REVIEW ARTICLE

INHALATION CONSCIOUS SEDATION IN PEDIATRIC DENTISTRY: THEORY TO PRACTICE

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ABSTRACT

Pharmacological behavior management in pediatric dentistry includes measures involving anxiolysis to minimal sedation to even induction of general anesthesia. It can be used safely with great effect in patients who are unable to receive treatment for various reasons such as young age, compromised state of mind, or health. Use of minimal and moderate sedation is usually more beneficial because of its minimal pre-operative preparation and acceptable comfort level of patients post-operatively as they require no or minimal hospitalization. Credentials of N_2O include its simple titration method, superior analgesic, anxiolytic, amnestic properties rapid onset of action, and equally rapid post-operative recovery. It is also preferred over other drugs in inhalation sedation because of its low tissue solubility, minimum alveolar concentration value that accounts for its rapid onset and fast post-operative recovery within minutes and its non-irritant property to the respiratory tract. N_2O-O_2 inhalation sedation aims at anxiolysis by raising the pain threshold of children during dental treatment with almost negligible adverse events and establishing a healthy communication with them for a cooperative future dental treatment.

KEY WORDS

Inhalation sedation,nitrous oxide anxiolysis, conscious sedation, behavior management

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INTRODUCTION

Most children during dental treatment are relaxed and relatively co-operative, but some display unwanted tantrums that may raise the difficulties of the practitioner in providing a safe acceptable treatment.[1] Ideally, various non-pharmacological behavior management techniques can be used to deliver a successful treatment to the child and guiding them to develop a positive behavior for the further appointments. Unfortunately, not all the children in pediatric practice can be managed by these techniques alone, pharmacological techniques of behavior management such as sedation and anesthesia are considered as a valuable tool by practitioners in such children.

Goals of conscious sedation in children

An ideal sedative agent for children should be easy to administer, have a rapid onset and offset, produce no residual symptoms, have minimal side effects, and should be cost-effective.[1] According to the Guidelines developed by American Academy of Pediatrics and the American Academy of Pediatric Dentistry in 2011 for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures[2], the goals of sedation in the pediatric patient for diagnostic and therapeutic procedures are:

1. To guard the patient's safety and welfare,
2. To minimize physical discomfort and pain,
3. To control anxiety, minimize psychological trauma, and maximize the potential for amnesia,
4. To control behavior and/or movement so as to allow the safe completion of the procedure, and
5. To return the patient to a state in which safe discharge from medical supervision, as determined by recognized criteria, is possible.

History of Nitrous Oxide and Use in Dentistry

Joseph Priestly(1772)-Nitrous oxide, one of the first modern anesthetics, was first manufactured in by this English chemist.

Sir Humphrey Davy (1800)experimented with the physiological properties , he coined the term “laughing gas” .

Dr. Horace Wells(1844)- Nitrous oxide was used for the first time as a dental anesthetic drug .

Gardner Quincy Colton (1863) nitrous oxide anesthesia came into general use, when 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.

Indications

Sedation with N_2O / O_2 is very useful in children from 4 years of age [3]. Patients indicated for sedation are fearful, anxious or agitated children; Certain patients requiring special care, such as in muscle disorders and cerebral palsy. [4,5]

Respiratory Physiology

Knowing the differences between the respiratory tract of a child and an adult is essential for the dentist who uses sedation with nitrous oxide to be safely administered[6]. The nostrils of the child, the oropharynx and the trachea are relatively narrow; any irritation of the mucous membrane can cause edema in this area, making proper ventilation difficult. Children have high metabolic rates, resulting in increased oxygen consumption (6 to 9 mL / kg per minute) compared to adults (3mL / kg per minute). For this reason, for sedation to be an effective experience for everyone, it is fundamental to know the characteristics of the respiratory system .[5]

Nitrous oxide –the Magic Gas

Houffe et al[7] in 2017 studied the efficacy of Intranasal fentanyl and inhaled nitrous oxide for fracture reduction. They concluded that There are several advantages in using the combination of oxide and oxygen by inhalation, such as: faster onset of action; The rapid recovery time due to the pharmacological characteristics of nitrous oxide and few side effects associated with sedation .

Samur Ergüven et al[8] in 2016 investigated the effects of conscious sedation with 40% nitrous oxide/oxygen on cognitive functions on 40 dental patients who were referred to the sedation unit at Gazi University Faculty of Dentistry Department of Oral and Maxillofacial Surgery. They received a combination of 40% nitrous oxide/oxygen inhalation for conscious sedation. Psychometric tests were applied three times: before sedation, during sedation, and at the end of the recovery, for assessing cognitive functions. The results of this study showed that the 40% N_2O/O_2 combination impaired cognitive functions during the conscious sedation. Recovery of most of the cognitive functions occurred 15 min after sedation. Their result showed that Its administration is simple and painless, its onset is rapid, as is also, the end of the effect as soon as its inhalation is suspended. It has the benefit of decreasing or even eliminating anxiety, reducing undesirable movements and reactions in dental treatment, increasing patient communication and cooperation, as well as tolerance to longer and more time-consuming treatment.

MECHANISM OF ACTION

Fujinaga and Maze[9] in 2002 hypothesized that N_2O induces opioid peptide release in the periaqueductal gray area of the midbrain leading to the activation of the descending inhibitory pathways, which results in modulation of the pain/nociceptive processing in the spinal cord. The types of opioid peptide induced by N_2O and the subtypes of opioid receptors that mediate the antinociceptive effects of N_2O appear to depend on various factors including the species and/or strain, the regions of the brain, and the paradigms of behavior testing used for the experiments

Emmanouil et al[10] in 2007 conducted an extensive study on research manuscripts on the pharmacology of N_2O which revealed 5801 articles between 1981 and 2006 exploring the pharmacokinetic and pharmacodynamic aspects of N_2O. They concluded that the gas acts via different pathways when used as an analgesic, anxiolytic, and anesthetic drug . They summarised that the analgesic effect of N_2O is opioid in nature, and, like morphine, may involve a myriad of neuromodulators in the spinal cord. The anxiolytic effect of N_2O, on the other hand, resembles that of benzodiazepines and may be initiated at selected subunits of the -aminobutyric acid type A ($GABA_A$) receptor. Similarly, the anesthetic effect of N_2O may involve actions at $GABA_A$ receptors and possibly at N-methyl-D-aspartate receptors as well.

Applications of nitrous oxide

For dental extractions-

Various studies have documented the success of nitrous oxide inhalation sedation for the provision of dental treatment especially for dental extractions, most commonly for orthodontic reasons.

Blain and Hill in 1998 compared the efficacy of nitrous oxide inhalation sedation with that of general anaesthesia for dental extractions. They found that the success rate for completion of treatment under inhalation sedation was significantly poorer than that of general anaesthesia. However, it should be noted that the success rate for nitrous oxide inhalation sedation was still good at 83%. The patients who successfully had dental treatment with nitrous oxide inhalation sedation represented 57% of those initially referred for treatment under general anaesthesia, confirming that with careful patient selection and management, inhalation sedation can be a successful alternative to general anaesthesia extractions.[11]

Shaw et al in 1996 reported a 90% success rate for dental extractions and minor oral surgical procedures carried out under inhalation sedation for patients who had been specifically referred for treatment under general anaesthesia. In this study the

parents of patients who had previously undergone dental treatment under general anaesthesia stated that they preferred nitrous oxide inhalation sedation .[12]

In a comparative study assessing the successful completion of orthodontic dental extractions under nitrous oxide inhalation sedation versus general anaesthetic, Shepherd and Hill in 2000 concluded that sedation was successful in 96.7% of times compared to 100% for general anaesthetic .[13]

The age range of the subjects reported in the above studies varied from 3 to 17 years.

For endodontic treatment and restorations-

Studies have also reported the successful use of inhalation sedation for completion of comprehensive dental treatment.

Hallonsten et al in 1983 reported the successful use of nitrous oxide inhalation sedation for the provision of restorations, endodontic therapy and dental extractions for children aged between 3 and 16 years.[14]

In a study carried out in a community dental clinic, Bryan et al in 2002 has shown that, in 83.9% of cases dental treatment, which included dental restorations and extractions, was carried out as planned for anxious children with an average age of 7.2 years.[15]

In a more recent retrospective survey, Naudi et al in 2006 reported that 84% of children referred for comprehensive dental treatment under inhalation sedation managed to have their treatment completed while the remaining 16% required referral for treatment using other pharmacological techniques . The mean age of the patients treated in this study was 9.8 years. [16]

Nitrous oxide inhalation sedation requires a certain level of co-operation and for this reason it is not as successful in very young patients and those with severe learning delay . [17]

Antunes et al in 2016 carried out a study to assess children's behavior in consecutive dental sessions following oral rehabilitation using different pharmacological regimens for behavioral control. Participants were preschoolers who were treated for caries under one of the following: no sedative, oral sedation with nitous oxide, or general anesthesia.The dental treatment of early childhood caries under moderate sedation was shown to significantly improve the future behavior of children during subsequent recall appointments 4 to 29 months after completion of treatment. [18]

Angela Galeotti et al in 2016 carried out a study to evaluate the effectiveness and the tolerability of the nitrous oxide sedation for dental treatment on a large pediatric sample of 472 children, aged 4 to 17 constituting precooperative, fearful, and disabled patients. The success rate was 86.3%. . They concluded that inhalation conscious sedation represented an effective and safe method to obtain cooperation, even in very young patients, and it could reduce the number of pediatric patients referred to hospitals for general anesthesia.[19]

Contraindications

Sedation of children under the age of 1 year is contraindicated, which is not relevant in the dental office[20] (Hoeffe, 2017 and Samur Ergüven, 2016). It is contraindicated in cooperative children, patients with lung diseases, problems in the upper airways such as rhinitis, sinusitis, adenotonsillitis or nasal obstruction[21] (Tian, 2015). The use of conscious sedation by oxygen and nitrous oxide should be used in the concentration of at least 30 to 40% oxygen in the gas mixture.

Adverse effects

Nitrous oxide inhalation sedation is not a new sedation technique. In fact, it has been used as a patient management technique in UK dentistry since the 1940s.

Studies by Jastak and Paravecchio[22] in 1975 and Roberts et al. in 1979 regarding the possible adverse effects have been researched extensively and it has been reported that the nitrous oxide inhalation sedation has an extremely low incidence of patient morbidity .

Duncan and Moore in 1984 reported that reactions associated with the use of nitrous oxide are infrequent, especially when it is administered to healthy patients and combined with at least 50% oxygen.

A study by Shepherd and Hill[13] in 2000 reported that the side effects that have been most commonly associated with inhalation sedation include nausea, vomiting and headache .

Diffusion hypoxia may occur as the sedation is reversed at the termination of the procedure The incidence of diffusion hypoxia during N_2O inhalation sedation, even at higher concentrations of $\geq$ 50% N_2O is very rarely documented in the available literature. Quarnstrom et al. with his clinical experience in over 10,000 administrations of N_2O sedation without postoperative O_2 could not detect any clinical problems like hypoxia Papageorge et al. monitored 80 patients and found that O_2 decreased with a mean of 2.1% in the study, all the decreased O_2 levels were stabilized independently within 12 s to 15 min. Dunn-Russell et al. assessed 24 children who were allowed to breathe room air after N_2O inhalation sedation. None of the children exhibited any abnormal levels of SpO_2 or any other side effects.

To minimize the chances of diffusion hypoxia, the patient should be oxygenated for 5 min after a sedation procedure.

DISCUSSION

Health is directly related to general health and wellbeing of pediatric patients, especially those with disabilities and those with behavioral management problems, because they have greater oral health needs. Although it can be a challenge, all pediatric patients should be able to expect painless, high quality dental care, maximizing comfort and cooperation.

Conscious sedation being safer than general anesthesia, it should be considered the first choice management treatment.[23] In addition, studies have shown that the morbidity associated with inhalation sedation is minor and infrequent with respect to general anesthesia.[19,24] Conscious sedation was a viable and cost-effective alternative to general anesthesia for children requiring extractions, especially orthodontic extractions. [19]

In dentistry, use of minimal and moderate sedation is usually more beneficial because of its minimal pre-operative preparation and acceptable comfort level of patients post-operatively as they require no or minimal hospitalization[23]. Children with special health care needs exhibit severe anxiety when visiting a dental office. It may be caused due to a number of factors including fear of the unknown, inability to communicate one's feelings and reactions to sensory stimuli. The effectiveness of nitrous oxide varies according to the extent and severity of the disability and it should be considered as an option before thinking about deep sedation or general anaesthesia. Various medical conditions, such as Parkinson's disease, Multiple Sclerosis and Cerebral Palsy, affect the child's ability to maintain an open mouth during dental treatment. Conscious sedation often helps in reducing these involuntary movements through muscle relaxation and anxiety reduction.[24]

Nitrous oxide (N_2O) has been used for well over 150 years in clinical dentistry for its analgesic and anxiolytic properties. Nitrous oxide inhalational sedation has been reported as an effective sedation and very safe technique to reduce dental treatment–induced fear and anxiety. It is generally delivered at a concentration of 30 to 40% with oxygen via a nasal mask.[12] N_2O-oxygen (O_2) inhalation sedation can be induced in two different techniques: Slow induction and rapid induction. Credentials of N_2O include its simple titration method, superior analgesic, anxiolytic, amnestic properties rapid onset of action, and equally rapid post-operative recovery. It is also preferred over other drugs in inhalation sedation because of its low tissue solubility, minimum alveolar concentration value of more than 1 atmosphere that accounts for its rapid onset and fast post-operative recovery within minutes and its non-irritant property to the respiratory tract.[25]

With the incorporation of nitrous oxide sedation, pediatric dentists can easily perform several types of dental procedures, both in deciduous and in permanent dentition, expanding the field of use, with the aim of restoring all aspects of oral health.

CONCLUSION

Sedation should be considered as part of management of pain and dental anxiety, to make the treatment a pleasant learning experience. Conscious sedation is a safe method with a wide safety margin that can be used effectively in managing dental fear and anxiety and can reduce the need for general anesthesia. Inhalation sedation using nitrous oxide is the recommended choice for conscious sedation in children.

REFERENCES

1. Pedersen RS, Bayat A, Steen NP, Jacobsson ML. Nitrous oxide provides safe and effective analgesia for minor paediatric procedures – a systematic review. Dan Med J 2013;60:A4627

2. American Academy of Pediatric Dentistry Clinical Affairs Committee – Behavior Management Subcomittee; American Academy of Pediatric Dentistry Council on Clinical Affairs – Committee on Behavior Guidance. Guideline on behavior guidance for the pediatric dental patient. Pediatr Dent 2005- 2006;27:92-100

3. Fallah R, Nakhaei MH, Behdad S, Nafisi Moghaddam R, Shamszadeh A. Oral chloral hydrate and intranasal midazolam for sedation during computerized tomography. Indian Pediatr 2013; 50(2): 233-5

4. Mekitarian OF, Finding the optimal initial dose of intravenous ketamine for pediatric procedural sedation is still challenging The American Journal of Emergency Medicine , Volume 34 , Issue 9 , 1892

5. Mekitarian F, De Carvalho WB, Gilio AE, et al. Aerosolized intranasal midazolam for safe and effective sedation for quality computed tomography imaging in infants and children. J Pediatr, 2013; 163(4):1217-1219

6. Louon, A., Reddy, V.G.. Nasal midazolam and ketamine for paediatric sedation during computerised tomography. Acta Anaesthsiol Scand. 1994; 38(3):259-26

7. Hoeffe, J., Doyon Trottier., Bailey, Shellshear, Lagacé M., Sutter C., et al . Intranasal fentanyl and inhaled nitrous oxide for fracture reduction: The FAN observational study. Am J Emerg Med. May; 2017,35(5):710-715. doi: 10.1016/ j.ajem.2017.

01.004.

8. Samur Ergüven, S., Delilbaşi, E.A., İşik, B., Öktem, F. The effects of conscious sedation with nitrous oxide/oxygen on cognitive functions. Turk J Med Sci., 2016. Jun 23;46(4):997-1003. doi: 10.3906/sag-1504-37.

9. Fujinaga M, Maze M. Neurobiology of nitrous oxide-induced antinociceptive effects. Mol. Neurobiol 2002;25:167–189;PubMed: 11936558

10. Emmanouil DE, Quock RM. Advances in Understanding the Actions of Nitrous Oxide. Anesthesia Progress. 2007;54(1):9-18. doi:10.2344/0003-3006(2007)54[9:AIUTAO]2.0.CO;2.

11. Blain KM, Hill FJ. The use of inhalation sedation and local anaesthesia as an alternative to general anaesthesia for dental extractions in children. Br Dent J 1998;184:608-611

12. Shaw AJ, Meechan JG, Kilpatrick NM, Welbury RR. The use of inhalation sedation and local anaesthesia instead of general anaesthesia for extractions and minor oral surgery in children: a prospective study. Int J Paediatr Dent 1996;6:7-11

13. Shepherd AR, Hill FJ. Orthodontic extractions: a comparative study of inhalation sedation and general anaesthesia. Br Dent J 2000;188:329-331

14. Hallonsten AL, Koch G, Schroder U. Nitrous oxide-oxygen sedation in dental care. Community Dentistry and Oral Epidemiology 1983; 11(6):347-355

15. Bryan RA. The success of inhalation sedation for comprehensive dental care within the Community Dental Service.[erratum appears in International Journal of Paediatric Dentistry. 2003 Jan;13(1):71.]. International Journal of Paediatric Dentistry 2002; 12(6):410-414

16. Naudi AB, Campbell C, Holt J, Hosey MT. An inhalation sedation patient profile at a specialist paediatric dentistry unit: a retrospective survey. [Erratum appears in European Archives of Paediatric Dentistry. 2006 ;7(3):210-1]. European Archives of Paediatric Dentistry; 7(2):106-109

17. Holroyd I, Roberts GJ. Inhalation sedation with nitrous oxide: a review. Dental Update 144; 27(3):141-14

18. Antunes DE, Viana K A, Costa P S, Costa L R. Moderate sedation helps improve future behavior in pediatric dental patients – a prospective study. Braz. oral res. 2016; 24;30(1):e107

19. Galeotti A, Garret Bernardin A, D'Antò V, et al. Inhalation Conscious Sedation with Nitrous Oxide and Oxygen as Alternative to General Anesthesia in Precooperative, Fearful, and Disabled Pediatric Dental Patients: A Large Survey on 688 Working Sessions. BioMed Research International.2016;2016:7289310. doi:10.1155/2016/7289310.

20. Hoeffe, J., Doyon Trottier, E., Bailey, B., Shellshear, D., Lagacé, M., Sutter, C., Grimard, G., Cook, R., Babl, F.E.. Intranasal fentanyl and inhaled nitrous oxide for fracture reduction: The FAN observational study. Am J Emerg Med. 2017;May; 35(5):710-715. doi: 10.1016/ j.ajem.2017. 01.004.

21. Tian, X. H., Yang, Y.Z., Li, X.F. Evaluation of N2O inhalation and oral midazolam conscious sedation in pediatric dentistry of children with intellectual disability. 2017, Shanghai Kou Qiang Yi Xue. Jun;24(3):370-2.

22. Jastak, J.T., and Paravecchio, R. An analysis of 1,331 sedations using inhalation, intravenous or other techniques. JADA;1975; 91(6):1242-1249

23. Attri JP, Sharan R, Makkar V, Gupta KK, Khetarpal R, Kataria AP. Conscious sedation: Emerging trends in pediatric dentistry. Anesth Essays Res 2017;11:277-81.

24. Krishna Priya V, Divya G, Mayuri G, Santosh Kumar Ch. Conscious sedation in pediatric dentistry: a review. International Journal of Contemporary Medical Research 2016;3(6):1577-1580.

Samir PV, Fere SS. Nitrous Oxide-Oxygen Inhalation Sedation: A Light on its Safety and Effi cacy in Pediatric Dentistry. Int J Adv Health Sci 2015;1(11):4-10