

Effect of nitrous oxide-oxygen inhalation with scavenging on behavioral and physiological parameters during routine pediatric dental treatment

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Abstract

Purpose: The purpose of this study was to determine the influence of 40% nitrous oxide/60% oxygen inhalation with scavenging on the behavioral and physiological parameters during routine pediatric dental procedures.

Methods: Twenty-two subjects, aged 60-116 months, were randomized into a double blind, cross-over study design and administered alternately either 40% nitrous oxide/60% oxygen or 100% oxygen during two sequential restorative appointments. All subjects were monitored continuously for respiratory rate, pulse rate, and hemoglobin oxygen saturation using a combined capnograph and pulse oximeter. The subject's breath sound and behavior were recorded every minute along with vital signs.

Results: When compared to 100% oxygen inhalation, 40% nitrous oxide/60% oxygen inhalation produced significant reductions in adverse patient behavior, respiratory rate, and pulse rate, but did not affect percent hemoglobin oxygen saturation. Nitrous oxide inhalation had no effect on breath sound revealed by auscultation or on the occurrence of the apnea alarm displayed by the capnograph.

Conclusions: This study demonstrated that the administration of 40% nitrous oxide/60% oxygen delivered via a scavenging nasal hood significantly improved patient behavior and altered physiological parameters commonly monitored during conscious sedation. (*Pediatr Dent* 21:417-420, 1999)

Nitrous oxide-oxygen inhalation is commonly used to alleviate patient anxiety and pain perception, improve patient-dentist communication, and enhance the patient behavior management strategies employed by the dentist.^{1,2} Clinical trials demonstrated that the administration of nitrous oxide-oxygen inhalation to mild to moderately apprehensive pediatric patients resulted in reduced anxiety and pain during stressful and stimulating dental procedures.^{3,4} In addition, the improved patient coping behavior produced by the use of this agent appeared to continue into subsequent dental visits.^{5,6}

Nitrous oxide-oxygen inhalation is used by increasingly more pediatric dentists and at a higher frequency of utilization.⁷ In a recent survey of pediatric dentists, 85% used nitrous oxide inhalation, with the majority using it greater than five times

per week.⁸ The survey respondents indicated that 20% or less of their patients required either nitrous oxide-oxygen inhalation alone or in combination with sedative agents.

Nitrous oxide-oxygen inhalation is commonly employed with oral conscious sedation of pediatric dental patients because it potentiates the sedative effect of the agents administered and enhances patient compliance and behavior.⁸⁻¹⁵ While these investigations studied the additive effect of nitrous oxide with sedative agents on behavioral and physiological parameters, there is a paucity of data available on the effect of nitrous oxide/oxygen inhalation alone on these variables. In addition, the influence of scavenging during nitrous oxide/oxygen inhalation has not been reported for pediatric patients undergoing routine dental care. This effect is worthy of investigation in light of a recent study reporting that scavenging at the evacuation rate of 45 L/min, as recommended by the National Institute for Occupational Safety and Health (NIOSH), could adversely affect the level of psychosedation achieved with 50% nitrous oxide administration.¹⁶ Therefore, the purpose of this study was to determine the influence of 40% nitrous oxide/60% oxygen inhalation with scavenging on the behavioral and physiological parameters of non-sedated children during routine dental procedures.

Methods

All children in the study were recruited from the Pediatric Dental Clinic at the University of Florida College of Dentistry. Only healthy children (ASA I) not taking any medications and without contraindications to nitrous oxide administration were selected as subjects. The sample was collected from children, ages five to nine years old, exhibiting cooperative but anxious behavior during previous dental treatment. In the judgment of the operator, all children recruited for the study could benefit from the use of nitrous oxide-oxygen inhalation during their proposed dental treatment. Criteria for subject selection also dictated that the patients required at least two appointments of restorative dentistry with similar complexity using rubber dam isolation and local anesthesia. The procedures, possible discomforts or risks, as well as possible benefits, were explained fully to the subjects involved and their informed consent as approved by the University's Institutional Review Board was obtained prior to the investigation.

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Table 1. Effect of 40% Nitrous Oxide Inhalation on Patient Behavior (per minute interval)

Behavior*	Nitrous Oxide	Oxygen	P-value**
Quiet	713 (98%)	630 (89%)	<i>P</i> <0.001
Crying	15 (2%)	70 (10%)	
Struggling	0	9 (1%)	

* Modified Ohio Scale⁹.

** chi-square analysis.

The subjects were randomly assigned to one of two groups. Group I received 100% oxygen at the first appointment and 40% nitrous oxide/60% oxygen at the second appointment. Group II received 40% nitrous oxide/60% oxygen at the first appointment and 100% oxygen at the second appointment. Nitrous oxide-oxygen inhalation was delivered by a portable nitrous oxide unit (MRX, Porter Instrument Co., Hatfield, PA) at a flow rate of 4-6 L/min. A scavenging system with a child-sized nasal hood (Brown Scavenging Mask, Porter Instrument Co., Hatfield, PA) was employed at a 45 L/min evacuation rate as recommended by NIOSH. The same operator administered the gases and performed the restorative dental procedures throughout the study. The subject and the observer/recorder were blinded to the percent concentration of the gases delivered. This double blind, cross-over study design allowed each subject to serve as his/her own control.

Prior to each trial, every subject received an airway patency assessment to verify the absence of upper respiratory infection and to confirm that the subject was able to easily breathe through the nose. All patients were monitored continuously for respiratory rate, pulse rate, and hemoglobin oxygen saturation using a combined capnograph and pulse oximeter (POET TE Plus, Criticare System, Waukesha, WI) by the same observer/recorder. The pulse oximeter probe was attached to the right great toe and a sidestream carbon dioxide sampling line, using 150 mL/min flow rate, was attached through the side of the scavenging nasal hood by a luer-lock adapter as previously reported.¹⁷

Baseline values were recorded for the first minute and then readings were taken subsequently at the end of each minute interval of treatment from the tabular trend display on the monitor. The apnea alarm on the monitor was set at a 10-second delay and each alarm incident was recorded corresponding to the one-minute interval of its occurrence. In addition, the patency of the airway was also continuously monitored using a pretracheal stethoscope and breath sounds were recorded every minute as either clear, stridor, or absent. An apneic event was noted only when the apnea alarm was confirmed by auscultation via the pretracheal stethoscope. The response to a confirmed apneic event was to ask and/or assist the subject in repositioning the head to obtain a patent airway. This maneuver was followed by continuous visual assessment, auscultation of breath sounds, and visualization of the subject's chest movement.

A simplified modification of the Ohio State University Behavior Rating Scale

(OS)⁹ was used by the observer/recorder to rate patient behavior using an ordinal scale that categorized behavior as either: quiet, crying, or struggling. These ratings were mutually exclusive and only one rating was selected as a global assessment of behavior displayed for each minute. The trial was terminated if the subject demonstrated non-compliant behavior that interfered with data collection.

Results

Twenty-seven subjects were recruited for the study. Three patients did not complete the study due to behavioral problems interfering with the recorder's ability to collect valid data, and two subjects did not return for the second appointment. The 22 subjects completing the study had a mean age of 7.3 years (range = 60-116 months). The population included 10 males and 12 females.

There were no statistically significant differences noted between groups I and II for the recorded behavioral or physiological parameters. This finding reduced the likelihood for a sequence effect due to the order of assigned treatment. There were also no significant differences between the two groups in gender, chronological age, or mean duration of the treatment appointments (32 minutes).

Table 1 demonstrates that the inhalation of 40% nitrous oxide/60% oxygen significantly reduced the incidence of adverse patient behaviors (crying and struggling) while conversely increasing the incidence of quiet, cooperative behavior. Table 2 reveals that nitrous oxide inhalation significantly lowered respiratory and pulse rates, but had no effect on hemoglobin oxygen saturation when compared to oxygen inhalation alone. Using nitrous oxide inhalation with scavenging did not affect the type of breath sound or the occurrence of the apnea alarm (Table 3).

Discussion

The simplified modification of the OS used in this study was confirmed by its authors to be well correlated to the original and more complex rating scale.⁹ Using this scale, sedated pediatric dental patients displayed decreased crying and struggling behavior and increased quiet behavior with 50% nitrous oxide compared to 100% oxygen inhalation.^{9,13} The results of the present study using 40% nitrous oxide inhalation with scavenging in non-sedated children supported the findings of these prior investigations with sedated children undergoing routine dental care.

Table 2. Effect of 40% Nitrous Oxide Inhalation on Physiological Parameters

Parameter*	Nitrous Oxide (Mean±SEM)	Oxygen (Mean±SEM)	P-value**
RR	22±0.3	23±0.3	0.018(s)
PR	87±0.5	89±0.6	0.004(s)
SaO ₂	99±0.01	99±0.01	0.754

* Respiratory Rate (RR) measured by capnography.

Pulse Rate (PR) and Hemoglobin Oxygen Saturation (SaO₂) measured by pulse oximetry.

** Factorial ANOVA (Fisher's PLSD).

(s) indicates statistical significance.

Results of the present study also showed that patients inhaling 40% nitrous oxide/60% oxygen experienced significantly decreased respiratory and pulse rates. There were, however, no changes revealed in hemoglobin oxygen saturation. Similar results were obtained in a study by Verwest et al.,¹⁸ where 40% nitrous oxide/60% oxygen inhalation given to non-sedated pediatric dental patients had no significant effect on the development of hypoxemia. The concurrent use of oxygen with nitrous oxide inhalation likely contributed to this finding. Oxygen supplementation via nitrous oxide/oxygen inhalation was shown to prevent decreases in hemoglobin oxygen saturation, even in the presence of apnea and hypoventilation, during pediatric dental sedation.¹⁹ The use of supplemental oxygen administration during pediatric dental sedation was advocated to decrease the risk of hypoxemia and its beneficial use was supported in several other animal²⁰ and human²¹⁻²³ sedation studies.

Some studies implied that sedated children receiving nitrous oxide-oxygen inhalation were at greater risk for hypoventilation and airway obstruction.^{14,15} In these reported studies, significant elevations (>45) in end-tidal carbon dioxide, indicating hypoventilation, were produced in sedated children receiving 50% nitrous oxide by full face mask prior to general anesthesia. In a dental setting, however, McCann et al.⁹ were unable to demonstrate significant differences in physiological parameters while using 50% nitrous oxide inhalation in sedated pediatric dental patients. They reported that the administration of 50% nitrous oxide inhalation produced only a tendency to decrease pulse rate when compared to 100% oxygen inhalation alone.

The findings of the above clinical studies may not be applicable to the dental setting where nitrous oxide inhalation is administered as the sole agent during stimulating and sometimes painful procedures. Insufficient investigation has been performed to test the effect of nitrous oxide alone on physiologic parameters routinely monitored during pediatric dental sedation. The results of the present study would suggest that nitrous oxide/oxygen inhalation as a sole agent produced a modifying effect upon some physiological parameters commonly monitored during conscious sedation.

Conclusions

When compared to 100% oxygen inhalation, 40% nitrous oxide/60% oxygen inhalation with scavenging:

1. significantly decreased the incidence of adverse patient behavior;
2. significantly decreased respiratory and pulse rates;
3. did not significantly change the percent hemoglobin oxygen saturation; and
4. had no effect on the type of breath sound revealed by auscultation or on the occurrence of apnea alarm displayed by the capnograph.

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Table 3. Effect of 40% Nitrous Oxide Inhalation on Breath Sound and Occurrence of Apnea Alarm (per minute interval)

Breath Sound*	Nitrous Oxide	Oxygen	P-value†
Clear	688 (94%)	682 (96%)	0.2824
Stridor	39 (6%)	26 (4%)	
Absent	1	1	
Apnea Alarm **			
No	688 (94%)	675 (95%)	
Yes	40 (6%)	34 (5%)	0.2203

* Via pretracheal stethoscope.

** Set at 10 sec. delay on capnograph.

† Chi-square analysis.

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ABSTRACTS OF THE SCIENTIFIC LITERATURE



END-TIDAL CARBON DIOXIDE MONITORING DURING SEDATION

This study describes an attempt to determine a safe and effective sedation protocol with minimum adverse effects on respiratory function for children requiring invasive procedures for treatment of cancer. Fifty patients, ranging in age from 12 months to 72 months, received a sedation regimen including an initial dose of IV glycopyrrolate (5 mcg/kg) and midazolam (0.05 mg/kg) followed by incremental doses of ketamine (0.5 mg/kg) every one to two minutes PRN. Oxygen saturation and $ETCO_2$ were recorded every 15 seconds; length of procedure ranged from 8 to 28 minutes. The following negative sequelae were reported in three medically compromised patients: 1) oxygen saturation decreased by 3% or more in three patients, with the lowest saturation being 84%; 2) two isolated $ETCO_2$ values were over 50 mmHg (90% of values were under 40 mmHg); 3) one brief episode of airway obstruction was identified by observing the $ETCO_2$ waveform. It was concluded that there was no relationship between occurrence of adverse corresponding events and the dose of ketamine or the duration of the procedure.

Comments: The discussion reviews several sedation protocols with respiratory depression reported in ranges from 11% to 30%. It further includes discussion regarding ketamine as a safe and effective sedation agent and $ETCO_2$ monitoring versus oxygen saturation levels, although there was no correlation made between oxygen saturation and $ETCO_2$ levels in the results. Because of the need to establish an IV line (to titrate ketamine doses every minute or two) and to monitor $ETCO_2$, which requires additional personnel, the described technique would not be practical for in-office sedations, as is often practiced in pediatric dental offices. It was disappointing to see that none of the 16 references were from the pediatric dental literature. **RFM**

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End-tidal carbon dioxide monitoring during sedation with a combination of midazolam and ketamine for children undergoing painful, invasive procedures. Tobias JD. *Pediat Emerg Care* 15(3): 173-5, 1999.

16 references



OXYPENTIFYLLINE IN THE MANAGEMENT OF RECURRENT APHTHOUS ORAL ULCERS

This is a report from a preliminary trial examining the effectiveness of oxypentifylline for the prevention of recurrent aphthous stomatitis. Twenty-four patients participated for six weeks. These were adult patients and were given 400mg of oxypentifylline (Trental) three times daily. Sixty-three percent of the subjects reported significant relief from symptoms and recurrence of their oral lesions. Once the drug was discontinued, half of the patients reporting relief had a recurrence of their ulcers. The authors point out that recent research is focusing on a probable immune component of recurrent aphthous stomatitis. This drug suppresses the inflammatory immune response. This may have contributed to the therapeutic success observed. A double blind study is indicated. **MGP**

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Oxypentifylline in the management of recurrent aphthous oral ulcers. Chandrasekhar J, Leim AA, et al. *OOO* 87:564-567, 1999.

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