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RESEARCH ARTICLE

Nitrous Oxide Conscious sedation- A guide for the practitioners

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Abstract

Nitrous oxide-oxygen conscious sedation is one of the safest pharmacological methods of behavior management technique that can be used in pediatric dental practice. It is not so popular in certain countries making it one of the least explored techniques. Training is mandatory prior to use of nitrous oxide-oxygen sedation. This article sensitizes the practitioners towards inhalation conscious sedation and explains the clinically relevant and practical issues.

INTRODUCTION

Conscious sedation is a minimally depressed level of consciousness that retains the patient's ability to independently and continuously maintain an airway and respond appropriately to physical stimulation and verbal command and that is produced by pharmacologic or non-pharmacologic method or a combination.

Conscious sedation can be achieved by drugs administered parenterally or through inhalation. Nitrous oxide-oxygen is the agent commonly used in dentistry as inhalation agent.

HISTORY

The discovery of nitrous oxide and oxygen is credited to Sir Joseph Priestly and Karl Scheele[3]. Sir Humphrey Davy[2], became the first to experiment with pure nitrous oxide. He experienced diminished toothache while using nitrous oxide and realizedits potential for alleviation of pain. This was the first indication regarding the anesthetic property of the gas. Dr. Horace Wells[3], a dentist in attendance was very intrigued by nitrous oxide and tried extraction of a tooth under the influence of nitrous oxide at his office. John Snow[4]from England first devised and used an inhaler in 1847 that was quite similar to the full-face masks used today in anesthesia.

In 1868, Dr. Edmund Andrews[2] suggested that, when 100% nitrous oxide is used, the blood is not appropriately oxygenated and advocated the addition of oxygen to the nitrous oxide and claimed the optimum ratio of oxygen to be one fifth of the total volume.

Paul Bert, later developed an equipment to deliver both oxygen and nitrous-oxide to the patient simultaneously. The inhalation sedation apparatus used today for the administration of nitrous oxide-oxygen is modified from this device.

In 1976, the American Dental Association's Council on Dental Materials, Instruments and equipment adopted standards for the manufacture of inhalation sedation units.[5]

NITROUS OXIDE

Nitrous oxide is a colorless and virtually odorless gas with a faint, sweet smell. It is an effective analgesic or anxiolytic agent causing central nervous system depression and euphoria[6].

It is rapidly taken up and is absorbed quickly from the alveoli and is relatively insoluble in blood. It is excreted quickly from the lungs.[3]

***Actions of Nitrous Oxide*[2,7-11]**

1. Analgesic Action

Nitrous oxide produces a mild analgesic effect at sub-anesthetic concentrations. The analgesic action of nitrous oxide appears to be initiated by neuronal release of endogenous opioid peptides. The anxiolytic effect involves activation of the gamma-amino butyric acid type A receptor either directly or indirectly through the benzodiazepine binding site.

2. Respiratory Effect

Nitrous oxide causes increase in respiration rate and provide a net increase in tidal volume. Therefore, when used alone for mild to moderate sedation, nitrous oxide does not depress ventilation. However, when it is combined with sedatives or opioids that depress ventilation, it may result in a more pronounced and clinically relevant depression.

3. Cardiovascular Effects

Nitrous oxide mildly depresses myocardial contractility, but this is offset by its ability to activate sympathetic activity. Sub-anesthetic concentrations of nitrous oxide have little influence on cardiac output, stroke volume, and heart rate. At higher concentrations, nitrous oxide actually increases these variables. Nitrous oxide increases venous tone, leading to increased venous return to the heart, and this likely contributes to the stable cardiovascular function observed with nitrous oxide. Cardiac output is slightly depressed with nitrous oxide but peripheral resistance is also increased thereby maintaining blood pressure. This is of particular advantage in treating patients with cerebrovascular system disorders.

4. Central nervous system

When administered in conjunction with physiologic levels of oxygen, nitrous oxide produces a mild depression of the CNS, primarily the cerebral cortex. **At**therapeutic levels, nitrous oxide does not exert any other actions on the CNS. The area postrema (the vomiting centre) of the medulla is not affected by nitrous oxide unless hypoxia or anoxia is present.

5. Skeletal muscle

Nitrous oxide does not produce relaxation of skeletal muscle. Any observed effect of this nature during inhalation sedation is attributable to the relief of anxiety rather than to a direct action of nitrous oxide.[11]

6. Psychomotor skills

Various studies on the effect of nitrous oxide have found that it impairs recall, alters position sensation and affects other psychomotor ability of the child.

OXYGEN[2]

Oxygen is a clear, colorless, odourless gas. It is non-inflammable, but will support combustion. Under high pressure in the presence of oil or grease, it may cause an explosion. Thus, the use of oil and grease should be strictly avoided in and around oxygen cylinders, reducing valves, wall outlets and cylinder outlets. Oxygen is used along with nitrous oxide to maintain the oxygen saturation in blood and reduce the risk of development of complications.

OBJECTIVES OF NITROUS OXIDE-OXYGEN INHALATION INCLUDE [12]

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.

INDICATIONS OF NITROUS OXIDE-OXYGEN ANESTHESIA

Inhalation sedation is primarily indicated for the management of dental anxiety, especially in children and should be considered as a part of overall behavior management strategy. Besides reducing mild to moderate anxiousness facilitated coping at subsequent visits[13].Arch et al[14] found that post-operative dental anxiety was lower in children who had chosen inhalation sedation in comparison to those who had chosen general anesthesia. Also those children and parents who selected inhalation sedation demonstrated less psychological stress.

Nitrous oxide-oxygen sedation can also be used in various dental procedures that cause stimulation of gag reflex. Paterson and Tahmassebi[15] in their review have proposed the use of inhalation sedation for treatment of various conditions like hypoplastic teeth to reduce sensitivity; kidney or liver disease as nitrous oxide does not undergo biotransformation in the body; sickle cell disease or trait and severe asthma where high oxygen tension is mandatory; cerebral palsy to control athetoid and dyskinetic movements; cardiovascular disorders as it reduces anxiety, elevates the pain threshold and provides increased levels of oxygen.

Indications given by American Academy of Pediatric Dentistry are:[12]

1. A fearful, anxious, or obstreperous patient
2. Certain patients with special health care needs
3. A patients 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.

CONTRAINDICATIONS

Nitrous oxide is considered safe for its use in medicine and dentistry, but however, similar to any drug may not be suitable for all patients. It is very important to carefully review the medical history of a patient and to consider the small number of situations in which nitrous oxide sedation may be contraindicated or may at least pose a relative contraindication.[16]

Waun et al[17]tested middle ear mechanics and hearing acuity before, during and after breathing nitrous oxide and non-nitrous oxide mixture, both with and without positive pharyngeal airway pressure. Decreased compliance and increased resistance was observed in all cases but was more pronounced when nitrous oxide was present. Positive airway pressure appeared to be unaffected. A conductive type of hearing loss for short duration was also noted.

Munsun[18] have stated that any recent surgery of the ear presents a contraindication for nitrous oxide as it diffuses into the gas-filled space like middle ear and may result in mild auditory changes leading to deafness.

A degree of patient cooperation is required for this technique to be successful as this procedure requires the children to hold the mask on to the nose continuously. Pre cooperative or uncooperative children will breathe through their mouths, crying, screaming, or moving about in the chair, thus negating the effects of any nitrous oxide they may inhale[19].

Fleming et al[20] (1988) have found that those who had bleomycin therapy within past few years are predisposed to pulmonary fibrosis after high oxygen concentration and should therefore not receive elevated levels of oxygen.

It is suggested that presence of congenital hernias as a major contraindication for use of nitrous oxide because its solubility properties allows rapid expansion of the herniated bowel, resulting in compression of the thoracic organs or strangulation of the herniated abdominal viscera. Thus the presence of a diaphragmatic hernia may necessitate a change in sedation or anesthesia plans to eliminate the use of nitrous oxide during prolonged procedure[21].

Patients undergoing psychiatric treatment should consult psychiatrist before the use of relative analgesia as sensations under analgesia may disturb the emotional poise of such patients[9].

Children with upper airway obstruction are not indicated for inhalation sedation[22].Becker and Rosenberg (2008)[23] have said that patients with significant chronic obstructive pulmonary disease rely almost entirely on hypoxemic drive thereforenitrous oxide should be avoided in these patients, Reasons cited include not only its depression of hypoxemic drive, but also, because high oxygen concentration are delivered with nitrous oxide and this may remove the stimulus for hypoxemic drive. However, if the principles of moderate sedation are followed, the patient can always be instructed to breathe more deeply.

Paterson and Tahmassebi[15] (2003) have suggested inability to communicate with the child as an important contraindication for inhalation sedation. The use of inhalation conscious sedation should be avoided in case of severe muscular depression like multiple sclerosis, mouth breathers and very young children.

Contraindications given by American Academy of Pediatric Dentistry are[24].

1. Some chronic obstructive pulmonary disease
2. Severe emotional disturbances or drug related dependencies

3. First trimester of pregnancy
4. Treatment with bleomycin sulfate
5. Methylenetetrahydrofolate reductase and Cobalamin deficiency

ADVANTAGES

Nitrous Oxide inhalational sedation has been found to have several advantages over other routes of administering sedation.

Edmunds and Rosen[25] studied the effectiveness of inhalation sedation with ***25*** per cent nitrous oxide over sedation with intravenous diazepam in a group of twenty five extremely anxious dental patients who experienced both methods in a total of 77 treatments. Although both the techniques were effective but inhalation sedation seemed to be better accepted by the patients. No patient refused treatment with nitrous oxide whereas ***7*** refused intravenous diazepam. Moreover, the induction and recovery rimes were significantly shorter with nitrous oxide and the standard of dental treatment was better.

Recovery with Nitrous oxide oxygen sedation is almost immediate upon termination of the gas administration.[26]

Leelataweewud and Vann[27]evaluated the safety of a narcotic safety regime when used in combination with 100% oxygen supplementation versus nitrous oxide-oxygen analgesia. It was found that nitrous oxide-oxygen deepened the sedation while improving its success with minimal alteration in physiologic parameters.

Nitrous oxide is found to cause amnesia, which helps further reduction of fear and anxiety in children.

Paterson and Tahmassebi[15] in their review on inhalation sedation in pediatric dentistry have suggested following benefits of inhalation sedation- minimal impairment of any reflexes, analgesia to supplement topical anesthesia and being noninvasive. Malamed[2] has described rapid onset of action, ability to titre, flexible duration of action, safety, early discharge, no systemic effects as some of the advantages.

<u>The benefits of inhalation sedation can be summarized as:-</u>

1. Better acceptance by the patient
2. It has rapid onset of action and rapid recovery
3. It produces amnesia which further helps in reducing anxiety of the patient
4. It minimally alters reflexes and thus protecting most important cough reflex
5. It produces a degree of analgesia and can therefore supplement topical anesthesia
6. It is non-invasive and therefore useful in needle-phobic patients
7. It has the ability to titer which a hallmarkof its safety
8. Flexible duration of action
9. Minimal systemic side effects
10. It is safer because of its ability to titer and inability to undergo biotransformation in the body

DISADVANTAGES

Nanthan et al[19] have found the need for patient cooperation to be disadvantages of the nitrous oxide-oxygen sedation.

Other disadvantages suggested by Paterson and Tahmassebi[15]include variability in postoperative amnesia, nitrous oxide pollution, interference of nasal hood with injection in the anterior maxillary region.

Other disadvantages are:[2]

1. The initial cost of the equipment required for the inhalational sedation is high.
2. The running cost of nitrous oxide and oxygen used in inhalational sedation is also high.
3. The inhalational sedation unit requires considerable space within the dental surgery suite. Even portable nitrous oxide-oxygen unit may be difficult to place in small dental surgery offices.
4. It is recommended that the operator is well trained with not less than 14 hours of training each year, to administer inhalational sedation.
5. The dental treatment is initially more time-consuming using nitrous oxide, especially if patients are not used to it; but this disadvantage is neutralized, if the more relaxed patient enables the dentist to work more efficiently.

COMPLICATIONS

Potential complications are associated with the use of inhalational sedation and are more important in children complications are of more importance because of their reduced body size, decreased oxygen reserve, higher basal oxygen consumption and lower residual lung capacity as compared to adults. The potential complications include[2,3]:

1. *Diffusion* hypoxia

Hypoxia occurs when nitrous oxide administration is discontinued and the absorbed nitrous oxide diffuses out of the blood and into the alveolar spaces. Because nitrogen is less soluble in blood than the nitrous oxide that replaced it, the uptake of nitrogen into the blood occurs more slowly than the excretion of nitrous oxide. This dilutes alveolar oxygen and potentially lowers the oxygen saturation of the arterial bod. The greatest excretion of nitrous oxide occurs in the first 3-5 min following cessation of administration. It is during this period that administration of 100% oxygen [advised to prevent diffusion hypoxia.

***2. Nausea* and vomiting**

It is the most common adverse effect of inhalation sedation occurring in 1-10% of *the*patients and is usually associated with the following causes:

a) Presence of food in the stomach

Heavy meals preceding an inhalation sedation administration can easily cause nausea and vomiting, particularly in pediatric patients. But patients treated on an empty stomach are also more susceptible to nausea and vomiting. It is therefore recommended to have a high-carbohydrate meal 4 to 6 hours before the appointment. This prevents starvation and yet allows for stomach content to be minimized.

b) Over sedation

A reliable and consistent sign of over sedation is a response from the patient that he or she feels bad, "sick to stomach", usually preceded by sweating and pallor. No matter the percentage of nitrous oxide, the patient is over sedated.

c) The "Roller Coaster Ride"

The ability to titrate can be used to a disadvantage by increasing and decreasing the nitrous oxide - oxygen flows, causing a so called roller coaster ride. This can precipitate nausea and vomiting.

d) Length of sedation - Longer the patient has sedation, the greater is the incidence of nausea and vomiting.

Management of nausea and vomiting

Stanley F Malamed[2] has given the following management of nausea and vomiting. Patient who are about to vomit usually have a period of impending awareness of the event such as hypersalivation, sweating, and nausea. If the patient experiences this awareness, the following should be carried out:

1. The clinician should turn off the nitrous oxide flow and have the patient continue breathing 100% pure oxygen.
2. As vomiting begins, remove the nasal hood or other delivery apparatus from the patient's face.
3. Remove the rubber dam, if present, and any other dental equipment from the oral cavity.
4. Turn the patient's head and body to the side away from the side on which rite person treating the patient is stationed. This permits the vomitus to pool in the cheek instead of flowing back into patient's pharynx, where airway obstruction may occur. A kidney or emergency basin and high-volume suction tip may be used to assist in removing the vomitus. A dry 4x4 piece of gauze can also quickly aid in removing vomitus.
5. Following the incident, replace the nasal hood on the patient's nose so that the child may be permitted to breathe 100% oxygen for at least 3 to 5 minutes. The patient may be somewhat reluctant to have the nasal hood placed back on for fear of becoming sick again Explain to the patient that he or she will breathe only 100% oxygen and that the reason for so doing is to minimize the chance of becoming sick again.

If the patient does not wish to continue with nitrous oxide-oxygen during treatment, it is best to adhere to their wishes. If necessary, anti-emetics may be prescribed preoperatively for this patient.

3.Tooth pain associated with sinus pressure

Nitrous oxide can displace air from the maxillary sinus. This complication is associated with prolonged use and noticed as discomfort, possibly presenting as a toothache. This is because the anterior, middle and posterior alveolar nerves pass through the sinus membrane and are affected.

4. Vertigo

Prolonged exposure of the vestibule-cochlear complex to nitrous oxide can result »n vertigo. This can cause increased tension on the tympanic membrane. This tensioncan result in an alteration in hearing acuity, and the patient may complain of thisalteration in hearing.

5. Bowel discomfort

Air spaces in the gut can be displaced by nitrous oxide. This non-rigid potential pace can have an enlargement to the extent that there are discomfort and flatulence as a result of high concentration and prolonged use of nitrous oxide.

6. Claustrophobia

It is a disorder that is shared by many patients. The nasal hood or face mask of the sedation unit can precipitate a claustrophobic response. Allow a patient with this concern to adjust the nasal hood can help improve the experience. Claustrophobia is a real fear that requires understanding on the part of the health-care provider.

EQUIPMENT REQUIREMENTS[12]

- Inhalation equipment must have the capacity for delivering 100 percent, and never less than 30percent, oxygen concentration at a flow rate appropriate to the child's size. The device should be checked and calibrated regularly.
- The equipment must have an appropriate scavenging system to minimize room air contamination and occupational risk.
- Emergency drug cart, readiness to assure proper emergency management response must be readily accessible. Emergency equipment must be able to accommodate children of all ages and sizes. Equipment to resuscitate non breathing, unconscious patient and provide continuous support until trained emergency personnel arrive should be available.

TECHNIQUE OF NITROUS OXIDE/OXYGEN ADMINISTRATION[28-29]

Nitrous oxide/oxygen must be administered only by appropriately licensed individuals. The practitioner responsible for the treatment of the patient and/or the administration of nitrous oxide must be trained in the use of such agents and techniques and appropriate emergency response. All the clinical personnel should be trained and possess certificate in basic life support.

- Selection of an appropriately sized nasal hood is the prime requirement for obtaining adequate sedation.
- A flow rate of five to six L/min is adjusted and is generally accepted by most patients. The reservoir bag should pulsate gently with each breath and should not be either over- or underinflated.
- 100 percent oxygen should be administered for one to two minutes
- Nitrous oxide-oxygen is titrated gradually at 10 percent intervals and the concentration of nitrous oxide should not exceed50 percent. A typical patient requires from 30 to 40 percent nitrous oxide to achieve ideal sedation. Nitrous oxide concentration may be decreased during easier procedures (eg, restorations) and increased during more.
- During treatment, it is important to continuously monitor the patient's respiratory rate and level of consciousness.
- It is important to continue traditional behavior guidance techniques during treatment as the effects of nitrous oxide is largely dependent on psychological reassurance.
- After completion of the treatment and the nitrous oxide administration is terminated, 100 percent oxygen should be delivered for five minutes.
- The patient must return to pretreatment responsiveness before discharge.

PRE PROCEDURE PREPARATION

Before administering sedation the operator should be familiar with medical history that may influence sedation such as (1) abnormalities of the major organ systems;(2) previous adverse experience with sedation as well as regional and general anesthesia; (3) drug allergies, current medications, and potential drug interactions; (4) time and nature of last oral intake; and (5) history of tobacco, alcohol, or substance use or abuse. Patients presenting for sedation/analgesia should undergo a focused physical examination, including vital signs, auscultation of the heart and lungs, and evaluation of the airway[30].

Pre procedural counseling about sedation, the risk involved, benefits and alternatives to sedation increases patient/parent confidence and satisfaction. Pre procedure fasting decreases risks especially during moderate or deep sedation. Patients undergoing sedation for elective procedures should not drink fluids or eat solid foods for a sufficient period of time to allow for gastric emptying before their procedure.[31]In emergency situations where the fasting is not possible, sedation should be kept to minimal level.

MONITORING[31]

- Level of Consciousness: Continuous monitoring of patients response through verbal commands or observation of facial signs should be done.

- All patients undergoing sedation should be monitored by pulse oximetry with appropriate alarms
- Changes in patients' heart rate and blood pressure will enable practitioners to detect problems and intervene in a timely fashion, reducing the risk of these complications. Vital signs should be monitored at 5-min intervals once a stable level of sedation is established. The primary complications of sedation is related to respiratory or cardiovascular depression, and therefore the operator should be trained to recognize arising complication and in basic life support skills.
- Pharmacologic antagonists as well as appropriately sized equipment for establishing a patent airway and providing positive pressure ventilation with supplemental oxygen and resuscitation medications should be readily available.

CO-MEDICATION RISKS

It is a known fact that N2O enjoys an undisputed safety record in children when used alone at 30-40% concentrations. Additional risks are posed by the combination of N2O with other sedative drugs given by a different route. Their actions become synergistic, and the potential for CNS depression is magnified, resulting in deeper sedation than desired or anticipated where reflexes are reduced or lost[32].

OCCUPATIONAL SAFETY

N2O is minimally metabolized when used as inhalation sedative and excreted primarily through the lungs at a rate similar to its absorption. But it retains its potency when exhaled by the patient into the room. This has led to concerns about occupational health hazards especially in poorly ventilated areas.

Long-term exposure may additionally cause bone marrow suppression and reproductive system disturbances.

The use of the rubber dam, scavenging equipment, and environmental monitoring, however, have significantly reduced these occupational risks[33-34].

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.[33,34,35,36]

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[37,38].

CONCLUSION

Nitrous oxide sedation is one of the safest pharmacological agents for behavior management. But the choice to use it should always be in the best interest of the child and should be used when all non-pharmacological methods of behavior management techniques has been proven non applicable.

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