



Assessment of the Effects of 2 Sedation Regimens on Cardiopulmonary Parameters in Pediatric Dental Patients: A Retrospective Study

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Abstract

Purpose: The purpose of this study was to evaluate the cardiopulmonary effects of 2 sedation regimens during treatment: (1) oral meperidine and hydroxyzine with nitrous oxide (N₂O); and (2) oral diazepam and hydroxyzine, submucosal meperidine, and N₂O. Nitrous oxide was tapered to oxygen (O₂) only 10 minutes following submucosal meperidine administration.

Methods: Sixty-two children were evaluated who met the following criteria: (1) history of uncooperative behavior; (2) ASA I or II; (3) nothing to eat or drink after midnight the night before the appointment; (4) an initial/recall exam prior to the sedation appointment; and (4) patients who met the American Academy of Pediatric Dentistry guidelines for sedation. Regimens I and II included 32 and 30 patients, respectively. A single clinician treated all patients. A Criticare monitor recorded the following at 5-minute intervals: (1) O₂ saturation; (2) respiratory rate; (3) heart rate; (4) systolic and diastolic blood pressures; (5) end tidal carbon dioxide concentration; and (6) mean arterial blood pressure.

Results: The *t* test indicated significant differences between the 2 regimens for: (1) heart rate; (2) systolic blood pressure; and (3) diastolic blood pressure (regimen II had higher values). Using the general linear model, no significant differences were found. All cardiopulmonary parameters were within normal limits.

Conclusion: Regimens I and II had similar cardiopulmonary effects. (*Pediatr Dent* 2006; 28:350-356)

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Sedation has been widely employed by pediatric dentists in the management of uncooperative patients who need extensive dental treatment. This procedure can:

1. reduce anxiety;
2. provide analgesia; and, thus
3. allow performance of surgical procedures that otherwise would be stressful.¹

The cooperation of a child depends on his or her chronological and developmental age. Developmentally delayed children and those younger than 6 years of age often require a deep level of sedation to gain their cooperation.² According to the American Academy of Pediatric Dentistry's (AAPD) Clinical Guideline on the Elective Use of Minimal, Moderate, and Deep Sedation (levels 3 and 4), deep sedation is defined as a "drug-induced depression of consciousness during which patients cannot be easily aroused, but may respond purposefully following repeated

verbal or painful stimulation."³ Thus, these developmentally delayed and younger children are especially vulnerable to the adverse effects of sedatives on respiratory drive, loss of protective reflexes, and airway blockage.² Since deep sedation may occur after administration of sedatives in any child, proper equipment and practitioner's skills are essential for safe management of sedated children.²

When selecting a drug regimen, the patient's safety, as well as the effectiveness of the sedation medication, must be considered. The safety of patients undergoing sedation has become of increased concern in recent years.^{4,5} Reports of deaths or serious long-term injuries following sedation have raised awareness of potential adverse events associated with sedation and increased attention to the safety and close monitoring of sedated children.⁴ The American Academy of Pediatrics in 1992 emphasized that the use of N₂O with other sedative agents, narcotics, or other depressant drugs could quickly cause a state of deep sedation or general anesthesia and requires the level of "deep sedation" monitoring.⁶

Nitrous oxide (N₂O) gas in combination with other sedative agents is often used in pediatric dentistry to manage uncooperative children.⁷ Due to the ease of administration of sedative medications and the experience of pediatric den-

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tists with oral sedation, this technique is the most frequently employed sedation route used by pediatric dentists.⁸

Coté et al investigated adverse sedation events in pediatric patients and concluded that there was no relationship between the outcome of the sedation and the drug class or route of administration of the medications.⁹ Negative outcomes were associated with:

1. drug overdose;
2. drug combinations and interactions;
3. the use of 3 or more sedative agents; and
4. administration of N₂O in combination with any other class of sedating medication.⁹

Coté et al concluded that the cause of the practitioner's failure to rescue the patient was either:

1. a delay in recognizing the severity of the adverse event; or
2. lack of experience of the practitioners in CPR and airway management.¹⁰

Selbest¹¹ reported that the analysis done by Coté et al¹⁰ had shortcomings, including possible poor and incomplete documentation in the clinical records, a small number of cases reviewed (118 cases), and old cases dating back to 1969. The author emphasized that evaluating only the adverse events, not the successful cases, creates a distorted view for practitioners and discourages the use of sedative agents.

Peña et al analyzed 1,180 sedation cases using different types of medications performed in a pediatric emergency department by trained nonanesthesiologist personnel.³ The dosage of medications used was according to published guidelines. The study revealed that adverse events—such as oxygen (O₂) desaturation requiring intervention, paradoxical reactions, emesis, apnea, laryngospasm, and bradycardia—occurred in over 2% of the cases. These events were minor, transient, and easily managed.

Bryan studied the efficacy of N₂O/O₂ inhalation sedation in pediatric dentistry and found N₂O to be a very successful tool in the clinical management of children undergoing dental treatment.¹² Treatment was completed as planned in 84% of children who were mostly between 5 and 8 years old using N₂O/O₂. Also, treatment was successfully completed in 38 out of 39 children (97%) who previously were treated under general anesthesia. Therefore, a second general anesthesia procedure for the purpose of dental treatment was avoided.

Litman et al showed that the addition of 30% or 50% N₂O to 70 mg/kg of oral chloral hydrate often caused decreases in ventilation and resulted in deep sedation in children.⁷ The addition of 50% N₂O produced a state resembling general anesthesia in 1 of 32 patients. There was, however, no physical stimulation of this study's patients.

Song et al studied the effect of oral vs submucosal administration of meperidine on the behavior of the pediatric patient.¹³ The study found no difference in efficacy regarding improvement of behavior between oral administration of meperidine (1 mg/lb) plus promethazine (0.5 mg/lb)

and 50% N₂O vs submucosal administration of meperidine (0.5 mg/lb)² and oral promethazine (0.5 mg/lb) plus 50% N₂O. The authors stated that because first pass metabolism of oral meperidine inactivates approximately 50% of the drug, this agent's plasma level in the 2 drug regimens was expected to be similar.

Hasty et al evaluated 2 drug regimens to determine if the addition of meperidine would improve patient behavior and increase the prevalence of respiratory compromise in children.¹⁴ Regimen I included 50 mg/kg of oral chloral hydrate with 25 mg of hydroxyzine plus 1.5 mg/kg of meperidine. Regimen II included 50 mg/kg of chloral hydrate plus 25 mg hydroxyzine. In this study, the addition of meperidine resulted in a significant improvement in patient behavior during operative dental procedures. Both regimens resulted in little respiratory compromise and apnea in patients.

The most concerning adverse effect of sedation is respiratory depression and its potentially long-term consequences.^{4,15} Respiratory compromise can eventually lead to hypoxemia and predispose the patient to more serious conditions.¹⁵ Sedative agents can potentiate the respiratory depression property of narcotics. Local anesthesia can exacerbate this condition.^{6,15}

Pulse oximetry is routinely used to monitor the O₂ saturation level of patients during sedation. It provides a reliable estimate of O₂ saturation of the patient.¹⁶ Detection of airway obstruction and apnea based on reduction in O₂ saturation rate alone, however, especially when supplemental O₂ is administered, can be a delayed process. Undetected apnea or hypoventilation may lead to hypercarbia and acidosis—which, by the time of detection by pulse oximetry alone, may be at a significant level.¹⁶ Apnea can accurately be detected by capnography, which is not affected by supplemental O₂ flow rate.¹⁶

The purpose of the current study was to evaluate the cardiopulmonary effects of 2 different conscious sedation regimens. Regimen I consisted of oral meperidine and hydroxyzine with the use of nitrous oxide (N₂O), and regimen II consisted of oral diazepam and hydroxyzine with submucosal meperidine and limited N₂O use.

Methods

A retrospective record review of 86 sedation records of a single clinician (second-year pediatric dentistry resident) from the postgraduate pediatric dentistry clinic at the University of Texas Health Science Center, Houston, Tex, was conducted. Research approval was obtained from The Committee for the Protection of Human Subjects at the University of Texas Health Science Center. Inclusion criteria for acceptance were: (1) healthy child (ASA I or II); (2) NPO after midnight the night before the dental appointment; (3) an initial/recall exam performed prior to the sedation appointment with documented uncooperative behavior; (4) patients who met the AAPD guidelines for sedation; (5) treatment that followed regimens I or II exactly; and (6) adequate printed data records.

Using a Criticare 8100 monitor (Criticare Systems, Inc, Waukesha, Wis), the data collected included: (1) O₂ saturation; (2) blood pressure; (3) heart rate; (4) end tidal carbon dioxide (CO₂; EtCO₂); and (5) respiratory rate. The monitor recorded the cardiopulmonary parameters at 5-minute intervals and the values were printed at the conclusion of treatment. Also measured were the: (1) length of the restorative visit; (2) time from end of treatment to discharge; and (3) amount of treatment accomplished under each regimen. Rubber dam isolation was used for all patients.

Data were entered in SPSS 10.0 (SPSS Inc, Chicago, Ill) using the mean values obtained. Cardiopulmonary parameters were compared using the *t* test and general linear model with repeated measurement. A *P* value of $\leq .05$ was selected as statistically significant. Recording of every data point was at times compromised by disruptive behavior of the patient or temporary blockage of the capnograph line. Only records that contained adequate data regarding the sedation period and the patients' cardiopulmonary status, however, were included in this study. Data were considered adequate when no more than 3 data points were not obtained for any 1 parameter. No patient had 3 or more data points missing for any other parameter, however, with the exception of 3 patients.

One of the 3 patients was not excluded from the study because 4 (for O₂ saturation) data points were missing, but only for that single parameter (no other data points were missing for all other parameters). For a second patient, 4 data points were missing for respiratory rate and EtCO₂ due to temporary occlusion of the capnography cannula. All other parameters, however, were recorded. For the final patient, the authors were unable to record the blood pressure for 7 data points; this patient, however, had all other data points recorded for all parameters. All patients were scheduled for sedation because of anxious, uncooperative, or resistant behavior at the initial or recall exam. Before the dental treatment on the day of the sedation visit, NPO status was confirmed with the parent and a preoperative physical exam was completed.

The exam included the use of:

1. a standard hospital scale to record weight in pounds;
2. a pulse oximeter unit to record blood pressure, pulse, and O₂ saturation.

Also completed were: (1) an examination of the oral cavity; (2) an assessment of tonsil size and airway patency; and (3) auscultation of the lungs. Each child who met the presedation criteria was given 1 of 2 sedation regimens. For both regimens, the maximum dose of 2% xylocaine with 1:100,000 epinephrine for all patients was limited to 4 mg/kg. Patients exhibiting more uncooperative behavior and those requiring longer treatment periods or surgical procedures were assigned to regimen II by the attending faculty member. Monitoring of patients for both regimens began as soon as all monitoring devices were in place and prior to local anesthetic administration.

Regimen I included the use of 1 mg/lb (maximum 50 mg) meperidine (meperidine hydrochloride syrup, 50 mg/5 mL, Roxane Laboratories, Columbus, Ohio) plus 25 mg of hydroxyzine (hydroxyzine pamoate 25 mg/5 mL, Pfizer Laboratories, New York, NY) orally. The drugs were drawn and administered to the patient by the operator via a cup or, if the patient was uncooperative, by a needleless 5-cc syringe into the buccal vestibule. Following the administration of the medications, the patient remained with the parent for at least 30 minutes before the initiation of treatment. Once in the treatment room:

1. the patient was placed on a papoose board, but not immobilized initially;
2. a pulse oximeter probe was placed on the patient's right thumb; and
3. a pretracheal stethoscope was placed on the patient with an adhesive sticker at the suprasternal notch.

An appropriate size blood pressure cuff was placed on the patient's left arm, and the capnograph tubing was taped next to the patient's nostril. A N₂O/O₂ nasal hood was placed over the child's nose, and N₂O was administered at 50% at a flow rate of 4 to 6 L/minute depending on the child's size. Monitoring began as soon as the patient was comfortably seated in the dental chair with all monitoring equipment in place and before local anesthetic injection and in the case of regimen II before the submucosal meperidine and local anesthesia was injected. Patients who became uncooperative and nonresponsive to the instructions of maintaining their hands on their stomach and keeping their head still were immobilized in the papoose board. Cardiopulmonary parameters were continuously monitored using the Criticare CSI 8100 monitor and recorded at 5-minute intervals throughout treatment. Respiratory status and breath sounds were continuously monitored via the pretracheal stethoscope.

At the conclusion of treatment, 100% O₂ was administered to the patient for 5 minutes via the nasal hood. Once AAPD discharge criteria (Appendix II: Recommended discharge criteria)¹⁷ were met, the patient was released and returned to the parent at which time postoperative instructions were given to the parent both verbally and in written form. The parent was then asked to sign a sedation discharge form, and the next appropriate appointment was scheduled before the patient left the clinic.

Regimen II included the use of 5 mg of diazepam (diazepam tablets 5 mg, Watson Laboratories Inc, Corona, Calif) and 25 mg of hydroxyzine (hydroxyzine pamoate 25 mg/5 mL, Pfizer Laboratories, New York, NY) orally with the submucosal administration of 1 mg/lb of injectable meperidine (meperidine hydrochloride injection, 100 mg/mL, Abbott Laboratories, Chicago, Ill). The 5-mg tablet of diazepam was crushed and mixed into 25 mg of liquid hydroxyzine and administered to the patient by the same manner in regimen I. The same regimen I waiting time and preparations were observed before regimen II

Table 1. Mean Values for Oxygen Saturation, Respiratory Rate, Heart Rate, End Tidal Carbon Dioxide Level, Systolic Blood Pressure, Diastolic Blood Pressure, and Mean Arterial Blood Pressure for the Duration of Treatment for Regimens I and II*

	Oxygen saturation (%)	Respiratory rate (breaths/min)	Heart rate (beats/min)	EtCO ₂ (end tidal carbon dioxide level)	Systolic blood pressure	Diastolic blood pressure	Mean arterial blood pressure
Regimen I	99	24.01	95.56	26.74	115.54	65.35	86.97
Regimen II	98	22.50	109.91	26.24	120.44	69.27	90.23
P value	.068	.311	.001†	.702	.048†	.033†	.122

*Regimen I: 1 mg/lb meperidine (maximum=50 mg)+25 mg hydroxyzine orally+N₂O; Regimen II: 5 mg diazepam+25 mg hydroxyzine orally+N₂O initially+1 mg/lb meperidine submucosally.

†P values ≤.05 indicate statistical significance.

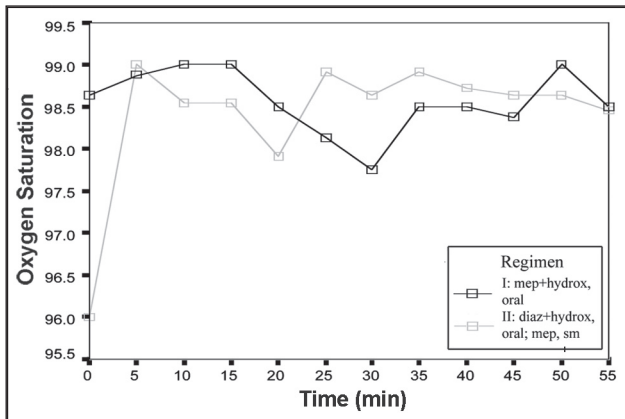


Figure 1. General linear model with repeat measurement: Oxygen saturation (%) during sedation. P=.629

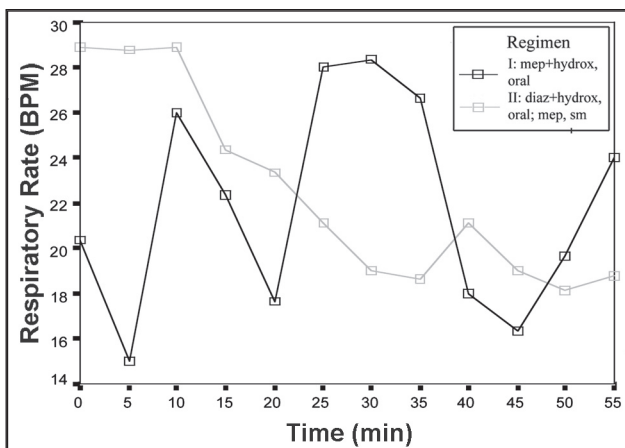


Figure 2. General linear model with repeat measurement: Respiratory rate (breaths per minute) during sedation. P=.844

treatment began. Using a 1-cc tuberculin syringe, 1 mg/lb of injectable meperidine was drawn up. Topical anesthetic gel (benzocaine 20%) was applied before less than 0.2 cc of 2% xylocaine 1:100,00 epinephrine was placed in the upper right or left buccal mucosa (contralateral arch to that receiving treatment) in the primary second molar region or first permanent molar (if erupted). The injectable meperidine

was then administered in the same injection site as the less than 0.2 cc of 2% xylocaine with 1:100,000 epinephrine with the bevel of the syringe facing the buccal cortical plate. Local anesthetic was then administered as required for restorative treatment, and the patient remained on N₂O with no treatment or stimulation for 10 minutes. After 10 minutes, N₂O was gradually decreased until the patient was on 100% O₂ and remained at that level for the duration of the treatment. Once treatment was completed, postoperative discharge was completed as in regimen I, with the parent being informed of the possibility of minor postoperative inflammation around the submucosal injection site.

Results

The sedation records of 62 patients met the inclusion criteria and were reviewed with 32 patients in regimen I (17 males and 15 females) and 30 patients in regimen II (23 males and 7 females). The mean age (range=2.92-8.6 years) and weight of the patients were 4.5 years and 46.7 pounds and 5.2 years and 45.2 pounds for regimens I and II, respectively. Two regimen I patients were classified as ASA II, whereas there was only 1 such regimen II patient. There was no statistical difference regarding age, weight, ASA category and gender between the 2 regimen groups (*t* test and chi-square with *P*>.05).

Additionally, length of the dental sedation visit in minutes (regimen I=45 minutes and regimen II=52 minutes) and time from the end of treatment to discharge in minutes (regimen I=14 minutes and regimen II=12 minutes) was noted.

For both regimens, the following mean numbers were noted:

1. sextants in which dental treatment was performed (regimen I=2.87; regimen II=2.7);
2. stainless steel crowns (SSCs) placed (regimen I=2.09; regimen II=2.23);
3. all other types of restorations placed (regimen I=2.06; regimen II=1.76);
4. pulp tomies (regimen I=0.88; regimen II=0.73);
5. extractions (regimen I=1.06; regimen II=0.96);
6. space maintainers cemented; or
7. impressions for space maintainers taken (regimen I=0.37; regimen II=0.30).

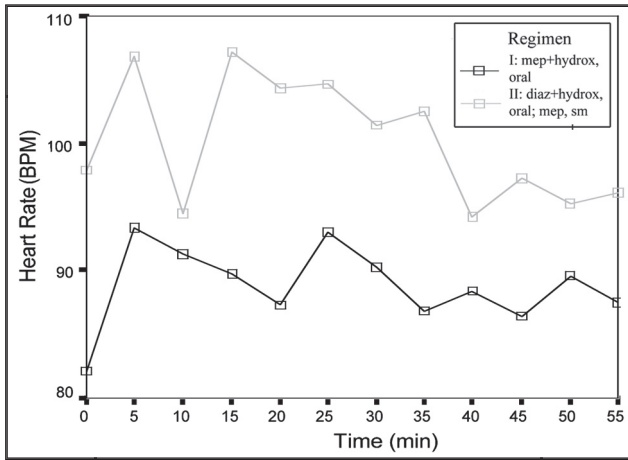


Figure 3. General linear model with repeat measurement: Heart rate (beats per minute) during sedation. $P=.064$

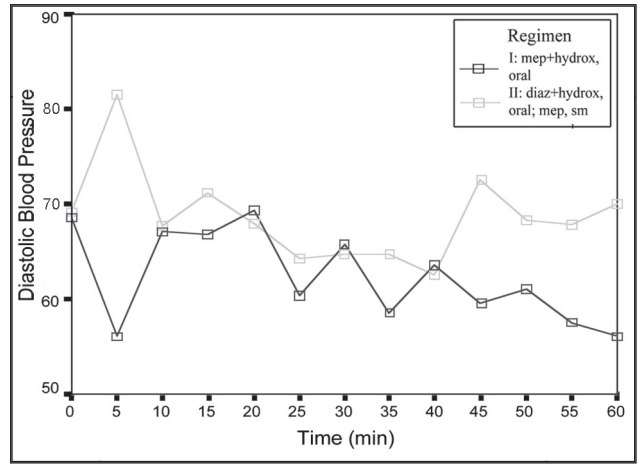


Figure 6. General linear model with repeat measurement: Diastolic blood pressure (mmHg) during sedation. $P=.084$

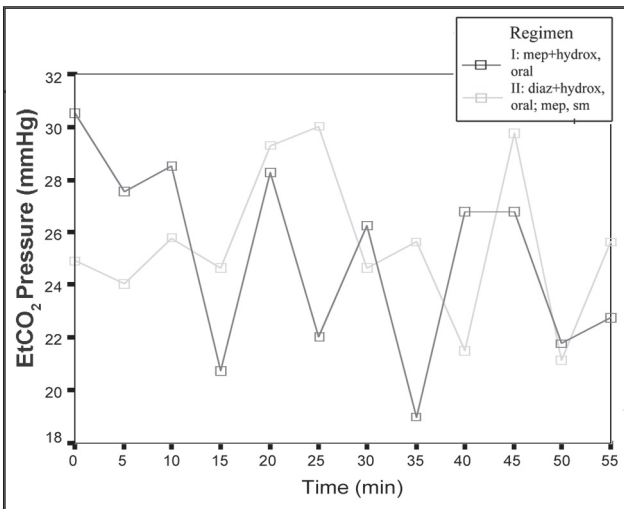


Figure 4. General linear model with repeat measurement: End tidal CO2 concentration (mmHg) during sedation. $P=.882$

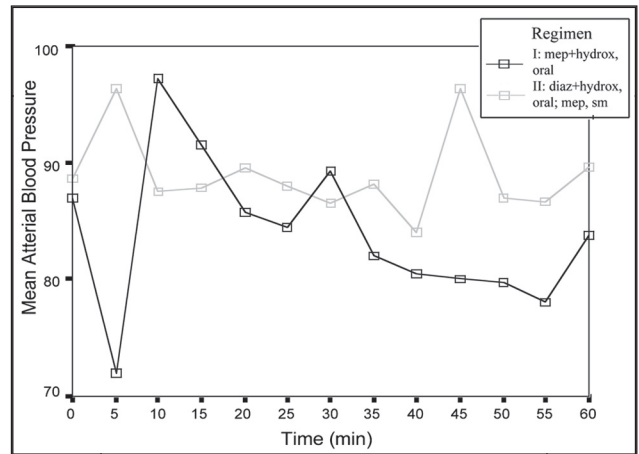


Figure 7. General linear model with repeat measurement: Arterial blood pressure (mmHg) during sedation. $P=.188$

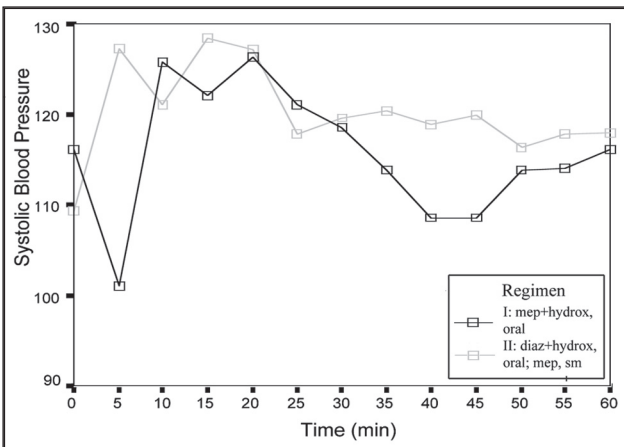


Figure 5. General linear model with repeat measurement: Systolic blood pressure (mmHg) during sedation. $P=.402$

Two lingual frenectomies were performed using regimen II; there were no such surgical procedures with regimen I. *t* test analysis of the data indicated significant differences between the 2 drug regimens for heart rate, systolic blood pressure, and diastolic blood pressure, but not for O₂ saturation, respiratory rate, EtCO₂, and mean arterial blood pressure values (see Table 1).

Comparing the data over time using the general linear model with repeated measurement resulted in no significant difference between the 2 drug regimens for any of the parameters (Figures 1-7). For patients undergoing dental treatment, all values for the cardiopulmonary parameters were within normal physiological limits.^{18,19}

Discussion

The safety of the sedated child has become an increasing concern during the past several years.^{4,5} Reports of adverse events and death in sedated children have increased awareness of potential hazards associated with conscious sedation, and have resulted in guidelines for the monitoring and care

of sedated children. Respiratory depression and its potential consequences remains the most concerning adverse effect of sedation in children.⁴

The peak plasma level of meperidine is achieved more quickly and with reduced inactivation of the medication when administered submucosally, as opposed to orally due to the first pass effect of the oral route.¹³ In the current study, however, there were no statistically significant differences in cardiopulmonary data between the 2 sedation regimens when the data were analyzed using the general linear model. The general linear model with repeated measurement uses between-subject tests and within-subject tests at each of the time points of data collection (5-minute intervals) to compare the 2 drug regimens. Regimen II produced higher heart rate values than regimen I ($P=.064$), but this was not statistically significant. Regimen II was selected for more uncooperative children and when longer treatment periods or surgical procedures were required.

The mean heart rate values were higher in regimen II. However, when one considers that these patients were undergoing dental treatment, the values were within normal limits. This finding was consistent with the study by Wilson et al that concluded uncooperative children have higher heart rates and mean arterial blood pressures during dental treatment.⁸

Comparing the data using the *t* test revealed statistically significant differences between the 2 drug regimens. This test uses averages of all 12 intervals of data collection (5-minute intervals) combined to compare the 2 regimens.

For regimen I and II groups, respectively:

1. heart rate mean values were 95.56 and 109.91 beats per minute (BPM; $P=.001$);
2. mean systolic blood pressure was 115.54 and 120.44 ($P=.048$); and
3. mean diastolic blood pressure values were 65.35 and 69.27 ($P=.033$).

Although all values were higher for regimen II, the values were within normal physiological limits. Of concern with regimen II is the higher number of sedative agents used and the higher available plasma level of meperidine, which may lead to respiratory depression, apnea, and possible bradycardia or reduction in blood pressure. The slight increase in blood pressure and heart rate found in regimen II patients may be attributed to more uncooperative behavior, crying, struggling, and movements rather than the physiological effects of the sedation regimen. The increase in blood pressure parameters for regimen II at 5 minutes into treatment may be attributed to the fact that it is at this time the submucosal meperidine was injected.

Oral administration of sedative agents is generally convenient, easy to administer, and a safe procedure. This procedure is well accepted by parents and most children, but requires patient's cooperation. Regimen II appears to have some clinical advantages, as one of the medications administered does not require patient cooperation (submucosal administration of meperidine) and the onset of action of the

drug is faster due to the elimination of the first-pass effect, which also approximately doubles the plasma level of this medication.^{13,20} Disadvantages of the submucosal injection, however, include the need for an additional injection, the discomfort associated with the injection, and the possibility of a local soft tissue reaction at the injection site. The vasoconstrictor found in local anesthetics maybe also have a potentially adverse effect on the uptake of the meperidine. For this reason, a very small amount (a few drops or less than 0.2 cc of local anesthetic) was injected in the site for the submucosal meperidine administration to diminish the discomfort associated with injected meperidine. Additionally, many states require the use of a parenteral permit to administer medications via the submucosal route, which may be a limiting factor for practitioners.

Children receiving regimen II were thought to be less cooperative and to require longer treatment periods than those placed in regimen I. In fact, upon looking at parameters related to the nature and duration of the treatment and length of time to discharge, no significant differences were found. Also, no significant differences between the 2 regimens were found when evaluating the number of: (1) sextants in which dental treatment was performed; (2) SSCs placed; (3) all other types of restorations placed; (4) pulpotomies; (5) extractions; (6) space maintainers cemented; and (7) impressions for space maintainers taken. Additionally, using the Houpt rating scale for overall behavior²¹ to compare behavior during dental treatment for the 2 regimens, the authors found no significant difference between the 2 sedation groups. For the rating of "excellent" (no crying or movement), there were 10 regimen I children and 6 regimen II children. Twenty regimen I children were considered to have "very good" behavior (some limited crying and movement), whereas 22 regimen II children were thought to have "very good" behavior. For regimen I, 2 children exhibited "good" behavior (difficult, but all treatment performed) and regimen II had 2 children exhibiting fair behavior (treatment interrupted, but eventually all completed). No sedations were considered poor or aborted.

This study's limitations include its small sample size and occasional missing data due to disruptive behavior of the patients or blockage of the capnograph line.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Using the *t* test, regimen II resulted in higher values for heart rate and systolic and diastolic blood pressures than regimen I.
2. When comparing the data over time using the general linear model, no significant differences were found between the 2 drug regimens.
3. All cardiopulmonary parameters were within normal limits.
4. Regimens I and II had similar cardiopulmonary effects on sedated pediatric dental patients.

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