IV sedation in pediatric dentistry: an alternative to general anesthesia

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Abstract

This prospective study was conducted to determine the sedative effects of IV ketamine and fentanyl on vital signs and behavior. Twenty-seven children, classified as ASA I, with a mean age of 34 months, were studied. The dosages of IV ketamine and fentanyl given were 0.5 mg/kg and 0.5 mcg/kg, respectively, approximately every 15–20 min. The pulse rate averaged 125 throughout the case. Blood pressure averaged 112/64. The respiration rate averaged 22 breaths per min. Mean behavior composite scores were 1.9 at the initial examination and 3.3 during treatment. One child vomited during treatment. Post-treatment complications were discomfort in 19% (5), nausea in 22% (6), and vomiting in 15% (4) of the patients. We concluded that IV sedation of precooperative healthy pediatric patients with ketamine, fentanyl, and nitrous oxide/oxygen appears to be a safe and effective sedation modality with minimal side effects when administered and monitored by a qualified anesthetist, offering the practitioner an alternative to general anesthesia. (Pediatr Dent 14:251–55, 1992)

Introduction

The precooperative child with extensive treatment needs presents a special challenge to the pediatric dentist. The most recent behavior management survey by Nathan1 found that oral sedation is still the most popular treatment modality chosen by the clinician to treat the difficult patient in spite of its limitations. In this same survey, general anesthesia was utilized by approximately 65% of the respondents. The parenteral route is used least frequently, chosen by only 18% of pediatric dentists. Liability costs and convenience of a hospital facility are cited as the factors which lead practitioners to favor inhalation general anesthesia over parenteral routes.

Parenteral sedation, specifically the intramuscular, subcutaneous, and submucosal routes, has been associated with an increased risk of morbidity and mortality when narcotics are used.[2] These administration routes are the ones most traditionally taught in pediatric dental training programs. Malamed[3] believes that the intravenous route is the most reliable and the safest when used properly. This rationale has led the author (E.B.) to use IV sedation in-office for the past eight years. A certified registered nurse anesthetist has been employed to administer and monitor IV drugs in patients who cannot be managed by behavior modification or oral sedation. This offers the parent a less-expensive alternative to general anesthesia. The combination of IV ketamine, fentanyl, and nitrous oxide/oxygen sedation (with IM hydroxyzine added for emesis protection) was the regimen used for the patients in this study.

Literature Review

Ketamine, an anesthetic agent used for the past 25 years, causes dissociation between the thalamoneocortical and limbic systems, resulting in a clinical dissociation from the environment. It has unique properties of sedation, amnesia, and analgesia. More than 11,000 reported cases of its use in children with no reported fatalities have been described in the literature by Green.[4] Ketamine advantages are the maintenance of spontaneous breathing and protective airway reflexes, making intubation unnecessary. Recovery occurs in 30 to 120 min, which allows for patient dismissal in a reasonable time after the procedure.

Ketamine is a dose-related cardiovascular stimulant. Even in children with congenital heart disease, it caused clinically only minor increases in heart rate and mean pulmonary artery pressure during catheterization.[5]

There are three primary disadvantages to ketamine. The most frequently cited is the emergence phenomenon, seen more commonly in adults (5–50%) than children (0–5%). Green reviewed the ketamine literature and found that in a series of 97 studies involving more than 11,000 children, the reported incidence of hallucinations and dreaming was 0.9%.

Because ketamine causes an increase in salivary and tracheobronchial mucus gland secretions, an antisialogogue is recommended for use with ketamine for general anesthesia.[6] However, in low doses, Hannallah found that an antisialogogue was unnecessary.[7]

Emesis is the third most common side effect of ketamine. In Green's review, he found that the reported incidence of vomiting in children was 10%, and was associated with dental procedures. He suggested that swallowed blood was the causative factor.

Fentanyl is a potent synthetic narcotic analgesic of short duration with a rapid onset. It is used in children

for inducing and maintaining anesthesia. Its potential complications and side effects are essentially those of any narcotic — respiratory depression, muscular rigidity, bradycardia, nausea, and vomiting.[8]

Hydroxyzine is a popular copremedicant which provides mild sedation, bronchodilation, some analgesia, and blood pressure stability, with minimal side effects. It is useful as an antihistaminic and an antiemetic.[8]

Purpose

The purpose of this prospective study was to determine the sedative effects of IV ketamine and fentanyl combined with nitrous oxide/oxygen on blood pressure, pulse, respiration, oxygen saturation, and behavior, and to report intra- and post-treatment complications on pediatric dental patients in a private practice setting.

Methods and Materials

The study was conducted prospectively and included all children treated with IV sedation during a 12-month period. There were 27 patients, 18 males and nine females, between the ages of 20–57 months with a mean age of 34 months. The children were selected for IV sedation because they were highly resistive during the initial exam, or because they were very young and required extensive treatment requiring numerous operative appointments under oral sedation. All children were healthy, with a classification of ASA I. Informed consent was obtained for the drug regimen and use of a Papoose Board (Olympic Medical Group, Seattle, WA). The parent was instructed to keep the child NPO for 8 hr before the appointment, except for a glass of water which was to be given one time 4 hr before the appointment. The parent also was instructed to place a diaper on the child.

A certified registered nurse anesthetist administered the drugs and monitored the child using a standard outpatient sedation form[9] to record vital signs and other details of the case every 10 min. The child was positioned on the Papoose Board and secured after the following monitors were attached: EKG (VSM 2 , Physio-Control, Redmond, WA), blood pressure cuff, axillary temperature probe, pretracheal stethoscope, and pulse oximeter (Model N-100, Nellcor Inc., Hayward, CA) with the sensor taped to the great toe. A baseline measurement of vital signs was obtained.

Sedation was initiated with 70% nitrous oxide/30% oxygen via a full-face mask. After changing to a nasal hood, the first dose of ketamine, calculated at 0.5 mg/kg, was given in the buccal mucosa . A 0.5 mcg/kg, dose of fentanyl was given a few minutes later by the same route. An intravenous line was established in the dorsal surface of the hand, and a continuous flow of D5W was infused throughout the sedation. A single dose of 6 mg IM hydroxyzine was given in the vastus lateralis muscle after the IV was in place.

IV subanesthetic dosages of ketamine (0.5 mg/kg) and fentanyl (0.5 mcg/kg) were titrated for the individual child and were given approximately every 15–20 min alternately throughout the treatment. This dosage was established by the anesthetist from a regimen used by the pediatric anesthesia department in a local hospital where she is employed. The last dosage of ketamine or fentanyl was given no later than 15 min before the anticipated end of treatment. During treatment an average of 2.6 mg/kg of lidocaine 2% with 1:100,000 epinephrine was administered. Naloxone (E.I. duPont de Nemours and Co., Manati, Puerto Rico), 0.1 mg, was given IV at the end of the appointment to counteract any residual effects of the fentanyl.

The anesthetist, the operator, and the dental assistant conjointly evaluated the child's behavior before treatment and at 10-min intervals during treatment. A behavior evaluation record (Table 1) was used to record these observations.

Descriptive data were generated and analyzed from the behavior and sedation records.

Results

Table 1. Behavior evaluation record

Rating scale for sleep:	
Fully awake, alert	1
Drowsy, disoriented	2
Asleep	3
Rating scale for movement:	
Violent movement that interrupts tx	
Continuous movement that makes tx difficult	2
Controllable movement that does not interfere with tx	3
No movement	4
Rating scale for crying:	
Hysterical crying that interrupts tx	1
Continuous, persistent crying that makes tx difficult	2
Intermittent, mild crying that does not interfere with tx	3
No crying	4
Rating scale for overall behavior:	
Aborted — no tx rendered	1
Poor — tx interrupted, only partial tx completed	2
Fair — tx interrupted, but eventually all completed	3
Good — difficult, but all tx completed	4
Very Good — some limited crying or movement	5
Excellent — no crying or movement	6

The average doses of IV ketamine and fentanyl were 2.5 mg/kg and 2.5 mcg/kg, respectively. Oxygen saturation during treatment had a mean of 98.5% (SD = 0.98). The average appointment length was 104 min, or 1.7 hr. Each child was infused with 330 cc of D5W.

The mean physiologic responses for this study are found in Fig 1–3. The mean temperature throughout treatment was 36°C, with a variance of 33.6–36.9°C.

The behavior during the initial examination was rated as negative according to Frankl,[10] with a mean

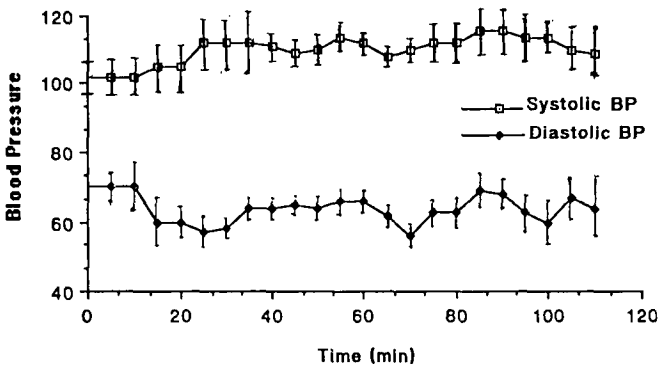

Fig 1. Time course of blood pressure during treatment. Each value represents a mean of 6–27 patients ± SE, with decreasing numbers of subjects as time increases. The baseline value for systolic blood pressure was 102. The baseline value for diastolic blood pressure was 70.

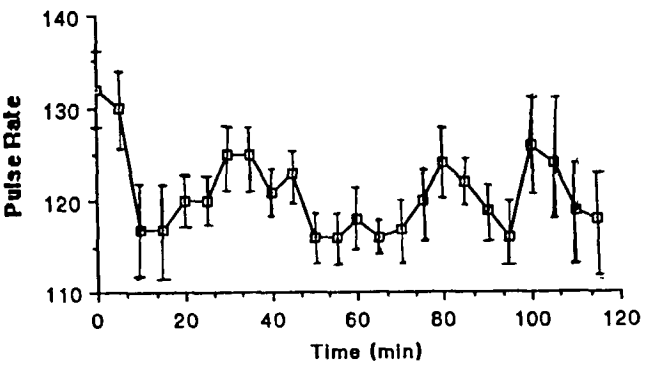

Fig 2. Time course of pulse rate during treatment. Each value represents a mean of 8–27 patients ± SE, with decreasing numbers of subjects as time increases. The baseline pulse rate was 132.

composite score of 1.9. The overall level and effectiveness of sedation during the treatment was rated conjointly by the three observers immediately after treatment (Table 2, next page). Fig 4–6 (Fig 4, next page, Figs 5 and 6, p. 255 are graphs of the mean rating scales for movement, crying and sleep. During treatment, ninety-three per cent of the children slept.

All patients were dismissed with their parents immediately after the end of the sedation appointment and postoperative consultation. Seventy-eight per cent appeared to be coordinated, 67% were awake, and 26% left the office crying. When the parents were contacted 4 hr after the child left the office, their responses to questions about the child's physical status after treatment were as follows: 96% of the children slept after the visit, 89% were ambulating well, 65% were alert, and 34% were still sleepy. When questioned about the child's attitude, the parents responded favorably for 88% of the patients; only 4% of the children were irritable.

One child vomited during treatment. Fifteen per cent of the children vomited after they left the office. Other post-treatment complications were discomfort in 19% of the children and nausea in 22%.

Discussion

The regimen currently being studied, which utilizes IV ketamine and fentanyl in subanesthetic doses with

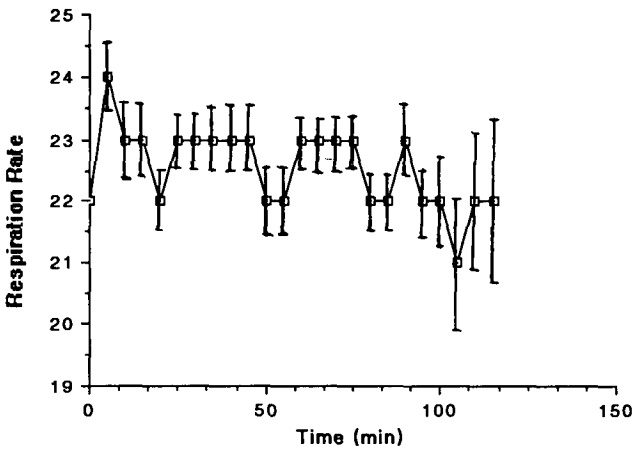

Fig 3. Time course of respiration rate during treatment. Each point represents the mean of 6–27 patients + SE, with decreasing numbers of subjects as time increases. Respiration rate was measured as the number of inspirations per minute.

nitrous oxide/oxygen, was developed by the anesthetist. Other combinations using ketamine, however, have been reported. Duperon used IM ketamine in doses of 2.5 mg/kg with nitrous oxide/oxygen, promethazine, atropine, and diazepam.[11] He found that dose of ketamine effective in sedating children. Kryshtalskyj used low doses of IV ketamine (25 mg) in 17 adult oral surgery patients combined with diazepam, meperidine, and nitrous oxide/oxygen.[12] It proved to be a safe and effective technique which was an alternative to light general anesthesia for oral surgery. Tucker also used IV ketamine at an induction dosage of 0.6 mg/kg and a maintenance dosage of 0.4 mg/kg every 10 min. Diazepam and nitrous oxide/oxygen were administered concurrently in 60 patients with good results.[13] O'Brien concluded that IM ketamine was effective in pediatric dental patients at a dose of 2 mg/kg, when

combined with droperidol, scopolamine, and nitrous oxide/oxygen.[14]

The decision to use fentanyl combined with ketamine was based on its rapid onset, brief duration, and short recovery time. Fentanyl has bradycardic action which possibly could counteract the cardiovascular stimulant properties of ketamine. It also would decrease the total amount of ketamine necessary to produce sedation through additive-synergistic interactions.

Table 2. Overall level and effectiveness of sedation

Overall Level of Sedation	*No. of Pts.*
No behavioral change	0
Sedated but disruptive when stimulated	3
Sedated but responsive to verbal command	4
Sedated, slept, but responsive to verbal command	5
Sedated, slept, responsive only to physical stimulation	12
Slept and unresponsive to normal verbal or physical stimulation	2
Unconscious and unresponsive	0
Effectiveness of Sedation	*No. of Pts.*
Ineffective, treatment could not be completed or was interrupted frequently	0
Effective, treatment was not interrupted, but the child cried or moved frequently	9
Very effective, the child was quiet throughout treatment	18

Ketamine often is classified as a general anesthetic. However, the unique clinical state induced by ketamine is distinctly different from the accepted definition of general anesthesia, which is "unconsciousness, accompanied by partial or complete loss of protective reflexes, including the inability to independently maintain an airway."[15] In subanesthetic doses, it produces a state of sedation and analgesia which Bennett has described as a safe, effective, and reliable modification technique.[16] In more than 500 pediatric patients, he used 50 mcg/kg/min of IV ketamine and reported that the child was conscious and responded to verbal commands if age permitted. Our study found a similar response. At an induction and maintenance dose of 0.5 mg/kg of ketamine and 0.5 mcg/kg of fentanyl, this is well below the recommended general anesthetic dose of 1–4.5 mg/kg of ketamine and 2–3 mcg/kg of fentanyl, IV. In fact, it is the nitrous oxide/oxygen which allows the use of such low doses of ketamine and fentanyl. This was evident at the end of the treatment when the nitrous oxide was discontinued; the child awakened within 1–2 min.

The respiratory rate in this study was 23 with no incidence of apnea. Normal respiration rate for a 3-year-old is 22 breaths per min. Since ketamine and fentanyl can be respiratory depressants, oxygen may have stabilized the respirations.

Blood pressure also was stable throughout the procedure. The mean blood pressure of a 3-year-old is 100/67. The children in this study had a mean baseline of 100/70. Fluctuations were minimal, with a mean throughout the treatment of 112/64, an increase of 12% above the norm. Ketamine is a known cardiovascular stimulant especially when given intravenously.[4]

The pulse rate showed a slight decline during treatment from baseline. The mean rate was 132 at baseline and averaged 125 during the sedation. The mean pulse rate for a normal, healthy 34-month-old is approximately 104. The difference between the normal value and that of the children in the study may be attributed to the cardiovascular stimulation of ketamine.

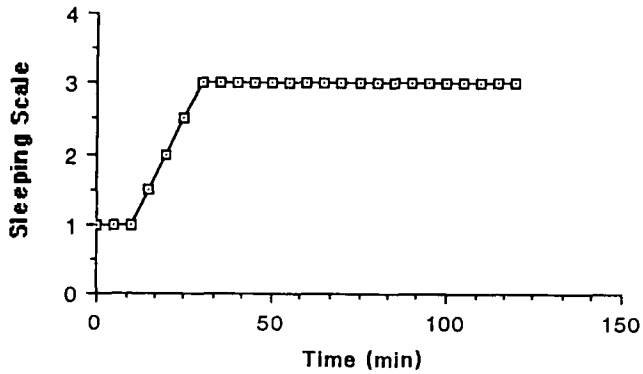

Fig 4. Mean movement rating scale. Each point represents the mean of 27 patients. The movement scale as shown on the Y axis was measured or defined as described in Table 1.

The high incidence of nausea and vomiting (22%) during the recovery period is undesirable. This may be due to the relatively low dose of hydroxyzine administered IM. Both ketamine and fentanyl are known to cause nausea and vomiting. Hydroxyzine is an effective antiemetic when given in recommended doses. McKenzie found it far superior to droperidol when given IM.[17]

Five patients experienced slight postoperative discomfort. None of the children were instructed to take an analgesic as a precaution against pain. Ketamine is an analgesic even in small doses. Extensive dental treatment was performed on the patients, most of whom had multiple pulp therapies, crowns, restorations, and extractions. Acetaminophen elixir was effective in con-

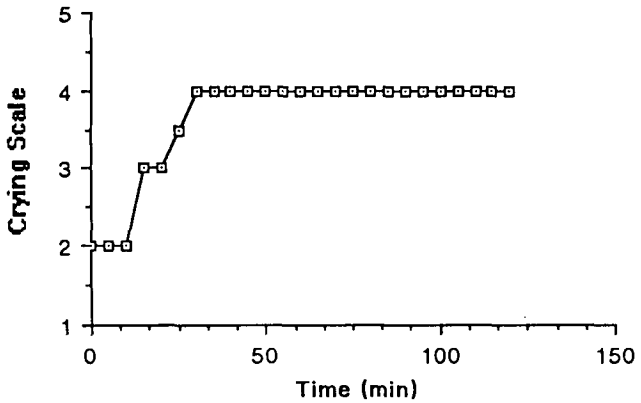

Fig 5. Mean crying rating scale. Each value represents the mean of 27 patients. Crying rating scale as hown on the Y axis was measured or defined as described in Table 1.

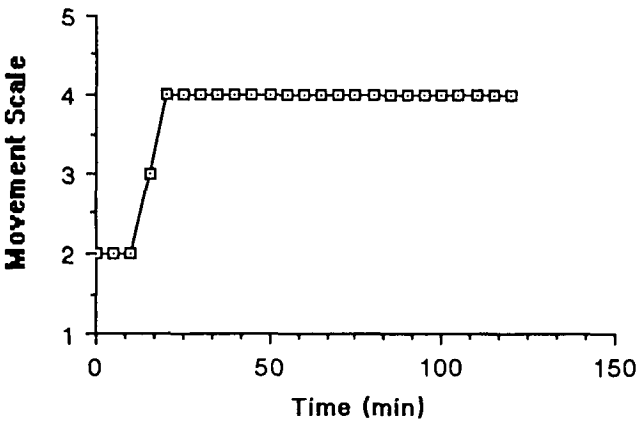

Fig 6. Mean sleep rating scale. Each value represents the mean of 27 patients. The crying scale as shown on the Y axis was measured or defined as described in Table 1.

trolling the mild discomfort experienced by the five children.

Only one child did not sleep after dismissal. This would be expected given the age group and the time of day, since most of the treatments ended between 11:00 AM and 12:30 PM. Parents were instructed to watch the children closely while they slept, and keep them on their stomachs in case of intraoral bleeding and excessive salivation due to the residual effects of the local anesthetic. No problems were noted in their sleep patterns. In summary, this technique appears to be safe, reliable, and predictable, rendering the patient sedated but rousable.

Conclusions

1. The mean blood pressure across all subjects during treatment was elevated 12% from the baseline.
2. The respiration rate was not affected by the drug regimen, remaining stable around 23 breaths per min.
3. The pulse rate was elevated from a normal value of 104 to 125, an increase of 20%.
4. All children, except one (96%) slept after the appointment.
5. The only complication was vomiting in one patient during treatment and in six patients postoperatively (22%).

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