Intravenous sedation in pediatric dentistry using Midazolam, Nalbuphine and Droperidol

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Abstract

Purpose: The purpose of this pilot investigation was to study the efficacy, physiologic responses, and safety of a multi-drug intravenous conscious sedation technique in an outpatient setting in children who demonstrated uncooperative behavior when comprehensive restorative dental treatment was attempted.

Methods: Using a time-based sedation record, the physiologic responses of 153 healthy children, age range 23 months to 14.5 years, were measured after they had received midazolam (Versed), nalbuphine (Nubain), and droperidol (Inapsine), each administered intravenously, and nitrous oxide and oxygen administered by nasal mask, while each child received comprehensive restorative or surgical dental care. Each patient was monitored according to the American Academy of Pediatrics Sedation Guidelines. Heart rate and rhythm, blood pressure, respiratory rate, hemoglobin oxygen saturation, end-tidal CO_2, level of sedation, and behavioral responses were recorded preoperatively, at 5 minute intervals during treatment and in recovery until discharge. Sedation was titrated to Level 2 or 3 during treatment as defined by the American Academy of Pediatric Dentistry Reference Manual.

Results: For each child, the sedation level was judged to be either acceptable or optimal for the completion of all planned dental treatment. There were no sedation failures. Children under 20 kg required significantly higher dosages of each sedative medication than children more than 20 kg to achieve the same level of sedation (P<0.001, ANOVA). There were no episodes of intraoperative vomiting, hypotension, cardiac arrhythmias, respiratory depression requiring respiratory support, or dysphoria during treatment, in the recovery period, or after discharge.

Conclusion: This multi-drug intravenous conscious sedation technique is a safe and effective method to control the behavior of uncooperative children who require comprehensive dental treatment. (Pediatr Dent 22:113-119, 2000)

Those who provide uncomfortable diagnostic or therapeutic health care procedures to children have continued to search for a sedative regimen which is predictable,[1,2] safe,[3,4] and efficacious.[5] The pediatric medical and dental literature contain numerous reports about various medications which have been administered alone or in combination via oral,[6-8] rectal,[9-11] transmucosal,[12,13] and intranasal routes.[14-17] These routes of administration are said to be advantageous because they are less frightening and more economical than the parenteral route. However, these reports have also shown that these routes of administration produce unpredictable levels of sedation and have a higher failure rate than the parenteral route when used for the pediatric patient who is to receive dental treatment.[18]

Unlike the pediatric dental literature, the pediatric medical literature is replete with reports of various combinations of medications, primarily benzodiazepines and opioids, which have been administered intravenously in conscious sedation techniques. Conscious sedation is a pharmacologically induced state that is designed to depress consciousness and control pain without sacrificing airway patency or respiratory drive,[19,20] although the use of this term is controversial. Children have received sedative medications intravenously for orthopedic procedures,[21] endoscopy,[22,23] oncologic procedures,[24,25] and emergency medical procedures.[26,27] Generally, these reports have shown that intravenous sedation is effective in controlling anxious or uncooperative behavior, as well as pain, during the performance of the various medical procedures. Conversely, there are few reports which have studied intravenous conscious sedation techniques in pediatric dentistry.[28,29]

Literature review

Overwhelmingly, the majority of sedation studies in the pediatric dental literature describe modalities which are primarily dependent on oral administration of sedative medications. Only two studies have been published in the pediatric dental literature which examined intravenous administration of sedative medications. Barr et al.[28] published the results of a study which examined the effects of ketamine and fentanyl administered intravenously by a certified registered nurse anesthetist and nitrous oxide and oxygen on vital signs and behavior in 27 children who received comprehensive dental treatment in a private practice setting. They found this technique to be an effective alternative to general anesthesia and reported minimal side effects, although nearly one quarter of the patients experienced either nausea or vomiting. Veerkamp et al.[29] reported the results of a study in which propofol, administered by a medical anesthetist, was used in an intravenous sedation technique to provide outpatient dental care to young children affected by nursing caries. However, the results showed that the depth of sedation was difficult to define during treatment

and that, frequently, administration of propofol often led more toward general anesthesia than sedation. In both studies, qualified anesthesia personnel were utilized to administer medications and monitor patients, presumably because ketamine and propofol are classified as general anesthetic agents.

Purpose

This paper presents the results of a pilot investigation of intravenous sedation, carried out in a private pediatric dental office, in which midazolam, nalbuphine, droperidol and nitrous oxide and oxygen were used to modify the behavior of uncooperative children in order to provide comprehensive dental treatment.

Materials and methods

Subjects: All subjects were enrolled prospectively as they presented for treatment to the private dental office of the principal investigator (ARM). Children enrolled had been referred because of anxious, uncooperative, or resistive behavior in the dental setting and required one or more quadrants of restorative or surgical dental care. A physical examination was completed and included an examination of the oral cavity, tonsil and adenoid assessment,[30,31] frequency of mouth breathing, snoring, speech hyponasality, and airway and chest examination by inspection and auscultation. The subjects were assigned a physical status classification as defined by the American Society of Anesthesiologists (ASA). Only children rated ASA 1 or 2 were enrolled in the study. A global behavior rating was assigned at the consultation appointment using the Frankl scale[32] and the child's interaction with the dental team was rated as either approachable or withdrawn.[33]

Sedation protocol: Sedation was provided to each child according to the guidelines developed by the American Academy of Pediatric Dentistry[20] (AAPD), and the American Academy of Pediatrics[19] (AAP). Informed parental consent was obtained for all children participating in the study. All children received oral midazolam preoperatively (0.75 mg/kg to a maximum dose of 15 mg) approximately 30 minutes prior to the actual appointment time. The child was then brought into the treatment room and placed onto a Pedi-board (Special Care, NJ) in the dental chair. The child's head was placed onto a VacPac 11 head rest (Olympic Medical, Seattle WA). Monitors were attached and nitrous oxide and oxygen were administered through a full face mask. Baseline vital sign readings were obtained. An angiocatheter was then inserted into a vein on the dorsum of the child's hand, the intravenous line attached, and the patency of the IV line verified by observation of both free flow of lactated Ringer's solution and inspection of the IV site to ensure that the catheter was not in the interstitial space. This was followed by administration of the initial boluses of sedative medications as follows: 2 mg of midazolam, 2-4 mg of nalbuphine and droperidol at 50 μg per/kg. Additional midazolam was administered in 2 mg increments no sooner than 3 minutes after the previous dose if the child had not reached a sedative level of 2 as defined by the AAPD.[20] The full face mask was removed and replaced by a nasal hood. The flow of nitrous oxide was reduced to 30% or less of the total fresh gas flow (generally 1 L depending on the child's tidal volume as determined by reservoir bag observation). Regard-less of the child's weight or physical stature, a minimum of 2L of oxygen was administered by nasal hood.[34] The child's head was placed into the sniffing position, breath sounds verified by auscultation over the larynx and chest and observation of chest excursions after which the VacPac was evacuated to maintain the child's head position. Additional dosages of sedative medication were titrated to clinical effect to maintain a sedation level of AAPD 2 or AAPD 3.

Measurements: Using a time-based sedation record, each child was monitored by the RN according the AAP[19]/AAPD[20] sedation guidelines. This included clinical observation by both the operator and the RN, both of whom were certified in Pediatric Advanced Life Support. SpO$_2$, heart rate, and systolic and diastolic blood pressure were continuously monitored using pulse oximetry (Criticare Systems Inc., Model 507 OP, Waukesha, WI). Respiratory status was continuously monitored by nasal/oral capnography (Criticare Systems Inc., POET TE Model 602-11, Waukesha, WI; Cannula 4101F, Salter Labs, Palo Alto, CA), and breath sounds were continuously monitored using a pre-tracheal stethoscope. Cardiac rhythm was continuously assessed by a Lead II electrocardiograph (PhysioControl Lifepak 7, Redmond, WA). These parameters and the level of sedation were recorded at 5 minute intervals by the RN The behavioral response of each child during treatment was continuously evaluated and recorded by the RN using The Ohio State University Behavioral Rating Scale.[33]

The dosage of each drug, as well as local anesthetic, volume of IV fluid, and adverse events associated with either the sedation or the treatment, were documented for each patient on the sedation record. The duration of treatment was recorded for each patient.

Recovery and discharge: At the conclusion of treatment, the patient was moved to the recovery area and reunited with the parent(s). Monitoring in the recovery area was carried out according to AAP[19]/AAPD[20] sedation guidelines. Children were discharged to their parent(s) when they met the recommended discharge criteria as defined by the AAPD/AAP sedation guidelines. Total recovery time was recorded for each patient. The parent was contacted the day after the treatment appointment to determine if the child experienced vomiting, fever, pain, sleep disturbances, or any other unusual reactions postoperatively.

Data analysis: Descriptive characteristics for all subjects were calculated and summarized into three age groups: 36 months or less, 37-60 months, and 61 months or older. These age groups were chosen because, practically speaking, each age group presents unique behavioral problems to the dental team. Subjects were also distributed to one of five weight groups: 15 kg or less, 16-20 kg, 21-25 kg, 26-30 kg, 31 kg, or more. These groupings were selected because it was expected that smaller and younger children may have required higher dosages of sedative medications to achieve sedation levels equivalent to those in older, heavier children. Physiologic measurements, drug dosages, and behavioral responses were also summarized and these data were compared statistically on the basis of weight.

The mean for each physiologic value by weight category was calculated at 5 minute intervals and plotted over time (graphs not shown). Mean dosage and standard deviation for midazolam, nalbuphine, droperidol, and lidocaine were calculated for each weight category and compared statistically. One

Table 1. Descriptive Characteristics for Children Participating in Study				
	Less than 36 months	37 to 60 months	61 months or older	Mean ($\pm$SD)
Number of children	11	58	84	153
Weight (kg)	14 ($\pm$2)	16 ($\pm$2)	25 ($\pm$7)	21 ($\pm$7)
Preoperative systolic blood pressure	102	98	101	103
Preoperative diastolic blood pressure	55	51	55	60
Preoperative heart rate	126	108	99	97
Treatment time (min)	34 ($\pm$21)	63 ($\pm$23)	58 ($\pm$27)	58 ($\pm$26)
Recovery time to discharge (min)	50 ($\pm$18)	56 ($\pm$24)	65 ($\pm$31)	61 ($\pm$28)

way Analysis of Variance (Student-Newman-Keuls test) was used to determine the statistical significance of differences between these groups.

Results

From a pool of 446 eligible patients who had received treatment under IV sedation in the study time period, 153 children with an age range of 23 months to 14.5 years met the enrollment criteria. Dental treatment was provided by the same pediatric dentist (ARM) and the same RN monitored and recorded all vital signs and recovered each patient. The sedation regimen employed was successful in producing compliant and relaxed behavior in all children so that dental treatment could be completed successfully. There were no failures in the sedation technique which prevented treatment or required the operator to abort treatment. Procedures completed included intra- and extra-coronal restorations in primary and permanent teeth, pediatric pulp therapy, dental extractions, and in several cases, placement of immediate space maintainers. All necessary restorative and surgical dental treatment was completed for each child enrolled in the study.

Table 1 shows the characteristics for the sample population according to age categories. One-hunderd and forty children were classified as ASA 1 and 13 children as ASA 2. All 13 ASA 2 children were well-controlled asthmatics whose physicians completed preoperative physical examinations and cleared their participation in the study. Tonsil and adenoid assessments for 121 children were within normal limits, with the tonsils occupying 25% or less of the oropharyngeal volume. In 21 children, the tonsils occupied 25-50% of the oropharyngeal volume and in 13 children more than 50%. Preoperative mean values for weight, heart rate and blood pressure, total treatment time, and recovery time are presented for each age group in Table 1.

All children were sedated at a level which was judged by the principal investigator and monitoring nurse to be either acceptable or optimal (at a level that the planned procedures could be performed to the pediatric dentist's and parents' satisfaction). The target sedation level (level 2 or 3 as defined by the AAPD[20] Sedation Guidelines) was attained for each child. Table 2 summarizes the behavior ratings during treatment for each age group. Children in each age category were quiet and relaxed for 85% or more of the entire appointment time. Crying behavior alone occurred more often in the younger age group. Struggling behavior without crying was more evident in the oldest age group. A combination of crying and struggling was most evident in children 37-60 months of age. The differences between groups were small and hence these data were not subjected to statistical analysis.

There were no episodes of hypoxia (defined as Sp02 less than 90%), which occurred in isolation from uncooperative behaviors in any child. Sp02 values below 90 were always associated with either crying or struggling behaviors alone or together in response to a painful stimulus such as local anesthetic administration, placement of rubber dam, dental extraction, or when the sedation level had lightened to a point where the child became reactive. When this occurred, the stimulus was removed and the sedation level evaluated to determine if administration of additional sedative medications was required. In each instance, oxygen saturations recovered to acceptable values. No intraoperative vomiting, hypotension, bradycardia or respiratory depression requiring respiratory support was noted during treatment or in the recovery period. There were no episodes of dysphoria or agitation postoperatively. There was no requirement to reverse the sedation for any child during the study because of adverse respiratory events.

Table 3 shows data for dosages of the sedative medications and local anesthetic which were administered in this study.

Table 2. Behavior during Treatment (The Ohio State University Behavior Rating Scale)			
Observed Behavior During Treatment	36 Mos. or Younger (% time behavior observed)	37-60 Mos. (% time behavior observed)	61 Mos. or Older (% time behavior observed)
Quiet, no movement	86	88	91
Crying, no movement	9	5	1
Struggling*, no crying	1	3	7
Struggling and crying	3	4	1

*Struggling defined as repetitive movement of the feet, legs, arms, or head and postural flexing of the trunk.

Table 3. Dosages of Sedative Medications and Local Anesthetic Administered to Children According to Weight

Weight (kg)	N	Midazolam (mg/kg)			Nalbuphine (mg/kg)			Droperidol (μg/kg)			Lidocaine (mg/kg)		
		Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
<15	33	0.32•	0.16	0.07-0.67	0.32•	0.08	0.20-0.53	42	9	10-50	4.4•	1.6	1.2-7.7
16-20	55	0.29•	0.14	0.06-0.65	0.29•	0.11	0.20-0.71	44	7	8-50	4.0•	0.9	1.2-6.4
21-25	36	0.21	0.14	0.10-0.72	0.21	0.06	0.16-0.38	47	6	10-50	3.0	0.7	0.8-4.2
26-30	15	0.18	0.12	0.03-0.44	0.24	0.09	0.13-0.37	49	8	14-60	2.3	0.8	1.0-3.7
>31	14	0.14	0.06	0.02-0.40	0.19	0.08	0.11-0.34	51	7	8-60	1.7	0.8	0.7-2.9

•Significantly different from other weight groups (*P*<0.001 ANOVA).

Analysis of these data found that children under 20 kg received significantly higher dosages of midazolam, nalbuphine, and lidocaine than children who weighed more than 20 kg (*P*<0.001).

Although physiologic responses of subjects were plotted for each weight group, data are not shown for any group because the changes over time were minor and each physiologic variable remained within normal limits during the course of treatment. However, of all the physiologic variables measured, heart rate and blood pressure showed the greatest variation for each group of children over time. These variations coincided with application of a painful stimulus such as injection of local anesthetic, placement of rubber dam, extraction of teeth, and, oddly, flossing of teeth after placement of restorations to remove excess cement or to burnish amalgam surfaces. In contrast, there was a slight downward trend in arterial oxygen saturation during treatment for children under 20 kg. These changes were neither clinically nor statistically significant. There were no cardiac arrhythmias detected in any child during treatment, the period of time during which each child was monitored with the electrocardiograph.

Although capnography was utilized to monitor respiratory rate during treatment, values for carbon dioxide concentrations in expired air have not been included. These values reflect end-tidal CO_2 concentrations when a child is sleeping and quiet. However, when a child is crying or struggling, as occurred for many children at various intervals during treatment, the absolute values are not useful because of inaccuracies in sampling.[35,36] The primary use of the capnograph was to measure respiratory rate and to assess the waveform exhibited on the monitor when children were quiet or sleeping in order to detect airway obstruction.[36]

Recovery times were somewhat longer than those expected with an oral sedation regimen. Seventy percent of the children (107) required 60 minutes or less to meet the discharge criteria. The remaining 46 children were discharged between 60 and 120 minutes after treatment was completed. In the postoperative period, 4 children had one episode each of vomiting. Eight children who exhibited prolonged crying postoperatively received elective administration of 0.01 mg/kg of flumazenil.[37] Flumazenil was administered so that the RN and parent could communicate with each child and settle them. In each case, the child settled once the parent was able to communicate effectively with them.

Follow-up telephone calls were made to the homes of all patients the day after treatment. The frequency of vomiting and nausea, possible dysphoric reactions, sleep disturbances, fever, and pain were documented. Six children experienced episodes of vomiting at home. None of these children required hospitalization. Most children required ibuprofen or acetaminophen for either fever or pain related to their dental treatment. There were no reports of children experiencing sleep disturbances.

Discussion

The results of this study show that the intravenous sedation regimen used was successful and safely administered for all of the patients treated. Moreover, there were no adverse events which required termination of treatment or administration of emergency medications. At various times in the treatment appointment for each child, more sedative medications were administered because the child's behavior became increasingly uncooperative. If a child began to struggle, more midazolam was given because of its anxiolytic property.[38] If the child appeared to be experiencing pain, treatment was stopped while the child was examined for the signs and symptoms of local anesthesia. Occasionally, more local anesthesia was required. In some cases, additional nalbuphine was also administered when a painful procedure was about to be completed. Although flumazenil and naloxone were available at the chairside in the event the child experienced significant respiratory depression, neither were required intra-operatively. Drug selection for an intravenous sedation technique requires careful consideration and the rationale for selection of the drugs used in this study follows.

Midazolam is now the most widely used benzodiazepine for pediatric sedation. It has important advantages over other benzodiazepines, including a rapid onset, shorter duration of action and water-solubility making injection less irritating.[38] The pharmacokinetic profile of midazolam differs from diazepam in that it has shorter distribution and elimination half-lives and its biotransformation leads to no significantly active metabolite.[38] When administered intravenously, it has a distribution half-life of 6-15 minutes and an elimination half-life of 1.7-2.6 hours in adults[39] but only 45-60 minutes in children.[38,40] Midazolam has been shown to have anxiolytic,[24,41] sedative,[2,15,26] anticonvulsant,[39] muscle relaxant,[25] and anterograde amnesic effects.[7,39] Careful titration of small doses of midazolam have largely eliminated early reports that midazolam was associated with respiratory depression and apnea.[2] Because of its many positive attributes, its wide safety margin, and the availability of a safe and effective reversal agent, flumazenil,[37] midazolam has become a primary agent in intravenous sedative regimens in pediatric medicine.

Nalbuphine is a semi-synthetic, agonist-antagonist opioid analgesic agent with analgesic potency comparable to morphine in doses of 10 mg or less.[42] Although this drug has been used in dentistry for adults, this is the first report of its use in pediatric dentistry. This drug is structurally related to the opiate receptor antagonist, naloxone, and the opiate receptor agonist oxymorphone. Nalbuphine exhibits partial agonist activity at κ and σ receptors and antagonist activity at μ receptors. Nalbuphine produces respiratory depression to the same degree as equianalgesic doses of morphine. However, nalbuphine exhibits a ceiling effect, such that increases in doses beyond 30 mg produce no further respiratory depression. Nalbuphine has also been reported to have a decreased tendency to produce nausea, vomiting, and psychomimetic effects when compared with morphine[43] and meperidine.[45] Jaillon et al.[49] reported the elimination half-life of nalbuphine in children under 8 years of age to be 52 minutes. This was statistically significantly shorter than the elimination half-life in young adults (114 minutes) and the elderly (138 minutes). This attribute makes nalbuphine a good choice for intravenous sedation in children since recovery will not be delayed.

Combinations of a benzodiazepine and an opioid have been found to produce effective and reliable sedation for short and painful procedures in pediatric medicine.[27] However, when used for sedation, combinations of a benzodiazepine and opioid can cause significant respiratory depression. Recent studies have shown that concomitant use of an opioid decreased the dosage requirements for the titration of midazolam.[46] Although fentanyl and its analogues are frequently used in combination with midazolam,[46] nalbuphine was selected because of reports describing the development of intercostal muscle rigidity when fentanyl is used in the presence of nitrous oxide.[47] The use of 50% nitrous oxide in an oral sedation technique has been shown to result in less crying and struggling and more quiet behaviors than when oxygen only was administered,[8] and, for this reason, it was included in the sedation regimen.

Concern about emesis, and the need to prevent it, has arisen because the optimal duration of fasting prior to surgery in children is still controversial. Recent studies suggest that clear liquids may be safely ingested up to two hours prior to anesthesia in healthy children.[48] A major factor in preventing aspiration is the maintenance of the state of conscious sedation, so that the patients may cough and clear their airway on command. Because the boundary between conscious sedation and deeper levels of sedation may be difficult to define in practice and varies among individual patients, in our view, it is a judicious practice to require pre-procedure nothing-by-mouth guidelines and to administer an anti-emetic medication. Droperidol is a butyrophenone neuroleptic and was chosen for inclusion in this regimen because of its well known antiemetic properties.[49,50] The antiemetic action of droperidol occurs as a result of competitive antagonism of dopamine at D2 receptors. The antiemetic effectiveness of droperidol has been studied in children who have undergone strabismus surgery,[51] adenoidectomy, and tonsillectomy.[52] Effective antiemesis has been shown with dosages of 0.050-0.075 mg/kg. Droperidol is short-acting with an elimination half-life of 101.5 minutes.[50] However, its antiemetic activity is prolonged, which may occur as a result of slow equilibration with binding sites. Additionally, it is possible that metabolites of droperidol have some antiemetic activity also.

Several studies have shown that children frequently require higher dosages of medication to achieve sedation levels comparable to those in adults who received lower dosages, and this study is in agreement with these reports. Tolia et al.[53] prospectively evaluated the pharmacokinetics of midazolam in children who underwent upper gastrointestinal endoscopy and concluded that children require larger doses because the drug is metabolized and excreted more rapidly than in adults. Although the dosages of midazolam which were administered in this study were higher than those administered intravenously in other studies,[21-26] the mean doses of 0.32 mg/kg for children under 15 kg and 0.29 mg/kg for children who weighed 16-20 kg are comparable to those used in studies by Gremse et al.[54] and Tolia et al.[53] of children who underwent gastrointestinal endoscopy. Our results also agree with those of Gremse et al.[54] which showed that an intravenous dose of 0.3 mg/kg of midazolam did not result in a higher incidence of adverse sedation events than in children who received less than 0.3 mg/kg. Similar observations regarding opiate dosages in children versus adults have also been made. In children who underwent upper gastrointestinal endoscopy, Chuang et al.[23] administered a mean total dose of meperidine of 1.5 mg/kg, whereas Andurs et al.,[55] performing the same procedure on adults, required only 0.8 mg/kg to achieve similar sedation outcomes. There are no comparable dosage data for nalbuphine in adults versus children undergoing surgical procedures.

Oral sedation studies, which have utilized various behavior rating scales to assess the behavioral response of children in order to determine if the sedation regimen was successful, have reported a 20-40% failure rate.[6,8,33] In this study, the sedation level and child's behavior were assessed continuously and the observations recorded at 5 minute intervals throughout the duration of treatment. If disruptive behavior was observed, it was categorized and recorded and the dental team was able to administer more sedative medication intravenously, thereby allowing treatment to continue. The use of both a restraining device and head positioning device helped to minimize the disruption caused by struggling behaviors. However, the ability to administer more sedative medication intraoperatively to reduce disruptive behaviors or control pain, is an important advantage of intravenous sedation.

Verifying the level of sedation throughout a sedation appointment is an important safety measure. In this study, although many children appeared to be asleep, most children actively vocalized, cried, and/or struggled when local anesthesia was administered, the rubber dam was either initially placed or, on removal, the slow and highspeed handpieces were used to complete tooth preparations. These sensations were sufficiently strong to provoke a purposeful response even though the children had been non-reactive only seconds previously when the same teeth were being prepared under rubber dam. These responses, as defined in the AAPD sedation guidelines,[20] were a more reliable method to assess depth of sedation than asking the child to "open your eyes," a command which frequently received no response. The coupling of physiologic data and behavioral responses allowed for an accurate determination of the level of sedation for each child, at any time during the sedation appointment.

The importance of presedation screening should also not be overlooked. Not all children are candidates for intravenous sedation. Presedation screening allows the responsible practi-

tioner to determine with greater certainty which children might encounter difficulties during or following sedation. Patients with intrinsic or extrinsic airway abnormalities that may increase the risk of obstruction or make it difficult to produce adequate mask ventilation will not be suitable candidates for intravenous sedation. Furthermore, patients with other systemic disorders such that they would be rated as ASA 3 or higher are not suitable candidates for this sedation technique.

Recovery times were somewhat longer than what would be expected following an oral sedation technique. There are several reasons for this. Children who remained in the office for more than one hour postoperatively were those who were sedated to level 3, a deeper level of sedation than that which is often achieved with most oral sedation techniques. Secondly, AAPD/AAP recovery criteria were applied rigorously, in particular, the criterion that children leave the office as close as possible to the preoperative level of alertness. This delayed discharge for many children and is the primary reason that recovery times were also long. In practical terms, long recovery times in a private office setting may complicate or impede the delivery of care to other children because there is insufficient space into which sedated patients can be placed to recover or because staff are preoccupied with sedated patients. A dedicated recovery space, equipped to AAPD/AAP guidelines, and a recovery room RN were available in the office. Obviously, dedicating space and staff will impact on the cost to provide this type of sedation. However, completing all treatment in one appointment and working at an increased pace as a result of improved patient behavior improved staff efficiency and compensated for the costs associated with the sedation program. In addition, fees for sedation services should be structured to account for both the physical and staffing requirements as outlined in the AAPD/AAP sedation guidelines as well as the responsibility and skill which the dental team must possess.

As this was a pilot investigation, no control group was included. Although this may appear to limit the value of the results, this study has shown that the technique was used safely and successfully with children across a wide age range, applied to a wide variety of treatment requirements (from simple to complex), and individualized for each patient at any point during the treatment appointment, unlike other enteral sedation techniques. Future research will be undertaken to compare the behavioral and physiological responses of children who have received different sedative medications administered intravenously.

Conclusion

The multi-drug intravenous conscious sedation technique presented in this paper is a safe and effective method to control the behavior of uncooperative children who require comprehensive dental treatment.

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