Nitrous Oxide Inhalation Sedation in Pediatric Dentistry: An overview of the available guidelines

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Abstract

Children with behavioral issues are usually inadequately treated using non-pharmacological behavior management techniques, making dental treatment a real clinical challenge for the practitioner. This leads to the indispensable need for advanced pharmacological techniques, such as inhalation sedation (IS). In pediatric dentistry, nitrous oxide sedation is considered the safest tool for a dental practitioner to use on uncooperative children, thus reducing the need for dental treatment under general anesthesia. To date, several sets of high-ranking evidence-based inhalation sedation guidelines are available, developed in the United States, United Kingdom, Europe, Australia, and New Zealand. This review summarizes the indications, contraindications, advantages, and disadvantages of using nitrous oxide sedation in children, and compares these in terms of inhalation sedation procedure and documentation. This review will assist the dental practitioner in developing appropriate practice regulations for safe and effective practice.

Keywords: Nitrous Oxide, Inhalation Sedation, Children, Pediatric Dentistry

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1. Introduction

Most pediatric patients feel highly anxious when receiving dental treatment and it is a challenge for these patients to accept conventional dental treatment. A variety of techniques have been used to manage these pediatric patients, including an advanced method of inhalation sedation (IS). Nitrous oxide/oxygen (N_2O) is the most common inhalation anesthetic in dentistry and has been classified as a minimal sedation method. N_2O has anxiolytic and sedative properties, with varying degrees of analgesia and muscle relaxation [1]. It is also an effective analgesic/anxiolytic agent causing central nervous system depression and euphoria, with minimal effect on the respiratory system [1]. This approach is suitable for mildly anxious but potentially cooperative children and minimizes the need for general anesthesia.

2. Mechanism of action

The N_2O acts as an N-methyl-D-aspartate (NMDA) receptor antagonist [2]. The NMDA

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receptor is a glutamate binding, non-selective ion channel involved in synaptic plasticity and memory formation. The γ-aminobutyric acid type A (GABAA) receptor is the main inhibitor, chloride-ion selective, and ligand-gated channel of the central nervous system (CNS). Through different mechanisms, N_2O and GABAA modulators act synergistically to induce amnesia and hypnosis, which is the reason N_2O is often referred to as a 'volatile-sparing agent'. The analgesic effects of N_2O are due to the interaction between the endogenous opioid system and the descending noradrenergic system. N_2O induces the release of endogenous opioids and causes the disinhibition of brain stem noradrenergic neurons that release norepinephrine into the spinal cord, inhibiting pain signaling [3].

3. The need for IS in pediatric dentistry

3.1 Indications of IS

The use of N_2O is best indicated in a pediatric patient as listed below [4]:

- American Society of Anesthesiologists Physical Grade (ASA) I and II
- A fearful or anxious child (mild to moderate)
- A child who has needle phobia
- Certain children with special health care needs/ a medically compromised child
- A child whose gag reflex interferes with dental care
- A child for whom profound local anesthesia cannot be obtained
- A cooperative child undergoing a lengthy dental procedure
- Children over 4 years old.

3.2 Contraindications of IS

The contraindications of N_2O include [5-6]:

- Children with behavioral issues
- Uncooperative children
- Children under 4 years old
- Severely fearful or anxious children
- Mouth breathers
- Chronic obstructive pulmonary diseases
- Current upper respiratory tract infections
- Recent middle ear disturbance/ surgery/ infection
- Severe emotional disturbances or drug-related dependencies
- First-trimester pregnancy
- Treatment with bleomycin sulphate
- Methylenetetrahydrofolate reductase deficiency
- Cobalamin (vitamin B12) deficiency.

3.3 Benefits of IS

The administration of N_2O is simple and painless, with a rapid onset and a short duration of action, as well as analgesic, anxiolytic, and sedative effects [4, 7].

The main benefits of IS include [8]:

- Rapid onset and recovery
- Easy to administer and no injection is required
- Flexible duration of sedation
- No hospital admission is required
- Wide safety margin
- Titrated according to the patient's response.

3.4 Disadvantages of IS

The disadvantages of IS may include [8]:

- Lack of potency
- The need for local anesthesia administration
- Poor acceptance of the nasal mask/hood
- Interference of the nasal mask/hood with an injection to the anterior maxillary region
- The child being able to breathe through

the nose
- Difficulty in introducing a nasal mask to young children
- N_2O pollution and potential occupational exposure to health hazards
- Dependence on psychological assurance.

4. Types of dental treatment

IS can be used as an adjunct for behavioral management in a pediatric patient for a simple, fast, and uncomplicated procedure, such as a restorative treatment, pulp therapy, stainless steel crown placement, extraction, and minor surgical procedures such as an excisional biopsy of mucocele or surgical toilet and suturing of a laceration wound. IS will be indicated when fewer than four extractions are needed [9], but several treatment sessions will be required to accomplish the treatment [9].

5. Administration of IS to pediatric patients

The American Academy of Pediatrics (AAP) [10] and the American Academy of Pediatric Dentistry (AAPD) [6] guidelines recommend the use of a systematic approach (SOAPME) before sedation (Table 1).

5.1 Pediatric consideration and preparation before treatment under IS procedure

1. Pre-sedation assessment: medical history, medications, allergies, hospitalizations, previous sedation experiences, and other relevant information related to anesthesia must be recorded. The pediatric patient is examined for adenotonsillar hypertrophy and anatomic airway abnormalities. In addition, dental needs and anxiety level are also evaluated and patients with special needs may require individual consideration. Dental practitioners are encouraged to consult appropriate specialisms for underlying medical and surgical conditions;

2. The pediatric patient should be accompanied by a parent, legal guardian, or another responsible adult;

3. Informed consent must be obtained from the parent/ guardian and must be documented in the patient's record before administration of the N_2O. The Intercollegiate Advisory Committee for Sedation in Dentistry (IACSD) [11] and the European Academy of Pediatric Dentistry (EAPD) [12] recommend that informed consent be confirmed in writing;

4. Fasting guidelines: the child's need for dietary restriction before dental treatment under conscious sedation is controversial topic based on the type of sedation. It is considered unnecessary for dental treatment under nitrous oxide sedation by all the available guidelines [6, 11, 13]. Despite the fact that the patient can eat and drink a large meal should be avoided before the sedation [6].

5. Pre- and post-sedation instructions: both the parent and the pediatric patient must be given clear verbal and written instructions regarding the effects of the proposed sedation and their responsibilities before and after treatment [6, 11, 13];

6. Safety checks: the monitoring of equipment before the procedure is vital. Such equipment includes the electrocardiography (ECG), an appropriate size for the pulse oximeters, end tidal carbon dioxide equipment, an appropriate size of the non-invasive blood pressure cuffs, precordial stethoscope, and a defibrillator (size appropriate defibrillator paddles). Monitoring must be performed regularly. An emergency cart or kit should be available with the appropriate drugs and

equipment to resuscitate a non-breathing and unconscious child [6].

5.2 Pre-operative preparation

Special consideration should be given when dealing with pediatric patients to minimize the risk of aspiration or any other complications. The pre-operative preparation includes:

1. Recording of preoperative and postoperative vital signs;
2. Selection of the nasal hood according to the size of the patient;
3. Determination of the flow rate for each patient. A rate of 5–6 L/min is acceptable for most pediatric patients. The flow rate should be established by observing the reservoir bag while delivering 100% oxygen [4];
4. Titration is the single most important concept to follow. Titration of N_2O in 10% intervals is recommended. The EAPD [12] and AAPD [6] recommend a "titration" technique that involves increasing the dose of N_2O in oxygen by 5–10% increments in the oxygen mix every minute or so, according to the patient's response until the desired sedative effect is achieved;
5. Having back-up emergency facilities, equipment, and personnel on-site to manage emergency and rescue situations.

5.3 Safety considerations for a pediatric patient

The administration of N_2O must be done by licensed individuals. A clinician working at minimal sedation level must be competent in managing emergencies related to moderate sedation. The AAP recommends the presence of a practitioner with skills in pediatric advanced life support and intravenous access to rescue a child with apnea, laryngospasm and/or airway obstruction [10]. The ANZCA recommends practitioners have IS formal training, competency in medical crisis management, and regular training in cardiopulmonary resuscitation (CPR), as well as continuing professional development (CPD) in IS [14]. The IACSD also recommends both the operating clinician and dental nurse have formal resuscitation and life support training [11].

Sleeping under N_2O sedation is not advisable for pediatric patients. Silent regurgitation is the greatest concern in this situation. Maintaining a conversation with the child ensures the protective laryngeal and pharyngeal reflexes are intact and that the patient can cough. The safety features of the N_2O equipment are presented in Table 2 [4].

5.4 Monitoring and clinical documentation

Dental practitioners have a tendency to take their 'eye off the ball' during dental procedures when monitoring the condition of the child. Sedation monitoring is a continuum from awake to the anesthetic stage, and it is less intrusive as the child is slightly conscious. Therefore, it is advisable to have at least two practitioners present—to perform the procedure and to monitor the patient. The practitioner performing the procedure and the practitioner administering the sedation must agree a plan for sedation. The monitoring and clinical documentation should be completed as follows:

- The practitioner administering the anesthetics needs to maintain constant attention to the level of consciousness, breathing, and airway patency of the patient;
- Adverse events (such as emesis, vasovagal reaction, seizure, anaphylaxis,

anaphylactoid reaction or cardiopulmonary impairment that leads to any interventions) need to be documented and disclosed to the patient and/or guardian(s) [6].

5.5 During and after the IS procedure

To ensure a smooth and safe recovery phase, the patient must be closely monitored during and after the inhalation procedure. The procedure and documentation are as follows [5]:

- The level and the flow rate of N_2O with times of initiation and times of changes should be documented;
- Cognitive function and physical coordination may be impaired but airway reflexes, ventilatory and cardiovascular functions are usually unaffected. Essentially, clinical monitoring by observation, which involves checking the level of consciousness, depth of sedation, airway patency, respiration (rate and depth assessing from the reservoir bag), skin color, and capillary refill is sufficient;
- Time of start and end of sedation, duration of 100% O_2 administration at recovery and time of discharge;
- Sedation level (not exceeding 50%);
- The patient's acceptance of sedation and treatment, for example, the Frankl Behavior Scale;
- Any adverse events/complications and signs and symptoms of over sedation interventions;
- Dose and type of local anesthesia administered;
- Dental treatment performed.
- Post-sedation assessment and written post-operative instructions given to the pediatric patient and parents;
- The parents must be informed of the detail of the procedure and that the patient should be fully recovered and alert at discharge.

6. Summary of the current guidelines worldwide

There are five main and well-established guidelines worldwide on the use of IS in children, namely those of the ADA and AAPD from the USA, the EAPD from Europe, the ANZCA from Australia, and the IACDS from the UK (Table 3). The ADA guidelines are produced by the ADA House of Delegates, whereas the AAP guidelines are produced by the AAP and AAPD. The EAPD guidelines are produced by European member countries of the EAPD. The ANZCA guidelines are produced by the Australian and New Zealand College of Anesthetists and the Faculty of Pain Medicine, endorsed by the Gastroenterological Society of Australia, Australasian College for Emergency Medicine, College of Intensive Care Medicine of Australia and New Zealand, Royal Australasian College of Surgeons, Royal Australian and New Zealand College of Radiologists, and Royal Australian and New Zealand College of Psychiatrists. The IACSD guidelines are produced by the Royal College of Surgeons (Edinburgh, Glasgow, and England) and the Royal College of Anaesthetists.

All guidelines specify a clear pre-operative assessment of IS, including details of the medical history, medications, and indications and contraindications of the IS procedure. However, there are a few differences, such as on obtaining consent and pre- and post-operative instructions. The EAPD and IACSD guidelines recommend a written informed consent whereby the other guidelines only recommend informed consent.

For peri-operative assessment on the day of the dental treatment using IS, there are

considerable variations in the guidelines on the level of documentation for the clinical monitoring criteria. These include the level of consciousness, heart rate, respiratory rate, skin color, the use of a pulse oximeter, the duration of the administration, dosage of the local anesthesia, the types of dental treatment, the presence of pain/distress, and 5 minutes O_2 (Table 3). There were also some differences in the post-operative IS assessment, such as the documentation of any adverse event due to the over-dose sedation, post-operative instructions to the child and parents, whether in written or verbal form, and discharge details. Written post-operative instruction is recommended by all guidelines, but additional verbal instructions are recommended by the ADA, AAPD, and IACSD guidelines (Table 3).

7. Conclusion

IS is a tool for a dental practitioner to assist pediatric patients who are anxious and fearful. IS has an excellent safety record when used for anxiolysis and conscious sedation. However, the pre-anesthetic assessment and proper monitoring are crucial to ensure that every child receives a correct and safe mode of treatment. Knowledge of medications and the ability to address over sedation and complications are essential for safe and effective management. The dental practitioner and the team must adhere to the clinical protocol and provide standard care to ensure the absolute safety of the patient and themselves.

Table 1: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update, 2020 (AAPD, AAP)

S	Size-appropriate suction catheters and a functioning suction apparatus (e.g., Yankauer-type suction)
O	An adequate oxygen supply and functioning flow meters or other devices to allow its delivery
A	Size-appropriate airway equipment (e.g., bag-valve-mask or equivalent device [functioning]), nasopharyngeal and oropharyngeal airways, LMA, laryngoscope blades (checked and functioning), endotracheal tubes, stylets, face mask
P	Pharmacy: all the basic drugs needed to support life during an emergency, including antagonists as indicated
M	Monitors: functioning pulse oximeter with size-appropriate oximeter probes, end-tidal carbon dioxide monitor, and other monitors as appropriate for the procedure (e.g., non-invasive blood pressure, ECG, stethoscope)
E	Special equipment or drugs for a particular case (e.g., defibrillator)

Table 2: Safety features of the N_2O sedation equipment

Safety feature	Description
Alarms	The alarm system cautions about the reduction in the pressure of oxygen
Color coding	This is to identify the gas in the cylinders and hoses
Diameter Index Safety System	This system, based on difference in diameter, prevents any cross-connection of tubings with the gas cylinders

Safety feature	Description
Pin Index safety	This system on the gas tank yoke has different geometric configurations for oxygen and nitrous oxide to be connected to the correct gas tank and avoid connection of non-oxygen tank to the oxygen portal
Emergency air inlet	This feature allows the patient to breathe ambient air through the inlet when the oxygen fail safe system shuts off the supply of gases or when higher minute volume causes the reservoir bag to collapse
Locks	These features prevent inappropriate use of nitrous oxide by the dental staff
Oxygen fail safe system	This feature prevents inhalation of nitrous oxide gas alone by the patient. Nitrous oxide supply is cut off when the oxygen supply is exhausted
Oxygen flush button	This allows for 100% oxygen to be administered through a reservoir bag
Quick connect for positive pressure	This feature allows positive pressure oxygen to be delivered to a patient in an emergency
Reservoir bag	This allows respiration rate monitoring. It is filled gradually as gases enter the circuit and is deflated with inhalation

Table 3: Summary of the current available guidelines worldwide [5]

Guideline	ADA (2007) [13] USA	AAPD (2019) [6] USA	EAPD (2005) [12] Europe	ANZCA (2014) [14] Australia	IASCD (2020) [11] UK
Patient selection and assessment	▪ ASA I and II ▪ Specified	▪ ASA I and II ▪ Specified	▪ ASA I and II ▪ Specified	▪ ASA I and II ▪ Specified	▪ ASA I and II ▪ Specified
Detailed medical history and medications	Specified	Specified	Specified	Specified	Specified
Indications and contraindications	Unspecified	Specified	Specified	Specified	Specified (Refer to NICE 2010) [15]
Informed consent	Specified	Specified	Specified	Specified	Specified (including informed written consent)
Pre- and post-op instructions (Verbal and written)	Specified	Specified	Specified	Specified	Specified
Fasting	Specified	Specified	Specified	Unspecified	Specified
Document pain/ distress	Unspecified	Unspecified	Specified (sedation scale and behavioral scale)	Specified	Unspecified

Guideline	ADA (2007) [13] USA	AAPD (2019) [6] USA	EAPD (2005) [12] Europe	ANZCA (2014) [14] Australia	IASCD (2020) [11] UK
Documentation	Time and duration of administration, and dosage of all drugs administered including local anesthetics, the dosages and monitored physiological parameters.	Time and duration of administration, and dosage of all drugs administered including local anesthetics and the dosages	Dose of sedative drugs administration and the dental treatment performed	Name of staff performing sedation and/or analgesia, with documentation of the history, examination and investigation findings. Dose and time of administration, resuscitation or rescue interventions and complications if any	Written contemporaneous record, pulse oximetry as well as blood pressure monitoring preoperatively, at appropriate intervals during the procedure and postoperatively
Monitoring	▪ Conscious-ness ▪ Oxygenation ▪ Ventilation ▪ Circulation ▪ Blood pressure ▪ Heart rate	▪ Observation and intermittent assessment of sedation level	1. Pulse oximetry is not required. Clinical monitoring: ▪ Physical and verbal response ▪ Observing breathing ▪ Movements of the thorax ▪ Passage of the air stream ▪ Respiratory frequency ▪ Observing skin color	▪ Pulse oximeter ▪ Records heart rate, O2 saturation, O2 and N2O dosage and blood pressure ▪ Monitor depth of sedation, respiratory and cardiac depression	▪ Level of consciousness/depth of sedation ▪ Airway patency ▪ Respiration (rate and depth) ▪ Skin color ▪ Capillary refill ▪ Pulse rate, rhythm ▪ Blood pressure ▪ Heart rate

Guideline	ADA (2007) [13] USA	AAPD (2019) [6] USA	EAPD (2005) [12] Europe	ANZCA (2014) [14] Australia	IASCD (2020) [11] UK
Document five mins oxygen administration	Unspecified	Specified	Unspecified	Unspecified	Unspecified
Staffing	At least one additional person trained in Basic Life Support for Healthcare Providers must be present in addition to the dentist	Trained and capable of providing advanced airway skills (PALS). The support person shall have specific assignments in the event of an emergency and current knowledge of emergency cart inventory	Theory and practical training in basic life support	Minimum two people. Sufficient training needed In high-risk patients, the presence of anesthetist is needed	A practitioner must undergo a minimum of 12 hours of continuing professional development every 5 years that are relevant to the techniques practiced. Certificate in Dental Sedation Nursing of the National Examining Board for Dental Nurses
Clinical governance and audit	Unspecified	Unspecified	Unspecified	Specified	Specified
Equipment check	Specified	Unspecified	Unspecified	Specified	Unspecified
Document adverse event and its treatment	Unspecified	Specified	Specified	Specified	Specified
Postoperative instructions	Verbal and written instructions provided	Verbal and/or written instructions given	Written instructions given	Written instruction given	Verbal and written instructions provided
Discharge	▪By qualified dentist ▪Document on the level of consciousness, oxygenation, ventilation, and circulation is satisfactory	▪The time and condition of the child at discharge from the treatment area or facility shall be document as well as the patient's condition, level of consciousness and	▪Post-sedation assessment and time of discharge ▪To be accompanied by a responsible adult	▪By the person performing the sedation or another qualified practitioner ▪To be accompanied by a responsible	▪By the person performing the sedation

Guideline	ADA (2007) [13] USA	AAPD (2019) [6] USA	EAPD (2005) [12] Europe	ANZCA (2014) [14] Australia	IASCD (2020) [11] UK
		oxygen saturation ▪Two adults to accompany child if one parent is driving		adult	

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تخدير استنشاق أكسيد النيتروز في طب أسنان الأطفال: نظرة عامة على الإرشادات المتاحة

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الملخص

عادةً ما يتم علاج الأطفال الذين يعانون من مشاكل سلوكية بشكل غير كافٍ باستخدام تقنيات إدارة السلوك غير الدوائية مما يجعل علاج الأسنان يمثل تحديًا سريريًا حقيقيًا للممارس. وهذا يؤدي إلى ما لا غنى عنه لتقنية متطورة (دوائية) مثل الاستنشاق بالتخدير (IS). في طب أسنان الأطفال، يعتبر التخدير بأكسيد النيتروز الأداة الأكثر أمانًا المتاحة لممارس الأسنان لاستخدامها مع الأطفال غير المتعاونين، وبالتالي تقليل الحاجة إلى علاج الأسنان تحت التخدير العام. حتى الآن، هناك العديد من الدلائل الإرشادية للتخدير بالاستنشاق عالية المستوى والتي تم تطويرها من قبل الولايات المتحدة والمملكة المتحدة وأوروبا وأستراليا ونيوزيلندا. تلخص هذه المراجعة المؤشرات، وموانع الاستعمال، والمزايا، وعيوب استخدام أكسدة النيتروز عند الأطفال، ولمقارنة الدلائل الإرشادية المتاحة من حيث إجراء تخدير الاستنشاق والتوثيق. ستساعد هذه المراجعة ممارس الأسنان على تطوير لوائح الممارسة المناسبة لممارسة آمنة وفعالة.

الكلمات الدالة: أكسيد النيتروز، استنشاق التخدير، طب أسنان الأطفال.