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Dental Sedation in Children

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Abstract Dental caries, a common ailment in children, often requires sedation. A majority of these sedations are provided by the dentist and take place in their offices. Dentists undergo training to deliver moderate sedation. The American Academy of Pediatric Dentists has published guidelines and policies for dentists who administer sedation and anesthesia in their offices. Oral sedation is the most common sedation technique used for dental caries, historically in the form of a "cocktail." However, safety concerns of the "cocktail" combined with the improved safety and efficacy of midazolam have shifted the sedation regimen toward midazolam. The intranasal route for moderate sedation is used increasingly in dental sedation. An anesthesiologist may provide moderate or deep IV sedation or general anesthesia in the office. Hospital-based anesthesia is also used, but access and cost restrict its use. Sedation is an important service, but patient safety always comes first.

Keywords Moderate sedation · Deep sedation · General anesthesia · Midazolam · Intranasal

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Introduction

Among children, the prevalence of tooth decay (dental caries disease) in primary teeth is high. The incidence in 2–5-year-old children is greater than 25 % [1]. Risk factors include minority children, poor families, and chronic illness [2]. The cost for this decay can be very high with respect to pain and infections. Dental caries in children, especially if untreated, can predispose them to significant oral and systemic problems including eating difficulties, altered speech, loss of tooth structure or tooth loss, inadequate tooth function, unsightly appearance and poor self-esteem, infection, difficulties concentrating and learning, and missed school days. There is also a significant financial cost in terms of the cost of operative rather than preventative care [3].

A child with extensive dental caries disease requires that all the carious lesions are treated to prevent progression of the disease [4] as well as the appropriate behavioral modifications required to prevent recurrence, such as modifications in oral hygiene procedures and dietary habits.

Children with extensive dental disease or those with dental anxiety presenting as uncooperative behavior during dental care may require some form of behavior modification therapy for the restorative work to be completed satisfactorily without general anesthesia. There are several different modes that the dentist can employ to facilitate the required dental care from distraction therapies (TV in operatory), nitrous oxide and moderate sedation to deep sedation and general anesthesia performed either in the dental office, ambulatory surgery center or a hospital setting. Complicating these choices is the substantial geographical difference in the availability of operating room access for pediatric dentists.

One of the more difficult aspects of treating these children is assessing which modality of behavior modification is most appropriate for each child. It is neither necessary nor reasonable to provide general anesthesia for all of these children. Most pediatric dentists use a behavior assessment, the Frankl score, [5] to stratify the child's behavior in the office as part of the decision-making plan for the best intervention for each child. The scale (Table 1) divides observed behavior into four categories, ranging from definitely positive to definitely negative. Table 1 provides a description of the Frankl score.

Although the Frankl classification has been a popular research tool, a shorthand form of the scale proved to be an effective clinical tool for recording children's behaviors in the dental office. One can identify those children who display a positive cooperative behavior by jotting down "+" or "++" or uncooperative behavior by jotting down "−" or "−−." One disadvantage of this scale is that it does not communicate sufficient clinical information regarding uncooperative children. If a child is judged as "−," the user of this classification system must qualify as well as categorize the reaction. By recording "−, tearful," a better description of the clinical problem is made.

In the dental setting, nitrous oxide is indicated primarily for behavior management for fearful, anxious, or difficult to control children. Other children who may benefit from the use of nitrous oxide include those with special healthcare needs and those with a hyperactive gag reflex that may interfere with the delivery of dental care. Nitrous oxide can also be beneficial in certain situations including lengthy dental procedures and instances in which it is difficult to obtain profound local anesthesia.

Up to 89 % of pediatric dentists offer minimal sedation with nitrous oxide/oxygen in their practices. In addition to substantially diminish anxiety in children, nitrous oxide also confers analgesia or an altered sensation of pain. Today's parents are more likely to request or expect a pharmacological management strategy for the child's pain or discomfort [6], although the child's best interest is paramount. Our concern with nitrous oxide is the environmental impact both locally for the office staff as well as globally. Intermittent nitrous oxide provides the same benefits as continuous administration [7]. In a review and of publications using nitrous oxide for sedation in children, the authors reported the many benefits of nitrous oxide for painful procedures in children, although when combined with other medications, specific risks and procedural sedation policies must be followed [8••].

Table 1 Frankl score [5]

Rating 1: definitely negative	Refusal of treatment, forceful crying, fearfulness, or any other overt evidence of extreme negativism
Rating 2: negative	Reluctance to accept treatment, uncooperativeness, some evidence of negative attitude but not pronounced (sullen, withdrawn)
Rating 3: positive	Acceptance of treatment; cautious behavior at times; willingness to comply with the dentist, at times with reservation, but patient follows the dentist's directions cooperatively
Rating 4: definitely positive	Good rapport with the dentist, interest in the dental procedures, laughter, and enjoyment

When delivering nitrous oxide, dentists use a double nasal mask system, to reduce the local pollution while maintaining access to the mouth. The nasal mask system has an incorporated scavenging system for the exhaled nitrous oxide [8••]. After dental procedures, 100 % oxygen should be administered for 3–5 min to preclude diffusion hypoxia in the children and occupational exposure by the dental team.

Training and Practice Credentials for Dental Sedation

Approximately, 10–20 % of all children who present for dental work require sedation because of their age, behavior, anxiety, lack of coping skills, or disabilities. Because of the large number of children who require sedation, the sedation is usually performed by pediatric dentists. The most common type of sedation used for this purpose is conscious sedation, which usually comprises nitrous oxide in combination with an oral sedative. Oral sedation offers many benefits when treating children and is an essential component to pediatric dental training [9]. To ensure a standard of care for sedation in children, conscious sedation is taught in every accredited pediatric dental postgraduate residency program.

Oral midazolam is the most common enteral sedative used in accredited postdoctoral residency programs, although most programs include three or four drugs for their oral sedation training. Anesthesiologists are involved in the teaching of sedation techniques in 91 % of pediatric dental residency programs.

The educational requirements to obtain a certification to practice oral sedation vary by state, but the ADA recommends a minimum of 24 h of didactic instruction combined with a minimum of 10 oral sedation cases and/or oral sedation/nitrous oxide inhalation cases [10]. If a dentist wishes to use the intranasal route for sedation, then most states require that they obtain a parenteral moderate sedation permit, which usually requires 60 h of didactic instruction and the management of 20 patients with intravenous sedation.

AAPD Recommendations for Anesthesia Services

If dentists wish to use the anesthesia services provided by another practitioner, the AAPD has recommendations for dentists who wish to provide deep sedation or general anesthesia in an office or hospital setting [11]. In addition to being trained in medical emergencies, the provider performing the deep sedation or general anesthesia services must be licensed to administer anesthesia. This provider must have completed an ADA-approved dental anesthesia or AMA-approved medical anesthesia residency program or equivalent, which is an additional 1–2 years of training.

Some states allow a certified registered nurse anesthetist or anesthesia assistant to work under the supervision of a dentist, but in this case the dentist must also be trained and licensed appropriately under state laws. Many dentists use dental anesthesiologists, these are providers who have completed an accredited postdoctoral anesthesiology residency training program for dentists, which included 2–3 years of additional training. However, dental anesthesiology is not recognized as a dental speciality by the American Dental Association.

Oral Sedation

The most commonly used single oral sedation agent is midazolam, which has an excellent safety record. As such oral midazolam is a commonly utilized sedation agent in pediatric dentistry because of its margin of safety, efficacy, rapid onset and recovery, and anxiolytic and amnestic properties [12]. The availability of a reversal agent for midazolam, flumazenil, is also a benefit in an emergency situation [13]. Although respiratory depression may be a side effect of midazolam, the doses commonly used for dental sedation in children, 0.25–1.0 mg/kg, have limited effects on ventilation and oxygen saturation [14]. These doses produce the desired degree of sedation and anxiolysis for conscious sedation in the dental setting. A dose of 0.75 mg/kg midazolam is more effective than 0.5 mg/kg for pediatric dental sedation procedures without producing side effects. There were fewer cases of under-sedation, no over-sedation and parental assessments scores were better for the larger dose [15•]. This is particularly important since many pediatric dentists use a polypharmacy regimen for sedation after claims that the smaller doses of oral midazolam, 0.5 mg/kg, may not be effective.

Several studies have examined the impact of the liquid vehicle for oral midazolam. Commonly used vehicles are flavored to overcome the bitter aftertaste of oral midazolam, whose pH is about 2 [16]. Although most children do not drink grapefruit juice, this vehicle is known to inhibit CYP450 3A4 metabolic pathway, so that the max blood concentration of midazolam may be twice that predicted [17]. In contrast, pomegranate juice has no significant effect on the metabolism of midazolam [18]. If citrate is added to the vehicle, the midazolam is well tolerated and has a better clinical effect than using Pepsi Cola, grapefruit, or pomegranate juice. This may be explained by the buffering effect on the pH so that more of the midazolam was in a lipophilic form and more effectively absorbed [19].

Midazolam although used orally has absorption kinetics that are very variable in children. The bioavailability of oral midazolam is approximately 36 %, with a range between 9 and 71 %. The maximum drug concentration is proportional to the dose administered. The elimination characteristics were similar between doses of 0.2 and 1 mg/kg [20]. The time to peak midazolam concentration is 50–60 min [21], although the peak clinical effect is much more rapid. The elimination half-life is between 1.7 and 4 h.

The variability in the pharmacokinetic variables of oral midazolam imparts a degree of unpredictability in the clinical outcome from a fixed-dosed sedation regimen. This may be responsible in part, for the failure rate of most oral sedation regimens, which must have a built in safety factor. Titrating oral sedation to effect is generally not practical.

The use of multiple triple sedative regimens was once common practice in pediatric sedation. This ceased after reports of serious cardio-respiratory events occurred from excessive sedation and hypoventilation [22]. The use of these "cocktails" is unfortunately still common in pediatric dental practice. An example of a popular sedative combination in pediatric dentistry consists of a cocktail of meperidine, hydroxyzine, and chloral hydrate [23]. Hydroxyzine (Vistaril) is an antihistamine with some anxiolytic properties that are a common additive to other sedative regimes. Although the behavioral outcomes with this combination are positive, recent concerns regarding potential carcinogenesis after chloral hydrate [24, 25] have led pediatric dentists to seek alternate regimens. Additional adverse responses to chloral hydrate have included laryngospasm, cardiac arrhythmias, cardiac arrest, and seizures, which raised safety concerns with the drug [22]. With cumulative adverse events mounting, chloral hydrate ceased to be manufactured in the United States in 2012, and will completely disappear soon once the drug stockpile is exhausted.

There are several issues with the use of a "triple cocktail" for sedation. First, the depth of sedation is often greater than recommended for moderate sedation, resulting in concerns and reports of respiratory complications. Furthermore, the elimination half-lives of chloral hydrate, 8–10 h [26] and hydroxyzine, 9–20 h, markedly exceed that of midazolam [27].

Two recent studies identified the increased risks of post-sedation complications after these long-acting drugs [23, 26]. The greater elimination half-lives of chloral hydrate and hydroxyzine increased somnolence in children after the procedure, which is a concern after the children are discharged from the office [23]. Large doses of chloral hydrate (75–100 mg/kg) have been associated with post-discharge adverse events in children having dental sedation, whereas large doses of oral midazolam (1–1.5 mg/kg) have not suffered similar consequences. This is a particular concern in young infants and children who may fall asleep in the car safety seats during the drive home from the procedure, and as their heads tilt downward their airways may became obstructed leading to a hypoxic event. Midazolam appears to be a safer choice than these long-acting sedatives as post-procedural somnolence has not been a feature [28•].

Substituting midazolam for chloral hydrate in the triple regimen significantly decreases the number of episodes of oxygen desaturation without affecting the quality of the sedation [26]. Furthermore, using midazolam affords the dentists the option to reverse the sedation if problems arise. A recent [29] review of polypharmacy sedation raised concerns about changes in behavior after midazolam was used. Children who received oral midazolam were less sleepy than those who received chloral hydrate, as several of the latter were difficult to arouse at home, a concern for many parents. There was some evidence that children who received midazolam had more ataxia than those who received chloral hydrate. These were multi-agent studies that evaluated the synergistic effects that can occur with these medications, effects that may not be apparent with a single agent sedation technique.

There are several other sedation regimens that have been investigated recently. Three different doses of oral dexmedetomidine (3, 4, 5 mcg/kg) an alpha$_2$ sedative agent were compared with oral ketamine (8 mg/kg) for pediatric dental sedation procedures [30]. The onset time for the ketamine and large dose dexmedetomidine was similar about 20 min, both also had a significantly greater discharge time of over 100 min. However, the success of the sedation was poor as only 50 % were adequately sedated with ketamine and the low dose of dexmedetomidine. Thus, as a single agent, oral dexmedetomidine appears to be superior to ketamine, but requires a large dose that will add a substantial cost to the sedation process. A 200 mcg vial of dexmedetomidine costs about $80 US. A less costly option is to use low dose ketamine (5 mg/kg) and diazepam (0.2 mg/kg). With these agents, the success was about 80 % with an onset time similar to the ketamine alone patients. There were no adverse recovery room episodes noted, which may have been the result of the concurrent use of diazepam. The long half-life of diazepam (24 h) could have affected the time to discharge, although that was not noted in the report [31].

Buccal Sedation

When the child is too uncooperative to swallow an oral premedication, alternative strategies are required to achieve adequate sedation. A variety of alternate buccal sedation approaches may be considered.

Submucosal injection of a sedative is a useful technique with some drawbacks. If the child exhibits signs of needle-phobia, administration may be difficult. The sedative is usually administered in the buccal vestibule between the first and second primary molars. This route of administration does not allow for titration and is often unpredictable. The drug most commonly used for this approach is meperidine. When comparing submucosal (0.5 mg/kg) to oral meperidine (2 mg/kg), both with oral hydroxyzine (1 mg/kg), there was no benefit to the buccal approach [32]. Topical lidocaine 5 % may be used before injection into the buccal mucosa. Neither the onset times nor the discharge times were reported.

The most common clinical route for buccal sedation is the intranasal approach. Numerous publications have exploited this approach for pediatric sedation. Intranasal sedation is useful because of its ease of administration and success with children who resist other routes. Administration of a sedative by an intranasal route has a rapid onset of action and is especially effective with medications that have a fast onset and relatively brief duration of action. The use of the intranasal approach bypasses first pass metabolism in the liver and thus allows for a greater bioavailability of the sedative medication.

Four drugs have been the focus of multiple reports for intranasal sedation: midazolam, sufentanil, dexmedetomidine, and ketamine. The mucosal aerosol device (MAD) is an aerosol device that attaches to any syringe to deliver accurate doses of a sedative intranasally. The MAD has a luer lock and a soft cone to allow comfortable placement of the syringe into the nares.

Midazolam is the sedative most commonly delivered intranasally. It has a quick onset time of about 10 min with a bioavailability of about 60 % [33]. The intranasal dose varies between 0.2 and 0.7 mg/kg [14] either as a single agent or in combination with other sedatives. The major drawback to intranasal midazolam is the burning aftertaste in the nasopharynx in approximately 50 % of children in whom it is given. The low pH (2.0) [16] often causes the children to cry due to the nasopharyngeal pain and burning, as well as a variety of other symptoms including coughing, sneezing, and runny eyes. Intranasal citrate has been used as a model for intranasal midazolam in volunteers, pre-dosing the nares with lidocaine, or mixing lidocaine with the citrate to reduce the discomfort [16]. Nasal pre-dosing with lidocaine has been shown to reduce the discomfort [34], although lidocaine itself gives a rather unpleasant taste.

The intranasal approach to sedation also lends itself to rapidly reversing the level of sedation if a problem arises without the need for IV access or any other specialized equipment. Intranasal flumazenil [35] achieves therapeutics blood levels in 2 min facilitating reversal of the effects of midazolam. Intranasal naloxone is now used routinely by many EMT's with a positive response in greater than 80 % of patients with suspected opioid overdoses [36]. A case report using both intranasal flumazenil and naloxone demonstrated efficacy in arousing a child and restoring normal respiration after sedation with intranasal benzodiazepine and opioids [13].

Dexmedetomidine has also been shown to be effective for intranasal sedation. With a bioavailability between 30 and 90 %, peak blood levels are achieved after 40 min [37]. Intranasal dexmedetomidine has been compared with intranasal midazolam as a premedication for general anesthesia in children undergoing dental restoration. The former had a slower onset (25 min), but provided a deeper level of sedation and was more effective at facilitating a smooth inhalation induction than the latter [38]. Dexmedetomidine alone is an effective sedative, although the child will arouse if a painful stimulus is applied [39••]. To avoid arousal, the combination of intranasal dexmedetomidine (2 mcg/kg) and intranasal sufentanil (1 mcg/kg) yielded a high success rate and a greater duration of moderate sedation [39••]. The maximum doses given in this study were 40 and 20 mcg, respectively, for a child weighing 20 kg. This accounts for the increased sedation requirements in younger children. Intranasal dexmedetomidine was also well tolerated, with no apparent discomfort during administration. The onset of sedation was slow, taking about 45 min and even longer to achieve its full effect. This allowed for more extensive procedures to be completed up to an hour in duration, compared with midazolam, which provides for about 30 min of procedural sedation. When a potent opioid such as sufentanil is administered intranasally, in doses between 1 and 4.5 mcg/kg, there are no local irritation issues as it is painless [40]. However, apnea and chest wall rigidity remain serious concerns. The routine use of capnography is recommended when using potent intranasal opioids. Sufentanil (1–2 mcg/kg) has been used for both premedication as well as for procedural sedation. Larger doses (2–3 mcg/kg) have been associated with hemoglobin desaturation when administered concomitantly with other sedatives. The use of intranasal opioids increases the risk of nausea and vomiting [40]. Sublingual ondansetron, 8 mg [41] may be required to prevent or treat these side effects.

Ketamine has also been administered intranasally for sedation. The method of intranasal drug administration, by the droplet or aerosol method, may affect the efficacy. When ketamine was compared between a droplet method and aerosolization using the MAD device, the quality of the sedation was no different [42]. At a dose of 6 mg/kg intranasal ketamine, the onset of sedation occurred within 10 min in both groups. Children who received intranasal ketamine found the spray to be a more acceptable delivery technique than droplets [42]. Vomiting has been reported after ketamine when it is administered orally or intranasally. In a comparison of ketamine, midazolam and dexmedetomidine for dental sedation, all three provided effective sedation. However, intranasal dexmedetomidine had a slow onset of action as well as recovery but provided analgesia, whereas midazolam was painful and provided no pain relief [43].

An alternative approach to the intranasal route of administration is the buccal spray. This has been reported as an alternative to submucosal injection. Midazolam (0.3 mg/kg) was given by a commercially available (INSED) buccal spray to children with a Frankl score of − or −− [44]. The spray administered orally, was well tolerated by the majority of the children, with the onset of sedation in less than 10 min. Most procedures were completed successfully. When the buccal spray was compared with intranasal midazolam administration [45], the success rates for 0.25 mg/kg with both techniques were similar, although the buccal spray was much better tolerated than the intranasal route.

Another approach for improving the success rate of the sedation relates to changing the concentration of the midazolam solution. For intranasal medications, the optimal dosing volume is between 0.2 and 0.4 ml. Midazolam used for intranasal sedation is usually the intravenous preparation in a 5 mg/ml formulation. If the prescribed dose is 0.2 mg/kg or greater, then the volume used may exceed 1 ml. Even when divided between the nares this is too large a volume. Furthermore, accessing the nares to deliver the second dose of midazolam may be difficult because of the child's pain, restlessness, and lack of cooperation associated with the first dose. [46]. A preparation of midazolam 20 mg/ml with lidocaine 1 % has been used (mixture of 40 mg/ml midazolam and 2 % lidocaine). This combination appeared effective, although more than 40 % exhibited side effects from midazolam administration even with the smaller volumes and added lidocaine.

IV Sedation

If moderate oral or intranasal sedation is not effective or not provided by the dentist, then IV sedation may be an option. Several recent reviews of the utilization of IV and deep sedation in the dental office have been published [47]. A minority of dentists provide their own IV sedation, with about 25 % of pediatric dentists employing an IV sedation service in their office, usually dental anesthesiologists. It would appear that if there were more readily available anesthesiology services for dentists, this service would be utilized far more frequently.

Pediatric dentists who use an IV sedation service [48•] have found by utilizing an IV sedation in their office, they do fewer procedures using both office-based oral moderate sedation as well as hospital-based general anesthesia. The reduced cost of office-based IV sedation compared with hospital-based sedation is an important aspect of this trend; however, for some parents, the out of pocket cost of the office IV sedation limits it utility.

Propofol is a common choice for office IV sedation. It is effective and safe for moderate sedation [49]. However, moderate sedation has limited success in young children for painful procedures such as those found during dental procedures. With sedation more likely to be successful if it is deep, deep sedation is more commonly used [47]. As with oral and intranasal sedation, there are many different options available for the sedationist providing deep sedation. The combination of ketamine with propofol has been suggested by some to be safer than propofol alone. In a study that compared propofol 1.5 mg/kg to ketofol (1 mg/kg propofol/0.25 mg/kg ketamine), propofol proved to be safer than the combination [50•]. Children who received ketamine were more likely to have respiratory complications such as oxygen desaturations and laryngospasm. This supports the concept that ketamine is not without complications when utilized for deep sedation.

Dexmedetomidine as a sole agent has been reported in case report format for dental sedation in children [51]. In young adults, the combination of dexmedetomidine and fentanyl was more effective than a midazolam/fentanyl regiment [52]. The children who received dexmedetomidine had better sedation scores, a more prolonged period of postoperative analgesia, and were assessed to have a better quality of the sedation by the oral surgeon than midazolam/fentanyl.

In combination with ketamine, there are case reports of the use of dexmedetomidine in children with cyanotic heart disease to provide deep sedation. There were no untoward cardio-respiratory complications in this very small sample of patients [53].

General Anesthesia

For children who are extremely uncooperative, have large treatment plans or have failed some form of office sedation, general anesthesia, often in the hospital setting, is required. Chair dental anesthesia was often provided by anesthesiologists using halothane, although this combination was not without its risks. Sevoflurane is a much safer agent and may be used to provide an appropriate level of anesthesia in an office dental chair location [54]. Anesthesia was induced using a full facemask and then replaced with a nasal mask. It is understood that the delivery and monitoring of the sevoflurane were now inaccurate due to a large gas leak from the mouth. A scavenging system for this nasal mask sevoflurane delivery has been proposed [55]. This mask was effective in reducing the ambient levels of both nitrous oxide and sevoflurane to safe levels. The use of a laryngeal mask airway is appealing for any outpatient procedure, especially if it avoids the need for oral or nasal tracheal intubation. A comparison of nasal intubation to the use of a LMA in children for elective dental procedures [56] demonstrated fewer airway complications, reduced incidence of sore throat, nausea and vomiting, and a quicker recovery in the LMA groups when compared to tracheal intubation. The nature of the dental procedure was unclear, whether it was dental restorations of the front teeth, which usually requires an occlusal assessment that is very difficult to perform with an oral tube in place.

The BIS monitor is used in some institutions to ensure an adequate depth of anesthesia, facilitate a quicker turnover, and reduce anesthesia drug costs. When using a traditional to BIS-directed approach for dental surgery, the doses of propofol or midazolam were similar [57]. Complications and discharge times were also similar. However, the need for rescue remifentanil was significantly greater in the traditional group suggesting that there may be a benefit to using the BIS. However, the BIS has limited reliability in children <5 years of age.

Postoperative analgesia is an important aspect of all surgical procedures including dental. Many dentists use local anesthetics in combination with general anesthesia to manage perioperative pain. This may delay the administration of postoperative analgesia until after the child is discharged and the local anesthetic block has worn off. Preemptive analgesia is believed by some practitioners to be more effective than initial symptom-based treatment. Preoperative acetaminophen or ibuprofen resulted in better postoperative pain scores compared with a placebo for the first 24 h postoperatively after primary molar extractions, even when local anesthesia was used during the procedure [58]. However, one complication of the use of local anesthesia is that some children may bite their lip/gum as they wake up after anesthesia. This can result in a serious intraoral injury, especially in children who may have some form of cognitive deficit or behavior issues [59, 60]. Phentolamine is now approved (children >6 years) and available to inject after a procedure with local anesthesia has been completed to abbreviate the duration of action of the local anesthetic and avoid post-procedure injuries. Phentolamine rapidly removes lidocaine from the tissues by virtue of its vasodilatory properties, thereby dramatically reducing the duration of the block. For example, when phentolamine was injected after a lidocaine block in the gums, the duration of effect of the block was reduced from 120 to 30 min [61•].

Children who require anesthesia for dental restorations are often uncooperative. Children undergoing anesthesia may experience post-anesthesia behavior issues, delirium, or sleeping problems. These postoperative problems have been described in dental patients after sedation for dental procedures [62]. However, whether the incidence of postoperative problems is greater in this group of children who have behavior issues in the dental office compared with non-dental children has not been addressed. Postoperative cognitive dysfunction in children undergoing general anesthesia for dental restoration with either isoflurane or propofol was similar. Both groups experienced some degree of cognitive dysfunction that lasted up to 24 h post-procedure [63]. Parents should be made aware of the possibility of such dysfunction before the children are discharged home from the dental office.

Sedation and general anesthesia may mask the signs and symptoms of local anesthesia toxicity [64]. Toxicity may occur secondary to the local anesthetic such as in the case of methemoglobinemia. This is a particular concern in younger children who received benzocaine [65] or possibly prilocaine, due to an immature metabolite pathway. In children, peak methemoglobinemia concentrations of 3.6 % occur approximately 1 h after injection of 5 mg/kg prilocaine [66]. This was significantly greater than the concentration in those children who received 2.5 mg/kg of lidocaine (peak 1.6 %).

Nasal tracheal intubation is the standard airway management for children who require general anesthesia for dental sedation. One of the more common side effects of nasal intubation is bleeding, a problem that may be prevented by prophylactic use of a vasoconstrictor spray before tracheal intubation. Phenylephrine has been widely used in this regard, but as a result of anecdotal reports of severe hypertension and pulmonary edema, oxymetazoline has supplanted it. However, one child who received nasal oxymetazoline before nasotracheal intubation experienced a prolonged period of systemic hypertension that lasted more than 30 min, for which no other cause could be identified [67•]. On review of the usage pattern for the oxymetazoline, it was discovered that when spray was activated with the bottle in the upright position, an effort-independent volume of about 0.03 ml was delivered. However, if the bottle is turned upside down, then a constant stream of liquid was delivered that depended on the pressure applied when the bottle was squeezed. Another method that reduces the incidence of bleeding during nasal intubation is to telescope the nasotracheal tube into the wide flange of a red rubber catheter to guide the tracheal tube through the nasal passage [68]. This technique significantly reduces the incidence of bleeding and only slightly prolongs the time to complete tracheal intubation without causing desaturation.

Complications

One of the main concerns with dental sedation is the risk of serious complications. Two articles by Coté et al. demonstrated that the procedures in non-hospital facilities had a greater incidence of cardiac arrest and poor outcome [69]. In most circumstances, this was preceded by respiratory arrest. Lack of appropriate knowledge about the pharmacological agents used, the use of long half-life medications, medications given at home, and poor resuscitation technique all contributed to these pediatric sedation-related complication episodes. Sedation by dentists was found to be one of the risk factors. It is most important that dentists and any other practitioners who provide sedation follow the recommendations of the AAP, AAPD, and the ASA for the safety of the children [70]. A recent review of mortality associated with dental sedation and anesthesia [71] noted mortality occurred more often in the dental office setting. The involved children were younger, and a majority of office deaths was related to moderate sedation practice provided by dentists. The concerns noted were similar to those espoused by Coté with respect to inadequate knowledge of pharmacology and monitoring. The authors noted that the numbers captured in this study were incomplete and the real incidence of complications remains unknown at the present time. A growing trend in the pediatric population is obesity, rising at an alarming rate. This has resulted in concerns in adults and children with respect to the risks of general anesthesia, and what does it mean for children undergoing sedation? A review of obesity and complications from moderate sedation [72] retrospectively reviewed this issue. Children who were heavier or had a BMI >85 % predicted, tended to have more respiratory complications, nausea, and apnea; however, even in this review of 510 patients, none of these differences were significant. This may have been related to the limited ability to collect accurate data in a retrospective study.

Conclusions

The need for dental restorative care is great. There are many children who need some form of sedation to facilitate this care. The majority of this care is provided by dentists in their office using moderate sedation. There are many different methods to provide this care, although currently, oral midazolam is the safest regimen for providing moderate sedation. All graduates from pediatric dental residency programs are instructed in the moderate sedation. However, despite the presumed innate safety of moderate sedation when policies and practices are followed, reports of severe complications relating from failure in medical care persist. Children often do not respond well to painful procedures with moderate sedation, and deep sedation or general anesthesia is required. There are significant financial restrictions on the access for these forms of sedation. Also access to hospital facilities may be difficult and the dentists may have difficulty finding a cost-effective method of providing deep sedation care in their office depending on the renumeration models in place for their patients. Overall safety is paramount, pediatric anesthesiologists should be made available, so that these children may receive the care they require. However, this will require substantial changes in the political will of the associations involved.

Compliance with Ethics Guidelines

Conflict of Interest Christopher Heard and Carrie Wanamaker declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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