

Best Practices on Use of Nitrous Oxide for Pediatric Dental Patients

Review Council

Council on Clinical Affairs

Latest Revision

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Purpose

The American Academy of Pediatric Dentistry (AAPD) recognizes nitrous oxide/oxygen inhalation as a safe and effective technique to reduce anxiety, produce analgesia, and enhance effective communication between a patient and health care provider. The need to diagnose and treat, as well as the safety of the patient and practitioner, should be considered before using nitrous oxide. By producing this guideline, the AAPD intends to assist the dental profession in developing appropriate practices in the use of nitrous oxide/oxygen analgesia/anxiolysis for pediatric patients.

Methods

This guideline was originally developed by the Council on Clinical Affairs and adopted in 2005. This document is a revision of the previous version, last revised in 2013. The revision is based on a review of the current dental and medical literature related to nitrous oxide use. An electronic search was conducted using PubMed® with the parameters: "Nitrous Oxide"[Mesh] OR "nitrous oxide reductase" [Supplementary Concept], Publication date from January 1, 2012; Humans; Child: birth-18 years. Thirty-nine articles met these criteria, and applicable articles were chosen and added to the references from the previous document. Additionally, the American Dental Association's *Guideline for the Use of Sedation and General Anesthesia by Dentists*¹ and the American Dental Association's *Oral Health Topics – Nitrous Oxide Dental Best Practices for Nitrous Oxide-Oxygen Use*² were reviewed. When data did not appear sufficient or were inconclusive, recommendations were based upon expert and/or consensus opinion by experienced researchers and clinicians.

Background

Dentists have expertise in providing anxiety and pain control for their patients. While anxiety and pain can be modified by psychological techniques, in many instances pharmacological approaches are required.¹ The outcome of pharmacological approaches is variable and depends upon each patient's response to various drugs. The clinical effect of nitrous oxide/oxygen inhalation, however, is more predictable among the majority of the population. When used for analgesia/anxiolysis, nitrous oxide/oxygen inhalation allows for diminution or elimination of pain and anxiety in a conscious patient, while entailing minimum risk.³ The patient responds normally to verbal commands.⁴ All vital signs are stable, there is no significant risk of losing protective reflexes, and the patient is able to return to pre-procedure mobility. In children, analgesia/anxiolysis may expedite the delivery of procedures that are not particularly uncomfortable but require that the patient not move.³ It also may allow the patient to tolerate unpleasant procedures by reducing or relieving anxiety, discomfort, or pain. Furthermore, it increases reaction time and reduces pressure-induced pain, but does not affect pulpal sensitivity, as shown in a double blind, crossover study.⁵

Nitrous oxide is a colorless and virtually odorless gas with a faint, sweet smell. It is an effective analgesic/anxiolytic agent causing central nervous system (CNS) depression and euphoria with little effect on the respiratory system.^{6,7} Nitrous oxide has multiple mechanisms of action. The analgesic effect of nitrous oxide appears to be initiated by neuronal release of endogenous opioid peptides with subsequent activation of opioid receptors and descending Gamma-aminobutyric acid type A (GABAA) receptors and noradrenergic pathways that modulate nociceptive processing at the spinal level. The anxiolytic effect involves activation of the GABAA receptor either directly or indirectly through the benzodiazepine binding site.^{8,9} Nitrous oxide has rapid uptake, being absorbed quickly from the alveoli and held in a simple solution in the serum. It is relatively insoluble, passing down a gradient into other tissues and cells in the body, such as the CNS. It is excreted quickly from the lungs. Nitrous oxide causes minor depression in cardiac output while peripheral resistance is slightly increased, thereby maintaining the blood pressure.⁵ This is of particular advantage in treating patients with

cerebrovascular system disorders. Nitrous oxide is absorbed rapidly, allowing for both rapid onset and recovery (two to three minutes). It causes minimal impairment of any reflexes, thus protecting the cough reflex.⁶ It exhibits a superior safety profile with no recorded fatalities or cases of serious morbidity when used within recommended concentrations.¹⁰⁻¹³

The decision to use nitrous oxide/oxygen analgesia/anoxiolysis must take into consideration alternative behavioral guidance modalities, the patient's dental needs, the effect on the quality of dental care, the patient's emotional development, and the patient's physical considerations. Nitrous oxide generally is acceptable to children and can be titrated easily. Most children are enthusiastic about the administration of nitrous oxide/oxygen; many children report feeling a tingling or warm sensation.¹⁴ Objectively, children may appear with their hands open, legs limp, and a trancelike expression.¹⁴ For some patients, however, the feeling of losing control may be troubling, and children with claustrophobia may find the nasal hood confining and unpleasant.¹⁵

Nitrous oxide has been associated with bioenvironmental concerns because of its contribution to the greenhouse effect.¹⁶ Nitrous oxide is emitted naturally by bacteria in soils and oceans; it is produced by humans through the burning of fossil fuels and forests and the agricultural practices of soil cultivation and nitrogen fertilization. Altogether, nitrous oxide contributes about five percent to the greenhouse effect.^{17,18} Only a small fraction of this five percent (0.35 to two percent), however, is actually the result of combined medical and dental applications of nitrous oxide gas.¹⁸

The objectives of nitrous oxide/oxygen inhalation include:

1. Reduce or eliminate anxiety.
2. Reduce untoward movement and reaction to dental treatment.
3. Enhance communication and patient cooperation.
4. Raise the pain reaction threshold.
5. Increase tolerance for longer appointments.
6. Aid in treatment of the mentally/physically disabled or medically compromised patient.
7. Reduce gagging.
8. Potentiate the effect of sedatives.

Disadvantages of nitrous oxide/oxygen inhalation may include:⁶

1. Lack of potency.
2. Dependent largely on psychological reassurance.
3. Interference of the nasal hood with injection to anterior maxillary region.
4. Patient must be able to breathe through the nose.
5. Nitrous oxide pollution and potential occupational exposure health hazards.

Recommendations

Indications for use of nitrous oxide/oxygen analgesia/anoxiolysis include:

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

Review of the patient's medical history should be performed prior to the decision to use nitrous oxide/oxygen analgesia/anoxiolysis. This assessment should include:

1. Allergies and previous allergic or adverse drug reactions.
2. Current medications including dose, time, route, and site of administration.
3. Diseases, disorders, or physical abnormalities and pregnancy status.
4. Previous hospitalization to include the date and purpose.
5. Recent illnesses (e.g., cold or congestion) that may compromise the airway.

Contraindications for use of nitrous oxide/oxygen inhalation may include:

1. Some chronic obstructive pulmonary diseases.¹⁹
2. Current upper respiratory tract infections.²⁰
3. Recent middle ear disturbance/surgery.²⁰

4. Severe emotional disturbances or drug-related dependencies.²⁰
5. First trimester of pregnancy.²¹
6. Treatment with bleomycin sulfate.²²
7. Methylenetetrahydrofolate reductase deficiency.²³
8. Cobalamin (vitamin B-12) deficiency.⁹

Whenever possible, appropriate medical specialists should be consulted before administering analgesic/anxiolytic agents to patients with significant underlying medical conditions (e.g., severe obstructive pulmonary disease, congestive heart failure, sickle cell disease²⁴, acute otitis media, recent tympanic membrane graft²⁵, acute severe head injury²⁶). In addition, consultation with the prenatal medical provider should precede use of nitrous oxide/oxygen analgesia/anxiolysis during pregnancy.²⁷

Technique of nitrous oxide/oxygen administration

Nitrous oxide/oxygen must be administered only by appropriately licensed individuals, or under the direct supervision thereof, according to state law. The practitioner responsible for the treatment of the patient and/or the administration of analgesic/anxiolytic agents must be trained in the use of such agents and techniques and appropriate emergency response.

Selection of an appropriately sized nasal hood should be made. A flow rate of five to six L per minute generally is acceptable to most patients. The flow rate can be adjusted after observation of the reservoir bag. The bag should pulsate gently with each breath and should not be either over- or under-inflated. Introduction of 100 percent oxygen for one to two minutes followed by titration of nitrous oxide in 10 percent intervals is recommended. During nitrous oxide/oxygen analgesia/anxiolysis, the concentration of nitrous oxide should not routinely exceed 50 percent. Studies have demonstrated that gas concentrations dispensed by the flow meter vary significantly from the end-expired alveolar gas concentrations; it is the latter that is responsible for the clinical effects.^{28,29} To achieve sedation, clinicians should keep patients' talking and mouth breathing to a minimum, and the scavenging vacuum should not be so strong as to prevent adequate ventilation of the lungs with nitrous oxide.³⁰ A review of records of patients undergoing nitrous oxide-oxygen inhalation sedation demonstrated that the typical patient requires from 30 to 40 percent nitrous oxide to achieve ideal sedation.³¹ Nitrous oxide concentration may be decreased during easier procedures (e.g., restorations) and increased during more stimulating ones (e.g., extraction, injection of local anesthetic). One study found that there was no benefit to continuous administration of nitrous oxide after profound anesthesia had been achieved.³² During treatment, it is important to continue the visual monitoring of the patient's respiratory rate and level of consciousness. The effects of nitrous oxide largely are dependent on psychological reassurance.³³ Therefore, it is important to continue traditional behavior guidance techniques during treatment. Once the nitrous oxide flow is terminated, 100 percent oxygen should be administered until the patient has returned to pretreatment status.³⁴ The patient must return to pretreatment responsiveness before discharge.

Monitoring

The response of patients to commands during procedures performed with analgesia/anxiolysis serves as a guide to their level of consciousness. Clinical observation of the patient must be performed during any dental procedure. During nitrous oxide/oxygen analgesia/anxiolysis, 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.³ 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.⁴

Adverse effects of nitrous oxide/oxygen inhalation

Nitrous oxide/oxygen analgesia/anxiolysis has an excellent safety record. When administered by trained personnel on carefully selected patients with appropriate equipment and technique, nitrous oxide is a safe and effective agent for providing pharmacological guidance of behavior in children. Acute and chronic adverse effects of nitrous oxide on the patient are rare.³⁵ Nausea and vomiting are the most common adverse effects, occurring in 0.5-1.2 percent of patients.^{36,37} A higher incidence is noted with longer administration of nitrous oxide/ oxygen, fluctuations in nitrous oxide levels, lack of titration, increased concentrations of nitrous oxide, and a heavy meal prior to administration of nitrous oxide.^{6,29,30} Fasting is not required for patients undergoing nitrous oxide analgesia/anxiolysis. The practitioner, however, may recommend that only a light meal be consumed in the two hours prior to the administration of nitrous oxide.³⁸ Studies have reported negative

outcomes associated with use of nitrous oxide greater than 50 percent and as an anesthetic during major surgery.^{39,40} Although rare, silent regurgitation and subsequent aspiration need to be considered with nitrous oxide/oxygen sedation. The concern lies in whether pharyngeal-laryngeal reflexes remain intact. This problem can be avoided by not allowing the patient to go into an unconscious state.⁴¹ Diffusion hypoxia can occur as a result of rapid release of nitrous oxide from the blood stream into the alveoli, thereby diluting the concentration of oxygen. This may lead to headache, disorientation, and nausea and can be avoided by administering 100 percent oxygen once the nitrous oxide flow is terminated.⁶ While the standard recommendation is to administer 100 percent oxygen at the end of the procedure, several studies have questioned the necessity for this step in nitrous oxide protocols in healthy patients.⁴²⁻⁴⁵

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 pretreatment 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.

Facilities/personnel/equipment

All newly installed facilities for delivering 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 percent, and never less than 30 percent, oxygen concentration at a flow rate appropriate to the child's size. Additionally, inhalation equipment must have a fail-safe system that is checked and calibrated regularly according to the practitioner's state laws and regulations.⁴⁶ The system components, including the reservoir bag, should be inspected routinely for cracks, wear, and tears. If detected, repairs should be made immediately. Pressure connections should be tested for leaks when delivery system is turned on and each time a tank is changed. Consult state and federal guidelines regarding storage of compressed gas tanks. Additional locks at the tanks or mixer/delivery level are available from many manufacturers to deter individuals from accessing nitrous oxide inappropriately.⁴⁶ If nitrous oxide/oxygen delivery equipment capable of delivering more than 70 percent nitrous oxide and less than 30 percent oxygen is used, an inline oxygen analyzer must be used. The equipment must have an appropriate scavenging system to minimize room air contamination and occupational risk. The scavenging system should vent outside.² Additionally, it has been shown that the double-mask system is more effective than the single-mask system in the removal of waste nitrous oxide.^{47,48}

The practitioner who utilizes nitrous oxide/oxygen analgesia/anxiolysis for a pediatric dental patient shall possess appropriate training and skills and have available the proper facilities, personnel, and equipment to manage any reasonably foreseeable emergency. The practitioner is responsible for managing the potential complications associated with the intended level of sedation and the next deeper level. Therefore, because moderate sedation may occur, practitioners should have the appropriate training and emergency equipment to manage this.^{4,34} Training and certification in basic life support are required for all clinical personnel. 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.

An emergency cart (kit) must be readily accessible. Emergency equipment must be able to accommodate 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 greater than 90 percent oxygen at a 10 L per minute flow for at least 60 minutes (650 L, "E" cylinder) must be available. When a self-inflating bag valve mask device is used for delivering positive pressure oxygen, a 15 L/min flow is recommended. There should be documentation that all emergency equipment and drugs are checked and maintained on a regularly scheduled basis.⁴ Where state law mandates equipment and facilities, such statutes should supersede these recommendations.

Occupational safety

In the medical literature, long-term exposure to nitrous oxide used as a general anesthetic has been linked to bone marrow suppression and reproductive system disturbances.^{10,49-51} However, it has been shown that appropriate scavenging is effective in reducing these reproductive system effects.^{21,52} In an effort to reduce occupational health hazards associated with nitrous oxide, the AAPD recommends exposure to ambient nitrous oxide be minimized through the use of effective scavenging systems and periodic evaluation and maintenance of the delivery and scavenging systems.⁵³⁻⁵⁵ Clinicians should try to minimize patients' talking and mouth breathing during nitrous oxide administration to prevent expired gas from contaminating the operatory.³⁰

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