivered to the breathing circuit in excess of the patient's requirements and the breathing circuit's capacity These gases are removed from the breathing circuit by the waste gas scavenging system.

Exhalation check valve, also known as expiratory unidirectional valve, refers to that valve that ensures that exhaled gases flow away from the patient and into the waste gas absorber.

Flow control valve, also known as the needle valve, controls the rate of flow of a gas through its associated flow meter by manual adjustment.

Flowmeter is a device that measures and indicates the flow rate of a gas passing through it.

Gas is defined as a formless fluid that expands readily to fill any containing vessel, and which can be changed to the liquid or solid state only by the combined effect of increased pressure and decreased temperature.

General anesthesia is a state of unconsciousness in which there is an absence of pain sensation.

HVAC system, also known as the heating, ventilating, and air conditioning system, supplies outdoor replacement (make-up) air and environmental control to a space or building. HVAC systems condition the air by supplying the required degree of air cleanliness, temperature and/or humidity.

Medical gas is any gaseous substance that meets medical purity standards and has application in a medical environment. Examples are oxygen, nitrous oxide, helium, air, nitrogen, and carbon dioxide.

Medical gas mixture is a mixture of two or more medical gases to be used for a specific medical application.

NIOSH RELs (recommended exposure limits) are occupational exposure limits for a 40 hour work week.

Nitrous oxide (N_2O) is used as an anesthetic agent in medical, dental, and veterinary operatories. N_2O is a weak anesthetic with rapid onset and rapid emergence. In dental offices, it is administered with oxygen, primarily as an analgesic (an agent that diminishes or eliminates pain in the conscious patient) and as a sedative to reduce anxiety.

Occupational exposure to waste anesthetic gases includes exposure to any inhalation anesthetic agents that escape into locations associated with, and adjacent to, anesthetic procedures. **Oxygen (O_2)** is an element which, at atmospheric temperatures and pressures, exists as a colorless, odorless, tasteless gas. Outstanding properties are its ability to sustain life and to support combustion.

Oxygen flush valve is a separate valve designed to rapidly supply a large volume of oxygen to the breathing system.

PACU (post-anesthesia care unit) is also known as the recovery room.

Pin Index Safety System is a safeguard to eliminate cylinder interchanging and the possibility of accidentally placing the incorrect gas on a yoke designed to accommodate another gas.

Pipeline supply source is a permanently installed piped distribution system that delivers medical gases such as oxygen, nitrous oxide, and air to the operating room.

Reservoir bag is also known as the respiratory bag or breathing bag. It allows accumulation of gas during exhalation so that a reservoir is available for the next inspiration. It can serve, through visual and tactile observation, as a monitor of a patient's spontaneous respirations and acts to protect the patient from excessive pressure in the breathing system.

Respiration is the process by which a rapid exchange of oxygen and carbon dioxide takes place between the atmosphere and the blood coming to the pulmonary capillaries. Oxygen is taken up and a proportional amount of carbon dioxide is released.

Scavenging is defined as the collection of excess gases from the breathing circuit and removal of these gases to an appropriate place of discharge outside the working environment.

Scavenging system is defined as a device (assembly of specific components) that collects and removes the excess anesthetic gases that are released from the breathing circuit.

Source sample is a sample collected at the origin of contamination.

Teratogenicity is the ability of a substance to cause birth defects in offspring, as a result of maternal (before or after conception) or paternal exposure to the toxic substance.

Tracheal tube also called the endotracheal tube, intratracheal tube, and catheter is inserted into the trachea and is used to conduct gases and vapors to and from the lungs.

TWA is a time-weighted average concentration. It is a way of expressing exposure such that the amount of time spent exposed to each different concentration level is weighted by the amount of time the worker was exposed to that level.

Unidirectional valve is a valve that allows gas flow in one direction only.

Vapor is the gaseous phase of a substance which at ordinary temperature and pressure exists as a liquid.

Ventilation is (1) the physical process of moving gases into and out of the lungs. (2) It is also defined for the purposes of industrial hygiene engineering as a method for providing control of an environment by strategic use of airflow.

Waste anesthetic gases are those gases that are inadvertently released into the workplace and/or can no longer be used.