Oral Sedation for Dental Procedures in Children

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Preface

Dentists have been sedating children for dental procedures for decades using the oral route of drug administration. Oddly, there has never been a book specifically dedicated to addressing this modality of clinical practice. This is the first book devoted to the oral sedation of children in the dental office to facilitate their dental care. To provide such a work, it is imperative to carefully blend broad clinical expertise and timely knowledge from many fields in attending to the primal factors associated with the sedation process involving young children. The contributing authors are well-respected and recognized leaders, educators, clinicians, and researchers in the field of sedation and in their respective medical and dental disciplines.

Although the outcome of sedations can never be guaranteed nor the process of sedation precisely prescribed, the information contained within this book represents the latest evidenced-based practice and clinical expertise in approaching this goal. Clinicians who sedate children should find consistent and timely tips in this book to aid in guiding their care knowing that the oral route is the least predictable route of drug administration in terms of behavioral and physiological outcomes.

The book is divided into distinct chapters addressing the key elements necessary to consider and follow in attempting to provide safe sedation to youngsters for dental procedures. These include, among others, patient assessment, drug(s) selection, protocol steps, emergency management, and the most up-to-date guidelines. Each chapter focuses its relevant contents to match the specific and idiosyncratic concerns associated with the pediatric patient. It is my desire to provide this book to those who elect to sedate children, using the oral route of administration of sedatives, for dental procedures in the office with the hopes of fulfilling an obvious gap in available textbooks.

Cincinnati, OH, USA — Stephen Wilson, DMD, MA, PhD

Acknowledgments

I have been contemplating writing this book for over a decade. One of the reasons for imagining that this book should be written is because the study of sedation for dental procedures specifically in children has never been written to my knowledge. Furthermore, I have spent most of my professional career investigating this topic, teaching residents of its benefits and drawbacks, and performing sedations. Until now, I have never been able to find the time to write the book, without sacrificing other time that I so freely and happily dedicated to other professional activities, family and friends, and other personal interests. I knew, in the last couple of years, that I had to make the book happen or else it never would. And I wanted to share my passion for helping young and anxious children get through dental procedures with as little stress on their little lives as possible – at least that they might recall. So, I stole the hours from my family, friends, and colleagues to finally produce this book.

I want to especially thank my family (Julia, my dearest friend and wife, and Jeff, my only son of whom I am most proud) and a host of residents and colleagues for their time, supportive criticism, encouragement, advice, and their patience. I also want to express my deepest heartfelt gratitude to my father who left my life (passed away) when I was a young man, but during my formative years always instilled the drive and desire to be the best in what I do to the best of my abilities. Of course, my mother provided the love and support during the daily proddings of my father's encouragement.

To my coauthors who are my friends, outstanding teachers, scholars, and excellent clinicians in their own right, I express my strongest gratitude for their assistance and contributions to the writing of this book.

I also want to acknowledge the efforts of Mariah Gumpert of Springer who aided me in the writing of the manuscripts and production of the book.

Most of all, I thank all of the children with whom I have interacted during their sedations and who have been my teachers in understanding how sedation affects their brief sedated moments while enduring dentistry with the goal, in the long run, of aiding their oral health conditions.

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Introduction

1

Stephen Wilson

Abstract

Invasive dental procedures with its barrage of instrumentation, smells, sounds, and reputation are often considered as one of the most anxiety-producing events in our society. The behavior of children in the dental setting during these procedures is interesting and often tricky for the clinical team. Most children are easily managed with behavioral guidance techniques and parental support. Some will require pharmacological management to endure the procedures. Pharmacological management is a continuum ranging from mild anxiolysis to general anesthesia. Many children undergoing invasive dental procedures will be managed with agents that produce mild, moderate, or deep sedation which represents a portion of this pharmacological continuum. The oral route of drug administration is the most popular and frequently used for sedating children in the dental operatory. Safe sedation requires appropriate training of the clinician and his/her understanding and adherence to clinical guidelines. This chapter introduces the concept of sedation of children for dental procedures as well as sets the tenor of the rest of this book.

Dental caries occurs in our society despite preventive interventions that could theoretically eliminate its occurrence. Furthermore, evidence suggests that preschool-aged children in recent years are incurring an increased rate of caries experience. Often these younger children present behavioral challenges for the dental team which may be complicated by a host of issues (e.g., parenting styles). Many of the behavioral dynamics can be managed with good communication, empathy for the patient's situation, and a dental team characterized as having a positive attitude and approach. However, a significant portion of these patients cannot be persuaded to cooperate for routine dental procedures. Thus, there is a need for more advanced approaches for managing behavior including pharmacological interventions.

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The pharmacological options include the use of an inhalation agent (i.e., nitrous oxide), sedatives, combination of sedatives and/or inhalation agent, and general anesthesia. General anesthesia has its own set of considerations some of which can be significantly daunting, especially for parents. For example, anesthesia can be quite expensive and many insurance plans do not cover general anesthesia for dental procedures. As a result, the options for sedation may become more viable.

Sedation is as much a part of behavioral guidance tools as is a communicative alternative such as "tell, show, and do." In fact, the seasoned clinician understands that a variety of behavioral guidance techniques could and should be used regularly during sedation to achieve the best outcomes of behavior and care. Unfortunately, little opportunities are presented during undergraduate dental training guaranteeing a widespread cadre of general practitioners who are competent in sedation techniques. Consequently, for general practitioners, sedation procedures involving children (and adults!) become an empirically learned process that can be fraught with potentially dangerous outcomes. Some specialties provide training in *parenteral* (mainly intravenous route) techniques of sedation administration to the level of competency (e.g., oral maxillofacial surgeons); but only advanced training programs in pediatric dentistry provide experiences with *orally* administered sedatives for children. Some of these pediatric dentistry training programs also provide some training in other *non-intravenous*, *parenteral* sedation techniques (e.g., submucosal route of drug administration). And from this writer's perspective, disappointingly, there is fairly wide variability among programs in sedation experiences for trainees in pediatric dentistry.

There is a need for oral sedation primarily for preschoolers and older healthy children who have significant anxiety or dental phobia or have temperamental and personality characteristics that interfere with effective coping skills. Indirect evidence consistently suggests that children who require sedation for invasive dental procedures represent 20–30 % of children who visit a dental office each year – and that is probably an underestimate [1–3]. As of the present writing, there is no book specifically dedicated to *oral* sedation techniques in children for dental procedures. Because of the continuing need for pharmacological management of children during dental procedures, the importance of recognizing and understanding critical aspects of this type of management becomes paramount.

Sedation Techniques for Children

Sedative agents for children to undergo dental procedures can be delivered by several routes of administration, each of which has benefits and risks. Nitrous oxide in oxygen, an inhalation agent that when administered alone, should be considered as the primary and safest sedation technique for children. The overwhelming number of children sedated for dental restorative procedures are managed amazingly well with nitrous oxide due to some of its properties and ease of use. These beneficial properties include onset of mild sedation, induction of mild distraction and patient-suggestive states, mild analgesia, ease of administration and titration, and control of depth of sedation with open dental delivery systems. Even though nitrous oxide is an excellent tool for sedating children especially when used with other sedatives in therapeutic doses, it has significant limitations in terms of potency and patient acceptance for a number of children.

The second most frequently used route of administration for children is via oral sedatives, often supplemented with nitrous oxide. Oral administration of drugs, supplements, and foodstuff is nicely tolerated by an overwhelming majority of children and quite acceptable to parents who use this route on a daily basis with youngsters. The oral route does have several limitations which will be discussed in several areas of this book. Some practitioners use other parenteral routes of drug administration such as submucosal or intramuscular injections. Another recently popularized *parenteral* route is intranasal administration of sedatives; nonetheless, the oral route continues to reign supreme over other routes in popularity among practitioners, children, and families.

Non-intravenous parenteral and enteral routes (i.e., oral and rectal), although popular and generally accepted by children and parents, can have significant limitations in efficacy and efficiency. The main limitation of these routes is the lack of titration of the drug. Safety also becomes an issue when more than one sedative is used or multiple administrations of a sedative occur during a single procedure. As might be expected, the failure rate of these routes can vary considerably. Often good communicative and distraction techniques of talented practitioners become very helpful when these techniques are employed. Also, nitrous oxide supplementation of orally administered sedatives is beneficial. Practitioner traits of flexibility, patience, and adaptability are important components for success using these techniques. Therefore, in minimal to moderate depths of sedation (which will be defined later in this book but essentially implies the child is interactive with the clinician), what you see and can communicatively finesse with a single oral dose is what you get in managing the young patient.

Intravenous sedation routes have a higher and more consistent rate of success than other routes of sedative administrations. But then, there are multiple challenges with this route which limits its use in children such as their natural fear and wariness of needles. The IV technique requires significant dedication and training. And generally, deeper levels of sedation are required to overcome many children's unwanted behaviors and disruptions. Deeper levels of sedation are known to cause an increased likelihood of adverse events, but practitioners who use this technique generally have a much broader scope of special training for intervening and managing these events. Importantly, this implies that the practitioner is comfortable in rescuing the patient from significant airway issues (e.g., laryngospasms) and respiratory depression. In reality and particularly when used for children, this technique usually requires more than one specialist with one who manages the patient through the sedation portion of care and the other to conduct dental procedures.

If one is looking for a "magic bullet" that guarantees that the disruptive and frustrating behaviors during dental procedures will be 100 % eliminated, then general anesthesia is the magic bullet. General anesthesia requires that a specialist will manage the anesthesia portion of the procedure while the dentist performs dental procedures. General anesthesia can be done in the hospital, outpatient surgery centers, and in-office settings. Often the latter venue is significantly less expensive and has become popularized in recent decades.

Guidelines

Another key factor for any practitioner using sedation techniques is an intimate knowledge of and adherence to appropriate sedation guidelines. Guidelines for the sedation of pediatric patients appeared around the early 1980s. There are a number of guidelines many of which are associated with specific professional groups (e.g., anesthesiologists). The one guideline most often associated specifically with pediatric patients for dental and medical procedures is the "Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update." This guideline was published in 2006 [4] and most recently re-approved in 2011 (http://www.aapd.org/media/Policies_Guidelines/G_Sedation.pdf). It is cosponsored by the American Academy of Pediatrics and the American Academy of Pediatric Dentistry. The guidelines address a host of considerations designed to increase patient safety and minimize procedural risk.

Dentistry

Invasive dental procedures performed on children often involve sedation and include restorative care, exodontia, and periodontal, endodontic, and some orthodontic or space maintenance. The majority of the procedures involve restorations such as composites, amalgams, pulp therapy (e.g., pulpotomies), stainless steel crowns, sealants, and extractions. Some of these procedures are very technique sensitive and require good

patient cooperation in order to have long-lasting clinical outcomes. Several considerations involving patient management and safety surrounding these procedures must be seriously addressed.

Local anesthesia is necessary during most invasive procedures accomplished under sedation. Actually, the process of obtaining local anesthesia using a syringe and hypodermic needle is one of the most feared procedures for children. Depending on the depth of sedation and the ability of the dental team to keep the syringe out of the sight of the patient, this procedure has a strong chance of provoking disruptive behaviors despite sedation adjuncts.

The technique of very slowly expressing the anesthetic solution from the syringe into the tissues over a period of a minute or longer is highly recommended to minimize pain and the elicitation of uncooperative behaviors. Other helpful techniques include applied pressure just distal to the anatomical point for needle insertion for palatal injections, movement of the cheek during infiltrations and blocks, and different types of distractions (e.g., auditory). Sudden movements during injections of children, who a moment earlier was peaceful and quite, must be anticipated. This implies that the operator will have a good finger rest and firmly holds or cradles the head between the nondominant arm and his/her body for stability in minimizing the extent of movement. If on the other hand the child is already exhibiting disruptive, uncooperative behaviors and the decision has been made to continue treatment, then proceeding through the injection phase as rapidly and safely as possible is recommended.

Rubber dams are also another feared procedure for children because of their natural fear of suffocation. Nonetheless, the rubber dam is the best means of protecting the airway from fluids, particulate vapors generated by high speed tooth preparation (e.g., tooth "dust"), and other foreign objects (e.g., stainless steel crowns). Another advantage of the rubber dam is its displacement and separation of oral tissues from the teeth being prepared. Noteworthy is the placement of the rubber dam clamp on the tooth. The clamp when initially placed may subtly slide apically and impinge on the more sensitive cementoenamel junction of the tooth possibly causing discomfort and usually an increased heart rate even under general anesthesia. Also, proper placement of the dam so that the nasal oris is not blocked is critical.

Children who complain that they cannot breathe can often be soothed by the practitioner's attentive focus to their distress. A sound ploy in ameliorating their breathing is the procedure of cutting a hole around the upper portion of the dam near the nose or in the middle of the dam but away from the operative field involved in the procedure. The size of the hole usually does not matter unless the dam otherwise frankly blocks their breathing efforts. The child is then instructed that they can now breathe through the new opening.

The dental handpieces due to their noises and vibrations are another source of irritation and fear to the child. The grinding noise produced, especially when maxillary teeth are being prepped, is transmitted not only by air but also via the facial bones to the ear causing even more dissonance for the child under the circumstances. If adequate anesthesia is not obtained, then one takes the risk of the child becoming conditioned to anticipate pain every time the handpiece is used.

The practitioner must remember the importance of using distraction and other behavioral guidance tools for milder and moderate sedation levels in order to expect a smoother operative transition. It is wise to expect that the rate of successful outcomes will not be exceptional or even excellent for mild to moderate levels of sedation using the oral route of sedative administrations. To do so would invite disappointment in the naïve belief that a sole dependence on drugs to control children's behavior is an all-encompassing panacea. Nonetheless on a more positive note, the competent clinician who utilizes a well-honed armamentarium of communicative behavioral guidance skills, astute patient selection processes, dedicated adherence to sedation guidelines, and a combination with therapeutic doses of sedative agents will find great satisfaction in offering a comprehensive approach to managing children in the dental office. Generally speaking,

the deeper the level of sedation that is produced, the less likely the child will respond to dental stimulation that normally causes agitation or to communicative interventions of the clinician. However, the risk for adverse events such as respiratory depression rises with increased depths of sedation. Properly trained clinicians can anticipate and manage adverse events and rescue a child, but those without advanced training who are unprepared to rescue a child from a life-threatening adverse event will likely be dramatically impacted financially, emotionally, and psychologically.

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Behavior and the Child

2

Stephen Wilson, S. Thikkurissy,
and Elizabeth S. Gosnell

Abstract

One of the greatest but most rewarding challenges in the dental profession is that of providing oral health care to children. The behavior and emotional expressions of children can vary from affable, humorous, and inspiring to rebellious and taxing for parents and professionals. This chapter will investigate children's behavior, important factors contributing to its expression, and set the stage for the introduction of pharmacological management of the child in the dental setting. Key concepts such as child temperament, age, anxiety and fear, and parents and their impact on child behavior will be discussed. In the end, the dentist importantly must fully embrace and constantly advocate for the child's oral health and safety even in the face of extreme states of health, behavioral challenges, diversification, and adversity.

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The authors of a classic textbook on child development (Mussen, Conger, and Kagan; *Child Development and Personality*) indicated that a full understanding of child development requires examining children's behavior by searching for universal patterns, individual differences, and situation or contextual influences [1]. One might consider dental appointments as brief snapshots of children, which as a collective whole affords practitioners their own unique laboratory for studying child development and behavior. Dentists, who treat and care for children, out of necessity must invest time, training, and reflection in child psychology, behavioral observation, and developmental physiology in

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order to appreciate how to successfully negotiate diversities of child behaviors. Also, the dental professional must always have a flexible and supportive predisposition in a variety of challenging situations. In doing so, the practitioner in the long run will become an enabler of beneficial oral health care of children.

The specialty of pediatric dentistry is an age-defined specialty that provides both primary and comprehensive preventive and therapeutic oral health care for infants and children through adolescence, including those with special health-care needs [2]. One of the primary hallmarks of advanced training programs in pediatric dentistry is the focus on developing competency in understanding behaviors of children, teenagers, and special needs individuals in the dental setting. Graduates must be capable of successfully and competently interacting with children and their parents. Parental response and acceptance of these skill sets will vary, sometimes considerably. So the dentist must provide information to them in an open, non-biased fashion, but always advocate for the child and his/her needs.

Successful practitioners can attain these states of competency through significant clinical training and experience, an intimate knowledge of the literature, and adherence to appropriate clinical guidelines. Many general practitioners and other dental specialists are also quite adept in working with children in the dental setting. Their success is also dependent on these acquired competencies and familiarity with professional resources and standards.

Understanding the "Context" of Child Behavior and Development

As outlined by Dr. Susan Fisher-Owens, there are multiple determinants within various levels of influence including the individual child, family, community, the caries process, and time contributing to children's oral health outcomes [3]. These have been formalized in a model for the purposes of discussion and study. The model recognizes child development as including internal and external factors that fashion the child's oral health behaviors. So too, factors regulate the expressions of child behaviors and their degree of malleability to interactive experiences that occur in the dental setting.

The primary "internal factors" affecting behaviors within the child–environment interface are temperament and the continuum of anxiety/fear; they will be discussed later in this chapter. External factors that have been shown to influence child behavior include (but are not limited to) family configuration, socioeconomic and poverty status, history of chronic illness, parental marital status, and extended family members and peer relationships/socialization. It is naive for the dental practitioner to ignore the effects of these external factors when determining what behavior guidance approach to employ during an appointment. Individual, social, situational, and environmental factors or even memory influence and contribute to the underlying fabric dictating how the child will respond, especially under perceived uncomfortable situations. An individual's age, cognition, emotional constitution, temperament, prior experiences (and thus memory), and even coping styles will modulate the expression of anxiety and fear [4]. Further complicating this setting is the dental team's "personality" and range of adaptability in rendering behavioral guidance for the child.

The concept of toxic stress in today's environment also is important. Toxic stress has been described as prolonged types of stress [5]. This includes child experiences of strong, frequent, and/or prolonged adversity or stress such as physical or emotional abuse, chronic neglect, caregiver substance abuse or mental illness, exposure to violence, and/or the accumulated burdens of family economic hardship sometimes without adequate adult support. This kind of prolonged activation of the child's stress response system can disrupt the development of brain architecture and other organ systems and increase the risk for stress-related disease and cognitive impairment well into the adult years [6]. Although not documented, the likelihood of disruptiveness, neglect, and uncontrollable behaviors increases in children who are from family settings wherein toxic stress is commonplace.

Living in poverty along with food insecurity (i.e., not knowing where the next meal is coming from) in early childhood adversely affects the development of health behaviors and overall resilience to emotional and physical insult [7]. Even in working class families and especially in a single parent, working family disruption and chaos in the household can lead to inadequate child competency and even learned helplessness or aggressive behaviors. This type of background and parenting styles may challenge the child's ability to cooperate for treatments in the dental chair.

Children with a previous history of chronic illness and negative medical experiences may have an impact on their memory and distress associated with such procedures [8, 9]. Also noteworthy is the decline in cooperative behaviors in otherwise healthy, well-behaved children that may manifest over two or more successive operative visits in young children during a treatment phase [10].

Some evidence suggests that children living in a nonnuclear (single parent) family have more worries, have fewer dental visits, are less likely to comply with adult requests, and have a higher likelihood of exhibiting severe emotional and disruptive behaviors [11].

Behavior

Behavior is defined as the way a person acts or behaves. The scope of human behaviors is almost limitless. Furthermore, socialization as a process in a cohesive society often dictates general expectations of what behaviors might occur in certain settings and as well as their appropriateness. For instance, one might logically expect bidirectional communication enabling a patient to cooperate and tolerate dental procedures while a competent, caring dental professional team performs the procedures in the dental operatory. Children may not always fit nicely into this model. That's when behaviors become interesting, challenging, and sometimes impossible to manage even by the most polished clinician without resorting to pharmacological management of the patient. Table 2.1 shows typical child behaviors, emotional responses, and some interventions aimed at successfully guiding those behaviors during dental procedures.

Since children may exhibit a variety of behaviors that are not compatible with a smooth, collaborative interaction desirable in a clinician–patient relationship, negative consequences may occur. The most simple and often most tragic consequential behavior of a "bad dental experience" is the patient's future avoidance of the dental environment. In classical reinforcement theory, avoiding a potentially fearful or negative situation is actually reinforcing or "pleasurable." Hence, avoidance behaviors are likely to increase in the future.

Disruptive Behaviors in the Dental Operatory and Their Causes

The disruptive behaviors best known and witnessed by the experienced clinician in managing children are vocalizations, movements, and "delay"-designed tactics (see Box 2.1). The vocalizations vary from normal speech to types of crying (viz., sobbing, whimpering, and loud crying), to frank and painful ear-piercing screams. Movements include, among others, covering the face, attempts to strike out at others (whether real or "shadow boxing"), grabbing the clinicians' arms and instruments inappropriately, biting, displaced aggressions toward the immediate family caregiver, repeated kicking of the legs and/or feet against the dental chair, or integrated active attempts to escape from the chair and operatory. Procedurally related delay tactics also may be present. In this case, the child will make statements, like "wait, wait, wait!!!," "I have to tell you something," "I have to use the bathroom," or "I can't breathe," all of which are designed to delay the procedure.

These behaviors may be frustrating for the dental team and, in the less experienced practitioner, may elicit negative feelings toward the child. Such feelings may even impact the quality of care delivered. Ignoring or not responding to the child's pleadings, once appreciated as a delay tactic, actually is known in behavior modification theory as "extinguishing" the response

Table 2.1 Typical characteristics of children, behaviors, dental needs, and interventions in the dental setting

Child's status	Age	Cognition	Emotional responses	Behaviors in clinic	Dental needs	Intervention
Infant	Birth – 1 year	Basic receptive and expressive language	Calm Quiet Degrees and intensities of crying	Social smile Grimacing Sitting up Crawling	Likely extraction of natal/neonatal teeth Trauma	Topical anesthesia General anesthesia
Toddler	1–3 years	Rapidly evolving Language acquisition and purposeful use	Calm Quiet Laughter Crying to screaming Pouting Anger Joy Surprise Shyness	Smiles appropriately Crying and temper tantrum in response to frustration Social adaptability or maladaptation Clumsy locomotion and coordination Kicking Hitting	Caries Trauma	Short TSD Distraction Positive reinforcement Rewards Sedation (usually moderate to deep) General anesthesia
Preschooler	3–6 years	Language skills rapidly progressing Speaks what he/she hears Imagination and magic dominate	Calm Quiet Laughter with purpose Crying with purpose Anger Sadness Recognition of others' emotions	Smiles Cries Kicking Hitting Spitting Obstinacy	Caries Trauma Space maintenance	TSD Distraction Positive reinforcement Rewards Voice control Nitrous oxide Mild to deep sedation General anesthesia
Primary school	6–12 years	Language skills approaching adult levels General compliance with authority figures (e.g., teachers) begins to dominate	Calm Quiet Laughter with purpose Crying with purpose Anger Sadness Compassionate Interactive	Smiles Cries Obstinacy Moody Cooperative	Caries Trauma Space maintenance Orthodontics	TSD Distraction Positive reinforcement Nitrous oxide Mild to moderate sedation
High school and teenagers	13–19 years	Adult cognition	Calm Quiet Laughter Moody Anger Avoidance Challenging Peer orient	Smiles Obstinacy Moody Cooperative	Caries (rampant) Trauma Space maintenance Orthodontics Tobacco-related periodontal issues	TSD Distraction Positive reinforcement Nitrous oxide Mild to moderate sedation

Box 2.1. Common Disruptive Behaviors in the Dental Operatory

- Vocalizations
  - Sobbing
  - Whimpering
  - Loud, controlled crying
  - Ear-piercing screams or yelling
  - Delay tactics
- Movement
  - Grabbing arms or hands of dental team members
  - Hiding their face
  - Repeated kicking of heels against dental chair seat
  - Swinging of arms (shadow boxing)
  - Frank attempts to escape from dental chair
- Others
  - Biting
  - Scratching
  - Spitting
  - Cursing

Table 2.2 Dental stimuli that may trigger pain, anxiety, and uncooperative behaviors

Potential provoking procedures	Key considerations
Injection of local anesthetic	Sites of painful injection Anterior maxillary infiltration Palatal infiltration Inferior alveolar injection Long buccal and mandibular infiltration Rate of solution administration Extraneous maneuvers Soft tissue vibration/movement
Application of rubber dam clamp	Inadequate soft tissue anesthesia Intrasulcular pressures Incorporated soft tissue
Tooth preparation	Transmitted auditory sounds Inadequate nerve blockage with local anesthetic Vibratory sensations
Crown placement	Pressure during placement Inadequate anesthesia Intratubular pressures
Elevation and extractions	Pressures Inadequate anesthesia Encroachment on unanesthetized tissues Excessive temporomandibular joint movement

(i.e., typically, the response rate decreases). One should appreciate that these types of behaviors are usually in response to dental stimuli and procedures, some of which may be perceived as unpleasant to a patient who is awake (see Table 2.2).

Cooperation refers generally to the child and provider interacting in a bidirectional fashion that is mutually supportive and beneficial. The process in which this occurs depends on such factors, among others, of timing, goal orientation, and personality characteristics of the two parties. Children may smile, listen intently, and wish to undergo the process with eagerness and ease. Some children are overtly shy and take longer to accept the explanations. Others frankly refuse to participate in cooperative interactions, sometimes issuing spine-tingling screams and escape movements that can become dangerous to both parties.

The concept of personal intrusiveness is also an important, but a rarely discussed consideration. One can appreciate that every individual has a "psychological space" within which the individual feels comfortable with his/her surroundings and situation (Fig. 2.1). This imaginary space can manifest both as a physical distance from one's face and a psychologically sphere that includes an emotional comfort zone when one interacts with another person. Intrusiveness refers to a sense of one's perceptions and feelings generated by another person who has, to some degree, physically or psychologically invaded this psychological space. More likely than not, the intrusion causes the individual some internalized distress possibly resulting in defensive responses. Children, for example, may turn their head, raise their hands, and protest by pushing away a doctor-guided, approaching nasal hood used for delivering nitrous oxide. Even basic techniques such as tell-show-do, as conveyed by the dental team, may not be sufficient to overcome the defensive reactions of the child in these circumstances.

Fig. 2.1 Photograph illustrating an example of the "psychological space" surrounding a person. The variably colored spheres around the patient's head indicate that the size of the individual's psychological space may change depending on social and environmental settings. For example, the size of the space may be expected to be much larger when in the presence of a stranger versus that of a family member. Intrusion by another person into an individual's space may cause the individual to experience anxiety and react in unexpected ways

Consequently, the dentist may function as a chairside psychologist who is exquisitely aware of each child's range of capabilities in expressing a multitude of responses in the dental setting. Repeated experiences, appropriate training, and dedication provide a basic platform for management techniques and skills necessary for the chairside psychologist. Nonetheless, the amount of effort invested in managing this wide expression of behavior is often physically and emotionally exhausting at the end of the day.

Is there a way to preoperatively characterize and, better yet, identify these challenging children? Not always, but some child characteristics have been investigated or empirically noted as prominent features that aid in anticipating disruptive behaviors. For instance, children who may be challenging are very young (i.e., 3 years of age or less); generally lack well-developed effective social and intrapersonal coping mechanisms; are temperamentally distressed and shy; suffer from fearful, anxious, or angry states, of which they cannot easily control; are mentally or cognitively challenged; or have chronic physical illness requiring frequent medical challenges sometimes involving unpleasant interventions. Unfortunately, many of these "challenging" children may also have dental caries; others may have suffered orofacial trauma, both of which likely require procedural interventions.

Age

A child's age and cognitive development are helpful in predicting the likelihood of disruptive behaviors associated with dental procedures. As a general rule of which there are exceptions, children who are 3 years of age or less may be expected to have a short attention span, be fearful of strangers, or lack sufficient cognitive and language skills, all of which can contribute to unfavorable reactions in the dental setting. Often, the primary coping responses of these toddlers are crying, expectations of immediate parental protective intervention, and avoidance behaviors. As the child approaches school age, the fear of strangers may subside, language and communication skills become more effective, and subtle socialization gains including better emotional control often become apparent. Once children are of school age, changes in cognition are notable. This developmentally cognitive and emotional growth often translates into fewer incidences of disruptive behaviors. Again, exceptions to this expected developmental change can and do occur.

From a sedation perspective, one can anticipate that toddlers will likely require deeper levels of sedation creating less opportunity for effective behavioral guidance in obtaining successful procedural outcomes. But as the child's age and cognitive/emotional states mature, the depth of sedation targeted may generally ebb more toward a need for only minimal to moderate depths of sedation along with a heavier emphasis on behavioral guidance.

Role of Anxiety and Fear

There are many factors associated with disruptive, uncooperative behaviors exhibited in the dental setting by children, but anxiety and fear

likely top the list. The prevalence of anxiety and fear of children in the dental setting has been estimated as ranging from 6 to 20 % [9, 12]. That's probably an underestimate.

In one review, fear and anxiety reportedly were more prevalent in the youngest of children decreasing with age, are associated with gender, and temperamental traits were notable. Temperamental characteristics of shyness, negative emotionality, poor adaptability, and high activity and intensity were consistent with anxiety and fear. Anxiety and fear are often thought to be the predominant states underlying many of these expressions of behavior. However, as pointed out by others, dental fear does not necessarily equate to the primary cause of disruptive behaviors, and such uncooperative behaviors do not necessarily imply that dental fear is the culprit [12].

Anxiety and fear cause a complex range of emotional behaviors. Recent neurobiological evidence has evolved aiding in the understanding of these states. Apparently, fear-elicited response patterns in the human are mediated primarily and initially in the limbic system of the CNS and, more specifically, in the area of the amygdala of the midbrain [13–15]. This system is *genetically* geared to rapidly assess impending danger and, within microseconds, initiate and orchestrate a pattern of motor, emotional, and autonomic responses designed specifically to protect the organism. Furthermore, the system seems particularly sensitive to and organized in such a way as to memorize and categorize each threatening situation in an attempt to prepare the organism for future encounters. Toxic stress likely plays an influencing factor on this system.

Behavioral inhibition has been described as a temperamental trait of young children who tend to withdraw from novel or unfamiliar stimuli [16–18]. Inhibited behaviors, such as avoidance of novelty, represent a coping mechanism by which the fearful reaction is decreased. Over time, coping with fear through avoidance is thought to reinforce the associated physiological responses and behaviors leading to continued behavioral inhibition and social wariness: a positive reinforcement cycle. Interestingly, it has been hypothesized that temperament types may be associated with different response sets within the limbic system.

Parenting and Environmental Influences

Evidence of change manifested as generational differences in parental management styles is associated with disruptive behaviors of children in the dental setting. Pediatric dentists are reporting that today's children are less cooperative, cry more, and are more disruptive in response to normal guidance techniques than children of a decade or more ago [19]. In order to address these changes, evidence is slowly accumulating suggesting a movement toward greater use of pharmacological management of children than has been done in the past.

Key Concepts of Behavior Associated with Sedation

Temperament

Temperament describes a child's overt responses as a basic and daily expression pattern to solitary and social situations. Temperament is believed to have a fairly strong genetic component and is somewhat stable over different situations and developmental phases of an individual's life. Some children may appear shy, withdrawn, irritable, and moody, whereas others may be friendly, approachable, euphoric, and pleasant during initial interactions with other children or adults.

There is fairly consistent and widespread evidence that temperament affects how children tend to respond in dental as well as other settings [20–22]. In fact, a child's temperament may aid in predicting, to a certain degree, how the child may respond while under the influence of therapeutic doses of sedatives and during perioperative periods surrounding general anesthetics [23–26]. Some authors have concluded that shy, withdrawn children do not behave as well compared to peers who are less shy and withdrawn [27].

Attachment

Attachment is another psychological concept wherein the presence and strength of emotional bonds to caregivers affect a child's response in different contextual situations. Evidence suggests that attachment may have implications for one's health and behaviors. Relationships between attachment and temperament have been reported, but the strength of these associations is not well understood. The interactions between the two concepts appear complex [28–30]. Attachment per se has not been studied in pediatric dentistry as of this writing.

Age

The patient's age and corresponding cognitive development are important considerations for anticipating different expressions of behaviors in children during dental procedures [31]. Generally speaking and in terms of broad classifications of patient age, the young preschoolers seem to have a higher likelihood of displaying disruptive and uncooperative behaviors [32]. Disruption and uncooperative behaviors usually wane as children age; however, traumatic episodes or series of such episodes may increase the expression of these behaviors. Some school-aged children and adolescents may actually regress and display an unwillingness to participate in dental procedures.

Another important factor of consideration associated with aging and cognitive development of youngsters, albeit not documented in any systematic fashion in dentistry, is language acquisition and its understanding and use [33]. Its importance, as a bridging mechanism for communication between the patient and provider, cannot be overstated and forms the basis of the popular technique of tell-show-do. Sedation of infants and toddlers, who may lack sufficient language skills to understand procedural interventions, is a well accepted and frequent adjunct for many types of medical procedures, thus recognizing the immature state of coping mechanisms characteristic of these very young children.

As children age and their personality begins to congeal, individualized traits and styles of interaction with others become more observable and predictable even into adulthood. Some individuals will have general as well as specific types of traits associated with potential anxiety or fear-provoking situations. The interaction of general and specific qualities in children is complex and not always intuitive. Evidence does suggest that procedural-evoked anxiety can be favorably modified through appropriate interventions. Thus, the astute clinician should make efforts to gain information from parents and guardians in anticipating patient anxieties and fears that may become manifest during dental procedures. Furthermore, the clinician should have a repertoire of interventions whose implementation may lessen these emotionally charged states.

Experience

Children's experiences with the medical field begin very early in life. Even infants learn quickly and express anguish during routine visits to the physician in anticipation of inoculations. Depending on the general health and incidences of traumatic episodes children may endure, those experiences may be well tolerated or induce a lifelong stigma possibly leading to unwanted avoidance behaviors of medical and dental needs. Family member's support or hurtful exacerbation (e.g., teasing) of anticipated experiences of planned procedures also may impact the outcome and contribute to the processes of internalizing coping skills of the child. For example, parental or sibling comments such as "next comes the painful shot" sometimes have deleterious effects even if not consciously intended. It is even possible that some degree of discussion about the "shot" has already occurred at home. Either way, these remarks heighten the child's sense of anticipatory dread of the procedure which at the time of occurrence may immediately overflow into an outburst of disruptive and uncooperative behavior.

Parenting

Parents are usually a beneficial source of knowledge about their children and how they may respond during procedures and interactions with

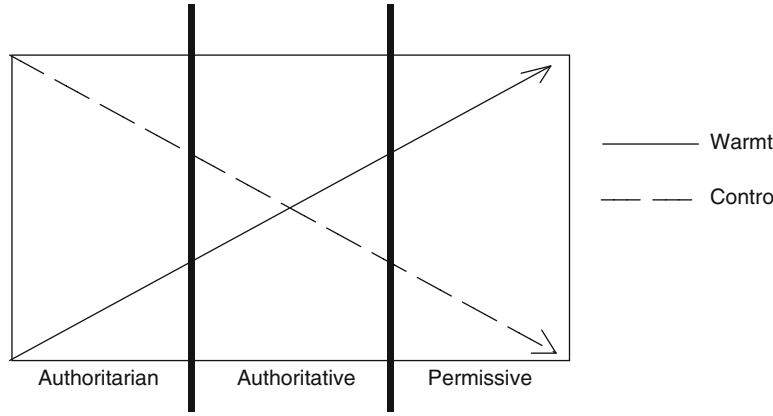

Fig. 2.2 Baumrind's parenting model. The solid line indicates rising levels of warmth and the broken line declining levels of control when moving from authoritarian to permissive style of parenting

professionals. Generally, parents know the child's behaviors, limits, adaptive skills, and emotional responses quite well. They are an obvious benefit to the professional who takes the time to understand the parent's perspective; acts in a caring professional manner when explaining expectations, techniques, procedural processes, and possible outcomes; and gains parental confidence in managing their child's situation. Parental knowledge of the child's medical and social history and insights regarding their child's typical responses in a host of settings is invaluable.

Occasionally, parents can become an obstacle to smooth delivery of health care to their children. Sometimes, parents may develop prejudices and preferences about certain therapeutic care that are incongruous with that of the health-care provider. Such personal attitudes and posturing can develop and be influenced by many factors including, among others, their own experiences when they were parented, other family preconceptions, religious or sect partialities, and importantly, by the wealth of information easily obtainable through the World Wide Web or Internet. These biases may manifest in various behaviors including dictating what should and should not be done on their children; others become emotionally distraught or even angry when they feel dissonance between their wants and wishes and the clinician's management of their child. The practitioner's patience and attempts to understand the parent's concerns are always helpful.

The issue of parental rearing styles in relation to children's behavior remains unclear, although some evidence supports the notion that parental rearing styles are associated with children's anxiety [34]. It is likely that a stronger emergence of evidence will occur in the future supporting parenting styles with many aspects of delivering dental care to children.

Baumrind has been associated with introducing parenting styles as a major influence on child behaviors. She described three parenting styles: authoritative, authoritarian, and permissive. The authoritative parent is characterized as compassionate and warm toward the child, but sets limits on behavior and permits interactive communication. The authoritarian parent uses harsh, controlling techniques to control their children, is less compassionate, and dominates conversations. The permissive parent is warm and compassionate, rarely sets limits on behaviors, and "spoils" the child [43] (Fig. 2.2).

Recent evidence indicates that parenting styles have changed in the past few decades causing more disruptive behaviors in the dental setting. This change in parenting styles may seem shocking to some older providers; however, it seems likely that such change occurs anyway as a natural drift across generations of parents. Regardless, the outcome in terms of child behavior in the dental environment is not necessarily positive.

Nonetheless, the changes in parenting styles frequently observed and reported today (i.e., by professionals) are that more and more parents are setting fewer limitations on their child's behaviors, are overprotective, and feel compelled to move their children through developmental stages with an engineering finesse designed to favor optimal happiness and minimal adversities.

In recent years, the descriptive term of "helicopter" or "hovering" parents has become a common cliché among professionals who care for children. The term describes parents who become highly attentive to the child during stressful situations, remain physically close to the child during professional–child interactions, make quick interpretive and "parroting" utterances of the professional's comments to the child, intercede by stopping or delaying a procedure when the child becomes upset, and sometimes become overtly belligerent toward the professional staff. Evidence suggests that this type of parental behavior may actually inhibit the child's adaptation to distressful circumstances possibly even leading to abnormal or consistently inappropriate child behaviors. Similar behaviors have been noted in other settings as well (e.g., in school classrooms).

Dental Team

The dental team is also a key element in ensuring a friendly, nonthreatening environment and quality care. Every effort should be made to orient all members of the dental team to the practice's philosophy, extent of care, policies and procedures, and management and resolution of clinical, financial, and interpersonal issues. The first encounter of the dental team with the family and new patient should set the tone for the philosophy of oral health care and its delivery. The encounter may be indirect through community hearsay but usually involves the direct interaction between the family and the receptionists, front desk personnel, and environment of the waiting area.

The clinical care team comprised of the dental assistants, hygienists, and doctors are very important aspects in gaining patient rapport and confidence. A framework of a friendly atmosphere that has expectations of behaviors consistent with patient age and cognitive status is an excellent opening message expressed to parents and children. Appropriate responsiveness by the dental staff along with pleasant, supportive attitudes reinforces the message.

The dentist's responses can have an effect on patient fears and feelings [35]. Criticism by coaxing, coercion, and putdowns without appropriate positive reinforcement adversely influences patient fears and increases disruptive behaviors. On the other hand, appropriate and well-timed use of positive reinforcement is beneficial in aiding children to accept invasive dental procedures.

Behavioral Interventions

A host of behavior management techniques is available to the practitioner. The American Academy of Pediatric Dentistry (AAPD) publishes and periodically updates guidelines on behavior management (see Table 2.3). As mentioned, the guidelines group different interventions into communicative guidance and advanced behavior guidance. According to the definitions, communicative interventions include tell-show-do (TSD), voice control, nonverbal communication, positive reinforcement, parental presence/absence, and nitrous oxide. Evidence for the effectiveness of these techniques exists and supports their discriminant use in guiding children's behavior through dental procedures.

Advanced behavior guidance is defined by AAPD as protective stabilization (e.g., temporary restraint), sedation, and general anesthesia. These interventions require specialized training and parental informed consent prior to their use. Communicative techniques can and should be used with some advanced behavioral guidance techniques such as mild to moderate levels of sedation. Temporary physical restraints are also frequently necessary to prevent harm to the patient and/or dental team.

Behavior guidance techniques require careful considerations including shared communications, consented understandings, appreciated contrasts of opinions, and open input from all parties (i.e., the child, parent, and dental team). To exclude any of the parties from open and clear discussions of management options is to invite distrust, anger, and disaster to the situation.

Few prospective, randomized well-designed studies have been done on behavior guidance

Table 2.3 Tabular description of behavior management techniques sanctioned by the American Academy of Pediatric Dentistry

General guidance category	Technique	Description	Specific consent
Communication and communicative guidance			
	Tell-show-do	The technique involves verbal explanations of procedures in phrases appropriate to the developmental level of the patient (tell); demonstrations for the patient of the visual, auditory, olfactory, and tactile aspects of the procedure in a carefully defined, nonthreatening setting (show); and then, without deviating from the explanation and demonstration, completion of the procedure (do) Contraindication: none	No
	Voice control	Voice control is a controlled alteration of voice volume, tone, or pace to influence and direct the patient's behavior. Parents unfamiliar with this possibly aversive technique may benefit from an explanation *prior* to its use to prevent misunderstanding Contraindication: hearing impaired	Implied – ask permission before using
	Nonverbal communication	Nonverbal communication is the reinforcement and guidance of behavior through appropriate contact, posture, facial expression, and body language Contraindication: none	No
	Positive reinforcement	Positive reinforcement is an effective technique to reward desired behaviors and, thus, strengthen the recurrence of those behaviors. Social reinforcers include positive voice modulation, facial expression, verbal praise, and appropriate physical demonstrations of affection by all members of the dental team. Nonsocial reinforcers include tokens and toys Contraindication: none	No
	Distraction	Distraction is the technique of diverting the patient's attention from what may be perceived as an unpleasant procedure Contraindication: none	No
	Parental presence/ absence	The presence or absence of the parent sometimes can be used to gain cooperation for treatment Contraindication: parents unwilling to participate	Implied – ask permission prior to implementation
	Nitrous oxide/oxygen inhalation	Nitrous oxide/oxygen inhalation is a safe and effective technique to reduce anxiety and enhance effective communication. Its onset of action is rapid, the effects easily are titrated and reversible, and recovery is rapid and complete Contraindications: Some chronic obstructive pulmonary diseases Severe emotional disturbances or drug-related dependencies First trimester of pregnancy Treatment with bleomycin sulfate Methylenetetrahydrofolate reductase deficiency	Yes

(continued)

Table 2.3 (continued)

General guidance category	Technique	Description	Specific consent
Advanced behavioral guidance			
	Protective stabilization	The broad definition of protective stabilization is the restriction of patient's freedom of movement, with or without the patient's permission to decrease risk of injury while allowing safe completion of treatment. The restriction may involve another human(s), a patient stabilization device, or a combination thereof. The use of protective stabilization has the potential to produce serious consequences, such as physical or psychological harm, loss of dignity, and violation of a patient's rights Contraindications: Cooperative nonsedated patients Patients who cannot be immobilized safely due to associated medical or physical conditions Patients who have experienced previous physical or psychological trauma from protective stabilization (unless no other alternatives are available) Nonsedated patients with nonemergent treatment requiring lengthy appointments	Yes
	Sedation	Sedation can be used safely and effectively with patients unable to receive dental care for reasons of age or mental, physical, or medical condition. Sedation refers to the use of medications in producing a change in a patient's mental, physical, and emotional state Contraindications: The cooperative patient with minimal dental needs Predisposing medical and/or physical conditions which would make sedation inadvisable	Yes
	General anesthesia	General anesthesia is a controlled state of unconsciousness accompanied by a loss of protective reflexes, including the ability to maintain an airway independently and respond purposefully to physical stimulation or verbal command Contraindications: A healthy, cooperative patient with minimal dental needs Predisposing medical conditions which would make general anesthesia inadvisable	Yes

techniques typically used in pediatric dentistry. The most frequently used behavior guidance technique is called "tell-show-do." The technique involves the dental team communicating to the patient what procedure will immediately occur, demonstrating the procedure if possible using different sensory systems (e.g., visual, auditory, and tactile), and actually performing the procedure on the patient while simultaneously describing again what is happening. Although used on a daily basis, studies designed to test the technique's effectiveness have not been done. Nonetheless, empirical and personal experiences support its continued use and popularity.

Positive reinforcement and distraction are two behavior guidance techniques reportedly used frequently by pediatric dentists [36–38]. Positive reinforcement in classical behavior modification theory refers to a reinforcer (i.e., stimulus) which is applied immediately after a desired behavioral response increasing the probability that the response will occur again. Reinforcers in dental settings can range from praising the child, gently patting of the shoulders, and giving of small toys, stickers, or trinkets. Children, who were

disruptive and had prior restorative experience, in one classical study, were rewarded using escape, stickers, and praise for cooperative behaviors during practice trials. All children completed treatment, and the amount of disruptive procedures decreased from 90 to 15 % at the final restorative visit [39].

Distraction is a popular technique whose use during potentially discomforting procedures aids in reducing the pain threshold and responsiveness of the patient [37, 40]. Distraction may involve many different approaches. Examples of distraction used in dental settings include listening to music or watching videos (i.e., monitors mounted on the ceiling while the child is reclined in the dental chair); dental team's use of stories, queries, singing, or other vocalizations; and even tissue manipulation (i.e., vibration) near a site where painful stimuli may be expected (e.g., injection of local anesthetic).

Voice control is inflection of the voice designed to gain an unruly patient's attention. Despite its use by pediatric dentists, only one published study has investigated its effects on disruptive children [41]. In the study, the tone of voice and the affect of the children who received voice control were studied. The results clearly demonstrated that a loud voice significantly suppressed disruptive behaviors compared to a normal tone of voice. Furthermore, the children who received the loud voice control were reported less aroused than those receiving a normal tone of voice.

Parental presence in the operatory during procedures has increased in recent years. There is evidence that such family support acts to inhibit painful medical procedures. However, one must be cautious and selective with the use of this model of behavior management as misunderstanding or frank disagreement of child management may occur between the dental team and parents.

Protective stabilization is the use of some form of restraint in managing a child (Fig. 2.3). Typically, the restraint is subcategorized into "active" versus "passive." Active restraint implies that another human is involved in physically restraining the child. Passive restraint refers to the use of a device (e.g., Papoose Board™ or mouth prop) that holds portions of the body in place or minimizes movement. Protective stabilization must be used with care, and informed consent is indicated before its use. Improper use of protective stabilization may result in tissue abrasion and bruising, joint displacement, fracture of long bones, soft tissue puncture and debridement, bites and scratches, and even exfoliation of teeth not involved in care. Training in the appropriate use and precautions associated with restraint is highly advised.

Fig. 2.3 Picture showing child properly placed in a Papoose Board™

Examples of Techniques Not Requiring Sedation

Each child is unique in terms of dental needs, temperament, and behavioral expressions in challenging situations. It is beyond the scope of this book to describe the various situations that arise and other resources that are available (e.g., Wright's textbook on behavioral guidance). However, there are two situations worthy of description because of their frequency of occurrence and common context involving "quick" dental procedures.

Children who are very young (e.g., 2 or less) and have minimal dental needs such as small carious lesions on maxillary primary incisors may be considered for minimally invasive restorative and preventive interventions. The small carious

lesions may be gently scooped out with a small spoon excavator, glass ionomer cements placed, and fluoride varnish applied. These interventions are usually designed to elicit minimal resistive behaviors and to gain time for better coping skills to develop as the child ages.

A good technique to remember for this type of intervention is the so-called "knee-to-knee" positioning of the child. This technique involves the child sitting on the parent's lap facing the parent. The child's legs are wrapped around the waist of the parent. The dentist sits in a chair and moves toward the parent until their knees lightly touch. A towel drape is placed on the dentist's lap. The child is then lowered onto the knees of the dentist while the parent holds the child's hands. Usually the child naturally looks up toward the dentist allowing good visualization of the child's face and oral cavity. Crying and protest may occur, but the head can be gently stabilized by the dentist's hands while using a spoon to scoop out the soft carious aspect of the lesions. A glass ionomer is then placed in the cavity and smoothed. Fluoride varnish is brushed over the teeth. Frequent recalls are arranged to monitor the lesions (e.g., every 2–3 months) and possibly apply more varnish.

Another common situation is when young children have significant lesions causing persistent discomfort that is poorly controlled by analgesics. In this case, an alternative approach, assuming the child has demonstrated disruptive and incompatible responses to communicative guidance, is the use of passive immobilization for extraction of the offending tooth (i.e., restraint, usually with a Papoose Board™). *A caveat of this technique is that witnessed consent of the parent for the use of this technique is a must*. Once consent is obtained, the child may be restrained in an appropriately sized device by an experienced dentist who understands selecting the correct restraint to meet the patient's size. Failure to respect the device and the child's natural struggle when placed in this restraint can result in physical harm to the child or others. The literature is not clear on whether psychological or emotional damage may occur in using this technique, and its use must be carefully weighed. Restraint is used though in other facilities on a fairly frequent basis (e.g., emergency departments of hospitals).

Local anesthesia may be necessary once the child is restrained and the head stabilized (i.e., the head is cradled between the side of the dentist's lateral abdominal wall and the forearm of the nondominant arm). *The most challenging*, *but important part of this technique*, *is waiting 15 min or more for profound anesthesia to occur once local anesthesia is infiltrated into the tissue*. Screaming and crying may occur during this period understandably disconcerting to all involved. Profound anesthesia will ensure that the patient will not suffer unnecessary discomfort during the extraction. Once profound anesthesia is obtained, the offending tooth can be extracted and hemostasis obtained. Generally, the child is crying and mildly struggling in this case, but the parent's presence and assistance in distracting the child can be helpful.

Behavior and Sedation

The child's understanding of the world is multifactorial but, as repeatedly stated, is generally a function of his/her age, temperament, cognitive and emotional overlays, and language skills (see Box 2.2). Very young children usually find comfort and security in close relationships to their parents, caregiver, and siblings. The strength of those relationships is well appreciated by the family and professionals and is likely dependent on complex socioemotional mechanisms, some of which have a genetic basis. Practitioners who interact and treat very young children (i.e., 3 or less) understand that they are infrequently compliant for invasive clinical procedures, especially if a significant amount of time or technical skills is required. Many require pharmacological intervention, but a few can tolerate simple procedures performed by an efficient dental team.

Different behaviors may be expected at different times during a sedation appointment. Initially and prior to drug administration, one may observe very shy or overtly fearful-like expressions of behavior. Once the drug(s) has been

Box 2.2. Child Characteristics to Assess Prior to Sedation

1. Age
   (a) Cognitive interactions consistent with cooperativeness
2. Temperament
   (a) Activity
   (b) Approachability
   (c) Shyness
   (d) Emotionality
3. Airway
   (a) Presence and size of tonsils
   (b) Normal respiratory sounds
4. Risk status
   (a) ASA I (healthy)

administered, often changes in behavior are seen including more interactive encounters, goofy play-like behaviors, chattiness, or even quiet but appropriate gestures. The changes are usually transient but somewhat dependent on the drug(s) used. These behaviors can again change quickly into less cooperative or frank disruption under certain circumstances (e.g., paradoxical reactions to drugs or painful stimulation).

Depending on the depth of sedation, children may actually appear as if they are sleeping. They may exhibit quiet, regular breathing; they have little or no movement and their eyes are closed; heart rate is steady and slightly slower than when awake; and in general, they appear peaceful. For the dental professional, this state can be disconcerting because one may not know exactly how deep the patient is but does not necessarily wish to disturb the patient and elicit disruptive behaviors. The quiet child who appears to be sleeping is theoretically and ideally suited for the dental team to move quickly in accomplishing dental procedures. Nonetheless, it is advisable to inquire of the child in a normal tone of voice if they are "ok," gently pat their shoulder, or both. These types of stimuli are rather innocuous and unlikely to cause disruptive behaviors. Also, a lack of response to these types of stimuli indicates the child is deeper than minimal or moderate levels of sedation.

If the child is truly in deep levels of sedation, there is a greater likelihood for adverse events to occur. Often, the discomfort and anxiety, associated with uncertainty of the patient's level of consciousness, may become overbearing for the attentive clinician and rightly so as deep sedation is an area of unconsciousness in which significant adverse events can occur (e.g., laryngospasm). His/her reaction is to stimulate the child. The clinician may vocalize in a more intense tone and use a simple, but strong thrust of the mandible. This response can cause a rapid emergence of the child from the sleep-like state, disorientation, and displays of combative behaviors. The clinician's decision to "test" the level of consciousness and these responses is often frustrating for the clinician. Successful resettling of the irritated child through assurance and calming techniques may become difficult, and any procedural progress may have come to a halt or at least be less favorable than desired.

Obviously, the most important safety measure at this point is keeping the airway patent, ensuring adequate respiratory function, and keeping the patient safe. If the clinician resists the need to test the patient's level of responsiveness, then more intense focus on monitoring of airway and respiratory function is needed. Stable trends in vital signs are desirable, but the first sign of variation from such stability requires immediate attention on the part of the clinician.

One can expect certain behaviors during different parts of a restorative visit. For instance, increased heart rate, sudden movements, and vocalization are often associated with the injection of local anesthetic in young children. Even those expectations of behavior can be modified by simple maneuvers such as exquisitely slow deposition of the local anesthetic solution over a minute or two of time. Also, simultaneous application of distraction techniques such gentle shaking of the soft tissue and a low tone of voice describing what is occurring is helpful (e.g., "we are going to have a small pinch").

It is often necessary and highly recommended that communicative behavior guidance techniques be used frequently during minimal to moderate levels of sedation. Failure to use

techniques like TSD, distraction, and even selective protective immobilization can lead to poor sedation outcomes. In other words, the clinician should never totally rely on the sedative mix to fully control the patient's actions and responses.

There are more than 200 studies on the sedation of children for dental procedures. The aim of the studies varies and addresses such topics as drug combinations, behavior before and during intraoperative care (rarely has postoperative behavior been studied), and monitoring of physiological parameters, depth of sedation, and adverse events. A systematic approach to the study of sedation in children, especially dose–response analyses across drugs and drug combinations, has not been accomplished to date.

A recent publication using a meta-analysis and specific selection criteria was done in which the purpose was to evaluate the efficacy and relative efficacy of sedation agents and dosages for behavior management in pediatric dentistry [42]. They reviewed articles from 1966 through 2010 and specifically targeted randomized controlled trials of sedation comparing two or more drugs/techniques/placebo undertaken by the dentist or one of the dental team in children up to 16 years of age. Crossover trials were excluded. They identified only 36 studies that met their selection criteria and those included a total of 2,810 participants. Of those studies, 83 % were considered to be at high risk of bias. Furthermore, they indicated that 28 different sedatives, with or without nitrous oxide, were used; the doses, modes of administration, and time of administration varied widely. The studies were grouped into placebo-controlled, dosage, and direct drug comparisons. They concluded that there was some weak evidence suggesting oral midazolam is effective for children undergoing dental treatment. And they suggested that nitrous oxide inhalation may also be effective. They indicated that further research using a well-controlled and comprehensive approach was needed. A review of studies involving different drugs will be addressed in Chap. 6.

When one asks, "what's the best drug and dose to sedate children in my dental practice?" it is obvious that there is no clear scientific evidence to answer the question. Thus, at this point in time, one can only rely on an opinion about sedation based on broad, repeated experiences with sedatives and their characteristics along with background knowledge of the child's medical and physical status, behavioral and temperamental attributes, the amount and type of dentistry needed, and sensitivity to subtle details. General anesthesia (GA) is always an option, is 100 % successful in terms of managing patient behaviors, and offers a situation in which quality of care is not dependent on the child's behavior. GA is expensive and is not always covered by insurance parties, and it has associated risks that need careful attention. GA will be discussed in Chaps. 9, 10, and 11.

In summary, a child's behavior will dictate how the child is managed in the dental setting. Key factors of temperament, age and cognitive development, fears/anxieties, family relations, and past experiences are important in understanding why and how a child responds in the dental setting. Some children will require pharmacological management for dental procedures. Choices of sedation versus general anesthesia will depend on the nature of the dental procedures, the maturity of the child's coping abilities, and family considerations including financial resources.

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Preoperative Assessment and Review of Systems

3

Alan R. Milnes and Stephen Wilson

Abstract

Before any sedative medications can be administered to a child in need of dental treatment, a medical history, review of systems, and physical examination must be completed by the practitioner. This chapter outlines a step-by-step process for completing successfully this essential component of a sedation appointment. A review of those systems in which we are primarily interested is presented along with data describing the normal state of affairs for these healthy systems. In addition, common variations from healthy states are presented with a discussion of the implications which will assist the practitioner in deciding whether further investigation is required before proceeding with treatment.

Prior to administering any sedative medications to a child, the responsible practitioner must have accurate and up-to-date information about the child who will receive treatment. This includes discussion and meticulous documentation of the child's medical history, assessing the child's present state of health, and a physical, social, and psychological assessment of the child. A fundamental component of any pediatric sedation is the absolute necessity of a thorough and carefully conducted review of systems, physical assessment, and flawless assessment of baseline vital signs.

The American Society of Anesthesiologists has developed a widely used system for classifying preoperative physical status (Table 3.1) [1]. Unfortunately, this system is highly subjective and lacks the scientific and clinical precision required to precisely define variables such as age, obesity, or the nature and duration of the surgical procedure. For example, an overweight but otherwise healthy 3-year-old who snores nightly and requires four quadrants of dental treatment as well as extraction of maxillary incisor teeth would be rated as ASA 1. In contrast, a 6-year-old child with mild asthma which is well

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Table 3.1 American Society of Anesthesiology

Class	Description
1	Healthy patient
2	Mild systemic disease – no functional limitation
3	Severe systemic disease – definite functional limitation
4	Severe systemic disease that is a constant threat to life
5	A moribund patient who is not expected to survive for 24 h with or without operation

Physical Status Classification [1]

controlled who requires one simple extraction would be rated as ASA 2. In actual fact, the first child, rated ASA 1, presents a greater risk for complications during treatment under sedation or anesthesia than the child rated as ASA 2 because of the length and nature of the dental procedure, the history of snoring, and the effect of extra body mass on the upper airway, even though the latter child has a mild systemic disease with no functional limitations.

Despite these shortcomings, the ASA classification system is useful in helping to determine a child's suitability to receive sedation in the dental office. Children classified as ASA 1 or 2 are generally acceptable candidates for treatment in the dental office. Children classified as ASA 4 are best managed in a hospital setting as inpatients. Patients classified as ASA 3 who are stable and well controlled can be safely managed in the dental office provided the procedures planned are of short duration and the targeted depth of sedation is anxiolysis. Unstable ASA 3 patients or ASA 3 patients who require longer, invasive dental procedures are best managed in a hospital setting under general anesthesia. For all patients with a preexisting medical problem (ASA 2–4), medical consultation is advisable prior to undertaking the dental procedure.

Preoperative Assessment

There are several reasons for completing a preoperative assessment and review of systems. Information gathered in the preoperative assessment influences decisions made during the remainder of the sedation appointment and in the postoperative period. A preoperative assessment provides the opportunity for the practitioner to identify risk factors which may impact on treatment planning, engage in a discussion with the parent and staff about the risks identified, and take steps to eliminate or reduce the impact of risks. Most importantly, the preoperative assessment helps the clinician to determine if the child is fit for the procedure. Completing a thorough preoperative assessment may help to reduce parent and/or child anxiety as a result of education and communication which occurs during the assessment. A preoperative assessment also allows the practitioner to determine if further investigations including laboratory investigations or medical consultations are necessary prior to initiating treatment further mitigating risk. Lastly, discussion about the anticipated procedure during the preoperative assessment ensures that the parent, and patient if necessary, has been informed appropriately about the anticipated risks and benefits of the proposed treatment and give consent for treatment.

Medical History

The standard of care dictates that, at the initial dental appointment, all practitioners must obtain an accurate medical history. It is important to remember that the medical history form is a synopsis of the child's medical history. It is a historical account of the child's medical experiences since birth. For the purposes of sedation, however, updating the medical history requires focusing on several key areas. This can be accomplished by the dentist themselves or delegated to a trained auxiliary. Often, a medical history update is completed while the child is assessed physically. The dentist should read the medical history update, confirm its accuracy, and seek clarification where necessary. Table 3.2 outlines key items in the medical history that should be reviewed prior to the sedation appointment. Answers to questions asked in this regard should be recorded and dated in the dental record.

Review of Systems

It is most important to review and assess the current status of the major systems before beginning the procedure as this provides the best indication of the child's fitness for the intended procedure. Important details obtained during the medical history review can be clarified during the review of systems and physical assessment. Generally, the review of systems and physical assessment is completed with the parent present. This may provide emotional comfort for the child but it also provides an opportunity for the dentist to ask the parent questions pertaining to each system as they are reviewed. A quiet environment without distractions helps to maintain child's attention as well as ensuring that the clinician can discern and interpret subtle sounds or signs. The results of the physical assessment should be recorded on the sedation record.

The physical assessment procedure should follow a logical routine beginning peripherally with nonthreatening procedures such as weight measurement and proceeding to those procedures which require more cooperation of the child such as blood pressure measurement. Beginning with relatively simple procedures for which the child is cooperative will help the child to gain confidence, thereby allowing more involved procedures to proceed. In addition to recording the results of a review of systems, clinicians should also record the child's age, weight, and the time when the child last ate and drank.

A general assessment of physical stature is also important. The recent reports of increasing prevalence of obesity in children are concerning to dentists who sedate children [2, 3]. Obesity has a significant impact on cardiovascular, respiratory, gastrointestinal, endocrine, and hepatic systems [2]. Management of the obese patient's airway during sedation can be tenuous at times. An increase in body mass and redundant oropharyngeal airway tissue can result in upper airway obstruction if the clinician is not vigilant in monitoring airway patency or if the patient becomes deeply sedated. Obese patients are also at risk for pulmonary aspiration secondary to increased gastric volume and gastric reflux. Because of these concerns, obese children needing dental treatment with sedation are best managed under general anesthesia. Table 3.3 summarizes the multisystem effects of obesity [4].

Table 3.2 Sedation-specific medical history review

Allergies, in general, and drug allergies, specifically
Adverse drug reactions and outcomes
Current medications including herbal remedies – frequency, dosage
Previous hospitalizations and ER visits – reason, course, and outcome
Previous general anesthetics or sedation – outcomes and complications
Diseases, disorders, or physical abnormalities – current management, responsible physician(s)
Respiratory system – asthma, frequent infections
Cardiovascular system – murmurs, congenital anomalies
GU (renal) system – diseases/anomalies affecting drug clearance
GI system – diseases/anomalies affecting drug absorption/metabolism
Central nervous system – developmental delay, emotional or psychiatric disorders
Special medical conditions – cancer, chemotherapy, visual or aural impairment
Family history of diseases or disorders

Table 3.3 Multisystem effects of obesity in children

Pulmonary	Cardiovascular	Gastrointestinal
Chest wall mass ↑	Cardiac output ↑	Intra-abdominal pressure ↑
CO_2 production ↑	Hypertension	Intragastric pressure ↑
Functional reserve ↓ ↓	Stroke volume ↑	Risk of aspiration ↑
Pulmonary compliance ↓		
Total O_2 consumption ↑		
Work of breathing ↑		

Adapted from Kost [4]

Evaluating Social and Psychological Factors

Clinicians, mistakenly, may overlook social and psychological factors during the assessment of the child believing that physical findings gained from a hands-on assessment are of greater importance than psychosocial issues. A child's personality, social situation, and experiences will determine how they will react to an experience like sedation for dental treatment. Gathering information about the family, its composition and dynamics, and the child's personality and temperament will assist the clinician in utilizing a communication style that is appropriate to the situation. Moreover, this information is very helpful in selecting a sedation regimen which is appropriate for the treatment required, the length of the appointment necessary, and the child's temperament. Is the household led by a single parent? Is the family blended? How many siblings does the child have, their ages, and their relationships with the patient? What communication style does the parent(s) use? Is there a language barrier? What parenting style is most evident? How has the child been socialized? What previous healthcare experiences has the child had, negative and positive, and how have these affected the child's subsequent behavior in healthcare settings?

Negative experiences are more likely to create anxiety about impending dental treatment especially for the young and inexperienced child or for the timid child. Gathering this information requires that the dental team interview the parent and observe the child. Asking the parent about how their child reacts in other social situations can be revealing especially if the situation is perceived by the child to be potentially threatening. For example, a parent who relates that their child clings to them and cries when visiting the family physician or meeting new people is providing information that is most likely predictive of the same reaction in the dental office. Observing the child's body language, facial expression, and willingness to make eye contact all help the clinician in developing a sedation plan.

If the child is developmentally delayed, the clinician must learn more about the developmental issues and how it impacts on the child's cognitive level, expressive and receptive language abilities, comprehension, and attention span. Consulting with the family physician or pediatrician is wise when dealing with a developmentally delayed child. Many developmentally delayed children have associated sensory deficits or hypersensitivities and learning disabilities and often demonstrate behavioral problems which may make the development and implementation of a sedation plan difficult.

Evaluating the Respiratory System

Physical assessment of the child's respiratory system can often commence with observations of the child while the history is being updated. Mouth or noisy breathing, the allergic salute, and a cough are all important signs to be noted. Important areas to consider in the history as related to the respiratory system are summarized in Table 3.4.

When evaluating the respiratory system of a child, it is important to have a working knowledge of normal values. Table 3.5 summarizes respiratory variable for various ages.

Physical examination of airway should include the following:

Identification of obvious anatomic abnormalities
Evaluation of mandibular shape and size, especially retrognathia

Table 3.4 Respiratory system – medical history

Allergies
Anemia
Asthma
Disordered control of breathing
Upper airway obstructions
Frequent airway infection
Chronic congestion
Bronchopulmonary dysplasia
Diaphragmatic hernia
Hyaline membrane disease

Table 3.5 Age-dependent respiratory variables

	3 years	5 years	12 years	Adult
Frequency (breaths/min)	24±6	23±5	18±5	12±3
Tidal volume (mL)	112	270	480	575
V_E (minute ventilation, L/min)	2.46	5.5	6.2	6.4
V_A (alveolar ventilation, mL/min)	1760	1800	3000	3100
V_C (vital capacity, mL)	870	1160	3100	4000
TLC (mL)	1100	1500	4000	6000

From O'Rouke and Crone [5]. Courtesy of George A. Gregory, MD, and Dean Andropoulos, MD

Assessment of the child's ability to open the mouth

Assessment of tonsil/adenoid and tongue size in relation to the volume of the oral cavity and oropharynx

Evaluation of the child's voice

Assessment of habitual breathing mode – oral or nasal

Important anatomical and physiological differences between the pediatric and adult airway are cause for concern in pediatric sedation. The pediatric airway is smaller and more compliant than the adult airway. Forceful contraction of the diaphragm can pull the child's compliant chest wall inward so that even maximal inspiratory efforts cannot generate adequate tidal volumes. The child's tongue occupies a larger volume in the oropharynx relative to the adult. Posterior displacement of a child's tongue during sedation by dental instruments or inappropriate head position may cause severe airway obstruction.

Sleep behavior can often give important information about the airway in children. Loud snoring, sleep disturbance, mouth breathing, nasal stuffiness, and frank sleep apnea are all suggestive of adenotonsillar hypertrophy and resultant partial airway obstruction [6]. Nocturnal enuresis and frequent nightmares also often occur in children with disturbed sleep patterns but, on their own in the absence of adenotonsillar hypertrophy, are not contraindications to sedation.

Tonsils and adenoids are often enlarged in children representing an important cause of upper airway obstruction during sedation. To evaluate tonsil size in a child, an airway examination is essential. Various tonsil classification schemata exist but that developed by Brodsky [7] is most applicable to pediatric dental sedations. Tonsil assessment is best done with the child either lying or sitting in a semi-reclined position. A good light is essential. The objective of airway assessment is to determine the size of the tonsils in relation to the pharyngeal airway. Tonsils that occupy 50 % or more of the oropharyngeal volume may be a significant cause of airway obstruction especially in children who are given medications which induce sleep such as chloral hydrate. Figure 3.1 shows tonsils which occupy less than 25 % of the oropharynx and will not constitute an airway obstruction hazard. Figure 3.2 shows tonsils which are kissing in the midline and represent a significant hazard for airway obstruction.

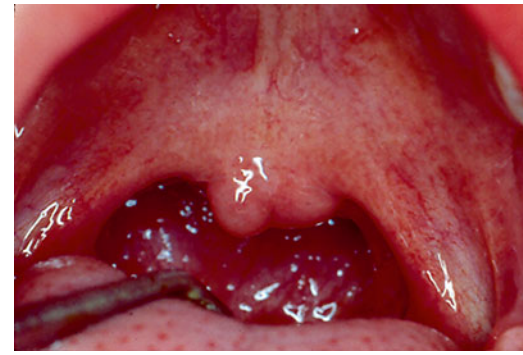

Fig. 3.1 Tonsils which occupy less than 50 % of the oropharyngeal volume are usually not associated with a risk of obstruction during sedation

If the child is cooperative, the clinician can ask the child to open their mouth as wide as possible and then to protrude the tongue as far as possible. It most cases it will be possible to have a quick look at the tonsil size in relation to the airway. If, on the other hand, the child is uncooperative or is crying, a more direct approach is required including parental assistance to firmly

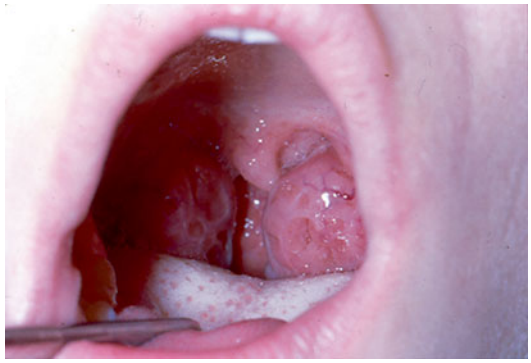

Fig. 3.2 Tonsils which occupy more than 50 % of the oropharyngeal volume are often associated with a risk of obstruction during sedation. As the size of the tonsils increases, the risk of obstruction also increases

hold the child. The knee-to-knee position is effective in this instance. Placing the mirror on the posterior third of the tongue will usually elicit a gag reflex. Rapid visualization is necessary as the child will become more resistant. Remember that the gag reflex will cause the tonsils to move toward the midline and anteriorly making them appear larger than when the airway is at rest. Children with tonsils which occupy more than 50 % of the oropharynx are probably not good candidates for dental treatment under sedation. General anesthesia, except in cases where the treatment is urgent or emergent and can be completed very quickly with minimal sedation, is preferable in these cases.

Examination of the child's respiratory system is best accomplished in a quiet room without distraction. Although the order of the examination is not important, for the purposes of ensuring that the child is fit for sedation, it must be complete. Be sure to use a pediatric stethoscope as the bell and diaphragm of an adult stethoscope are often too large. There are several key differences between adults and children that must be remembered during the physical assessment:

Table 3.6 Respiratory noises

Noise	Quality	Comments
Snoring	Inspiratory, irregular quality	Partial obstruction of upper respiratory tract, usually nasopharyngeal
Stridor	Continuous, harsh inspiratory	Extrathoracic airway obstruction, often subglottic or tracheal
Wheeze	Continuous, musical, usually expiratory	Intrathoracic airway obstruction, dynamic compression of large central airways
Rattling	Coarse, irregular, inspiratory, palpable with hand on chest	Indicates secretions in the trachea and major bronchi

1. Normal respiratory rates for children are faster than for adults.
2. Respiratory sounds are readily transmitted to the child's thorax from the upper airway; the air-filled thorax acts as an amplifier for breath sounds.
3. Because of greater chest wall compliance in children, indrawing is readily observed in children with a respiratory illness such as bronchiolitis.
4. Children have more abdominal movement during respiration than adults.

Pay careful attention to noises emitted by the child during inspiration and expiration (Table 3.6).

Auscultation of the chest requires that the clinician listen over each of the pulmonary lobes. Figure 3.3 highlights auscultation points on the child's chest. Always compare the two sides of the chest during auscultation, characterize the breath sounds, and listen for adventitious sounds. Determine whether the breath sounds are normal, increased, or decreased in intensity and note their quality [5, 8, 9]. Always note any asymmetric differences. Table 3.7 describes adventitious or extra sounds heard during chest auscultation.

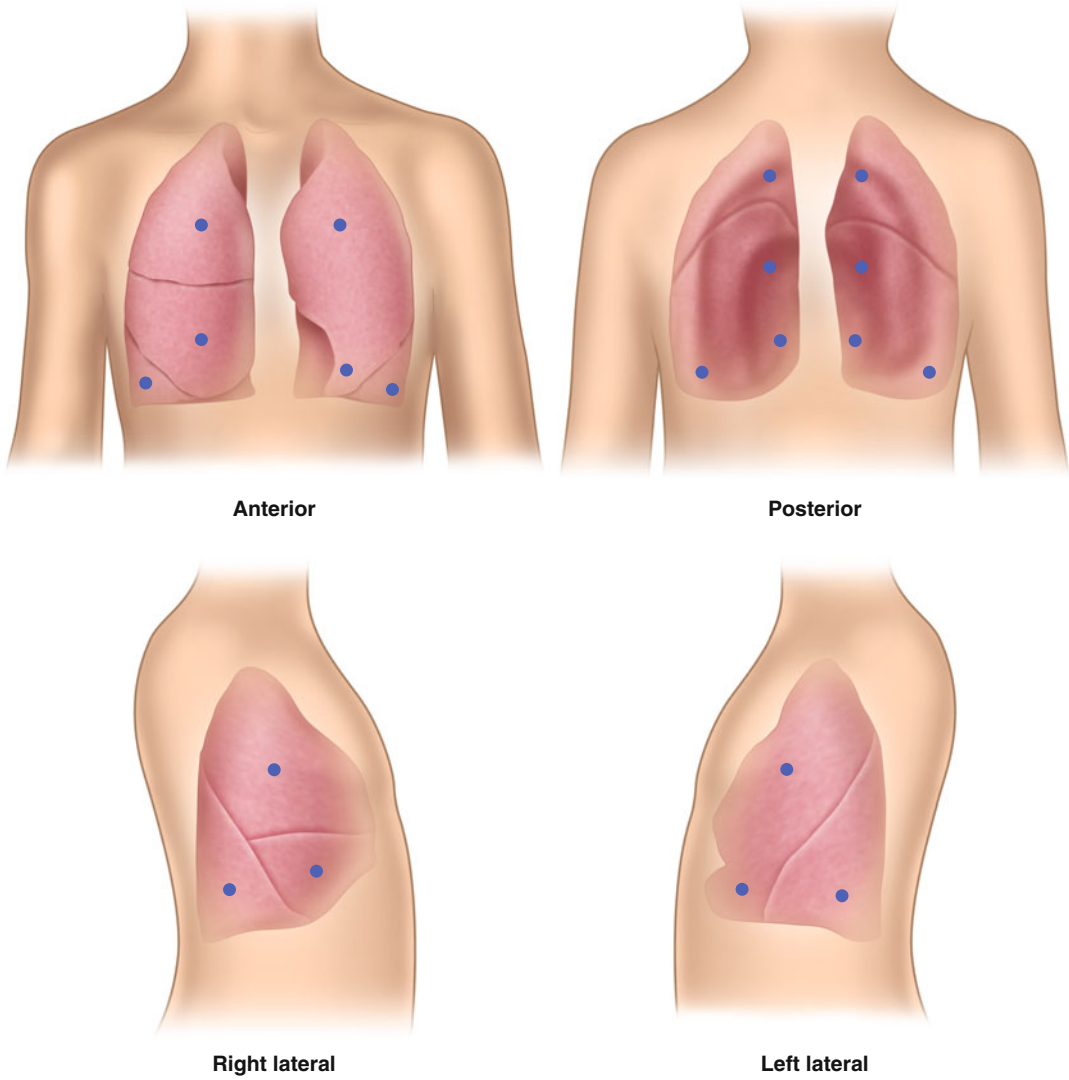

Fig. 3.3 Surface anatomy of the pulmonary lobes and suggested auscultation sites as indicated by the solid circles [8]

Upper Respiratory Infection

The child with a runny nose or cough who presents for dental treatment under sedation is a common scenario in pediatric dentistry. A relatively small amount of airway edema, as would occur when the child has an upper respiratory infection, or an airway obstruction causes a relatively large reduction in the diameter of the pediatric airway. This, in turn, results in a dramatic increase in airway

Table 3.7 Adventitious sounds in the chest

Sound	Description	Comments
Crackles/crepitations (rales)	Short, crackling nonmusical sounds heard on inspiration and expiration	Fine, inspiratory crackles due to alveolar or bronchiolar disease; collapse of peripheral airways; crackle develops as airway reopens and thin film of fluid bursts
Wheezes	Continuous, musical, usually expiratory sounds produced by air moving past obstruction or narrowing airway	Wheezes arise from larger bronchi as air velocity in smaller airways is too slow to produce musical sound. Distinguishing between high-pitched (sibilant) and low-pitched (sonorous) wheezes is probably unnecessary as it may reflect differences in flow rate
Friction Rub	Harsh grating sound synchronous with respiration; friction between two layers of pleura	Distinguish from a pericardial rub; synchronous with respirations

After Hughes [8]

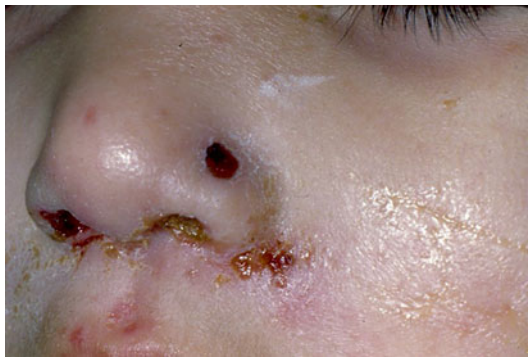

Fig. 3.4 The child in this photo has a significant upper respiratory tract infection (URI) with copious mucous secretions in each nostril. Children with URIs are not good candidates for outpatient sedation

resistance thereby increasing the work of breathing. For this reason, the child with a respiratory illness (Fig. 3.4) is not a good candidate for sedation. It is important to differentiate the reasons why a child has a runny nose or a cough and to differentiate between coughs with which children occasionally present. Table 3.8 lists some common respiratory illness and associated coughs. Table 3.9 describes the pathophysiology of an upper respiratory infection in children. A viral upper respiratory infection (VURI) carries different sedation implications than allergic rhinitis; sinusitis; the prodromal stage of a systemic viral illness such as varicella, rubeola, or influenza; or the prodromal stage of a bacterial illness such as epiglottitis or adenotonsillitis. On the other hand, vasomotor rhinitis associated with crying is quite common in the pediatric dental patient and generally ceases when the crying ends [10].

Table 3.8 Common illnesses and associated coughs

Illness	Cough	Comments
Bronchitis	Initially dry, becomes loose, rattling with time	Sputum production, yellow color not always indicative of secondary infection
Asthma	Dry, tight, and wheezy	Spasmodic, often nocturnal, sometimes associated with vomiting, frequent throat clearing early manifestation of asthma
Croup	Bark of a seal	Sudden onset, URI, inspiratory stridor, hoarse voice
Psychogenic	Canada goose honk	Never occurs during sleep

After Hughes [8]

Table 3.9 Pathophysiologic effects of upper respiratory infection (URI)

Symptom of URI	Effects
Increased nasal secretions	Coughing, laryngospasm
Increased lower airway secretions	Bronchospasm, atelectasis, pneumonia
Increased airway edema and inflammation	Bronchospasm, increased work of breathing, coughing
Increased tachykinins	Increased airway reactivity
Decreased M_2 receptor function	Increased airway reactivity

Modified from Bailey and Badgwell [10]

Most children average 6–9 URIs per year [10]. Children who attend day care or live in homes where parents smoke may have a higher incidence of URIs. The mean duration of a URI is 7–9 days but reactive airways may persist

Table 3.10 History, physical, and other factors for determining whether to proceed with elective dental treatment and sedation in a child with URI

Proceed	Postpone
History	
Recovering from URI – "worse last week; much better now"	Recent or ongoing fever
Runny nose, no other symptoms	Child is acting sick
	Child has been coughing regularly
	Symptoms recently developed (might develop into full-blown systemic illness)
Physical examination	
Clear lungs	Thick, green, or yellow purulent nasal discharge
Activity level unchanged, child looks well	Lethargic, ill-appearing child
Clear rhinorrhea	Wheezing, crackles (rales or rhonchi)
Other factors	
Older child	Child younger than 3 years of age
Short, minimally invasive procedure	History of reactive airway disease
[a]Social issues – large travel distance to facility, lost wages, insurance issues, child care issues, time away from home	Major or lengthy procedure

Modified from Bailey and Badgwell [10]
[a]Least important of all variables. No one variable swings the decision; ALL FACTORS must be considered collectively including treatment required and its urgency

for up to 6 weeks. Trying to schedule elective dental treatment under sedation around a URI can be difficult for both parents and clinicians. A VURI may affect many portions of the respiratory tract. In children with lower respiratory tract involvement, postponing dental treatment until the child is well is prudent as lower airway involvement is associated with airway hyperresponsiveness which may lead to coughing, bronchospasm, and even laryngospasm. The decision to proceed can be based on the history and physical findings and Table 3.10 contains guidelines that may help in making that decision.

Asthma

Asthma is a reactive airway disease that affects many different age groups but is especially problematic in childhood. Three definite characteristics are common to all asthmatics:

- Airway obstruction is reversible or partially reversible either spontaneously or with treatment.
- Airway inflammation.
- Airway hyperreactivity to a variety of stimuli

As airway obstruction is initiated by an inflammatory response which in turn triggers the release of inflammatory mediators from bronchial mast cells, macrophages and epithelial, therapy is directed at reducing bronchial inflammation. A classification for asthma has been recently developed and is of assistance in triaging patients with asthma who require sedation for dental treatment (Table 3.11) [11].

Children with asthma should have a medical consultation before elective dental treatment. During the physical assessment of a child with asthma, active wheezing or decreased breath sounds are ominous signs and should be corrected before dental treatment is undertaken. Medical care should be optimized before dental treatment is attempted. A child using inhaled β-agonists on an "as needed" basis should optimize treatment by taking the β-agonist daily for 3–5 days prior to the scheduled date for dental treatment [12]. A child taking oral or inhaled medications on a daily basis is not a good candidate for dental treatment under sedation and should be treated under general anesthesia in a hospital setting.

Upper respiratory infections in asthmatics are especially problematic. An 11-fold increase in respiratory complications has been reported for children with asthma and concurrent URIs who subsequently underwent elective surgery under general anesthesia [12]. No comparable study has been conducted for dental treatment under sedation for children with asthma and a URI. However, the prudent practitioner should postpone elective dental treatment for 4–6 weeks in these kinds of cases. Furthermore, emergency treatment for

Table 3.11 Severity classification of asthma: before therapy

Severity	Symptoms	Night awakenings	Lung function
Mild intermittent	≤2×/week Exacerbations brief	≤2×/month	FEV ≥ 80 % predicted PEF variability <20 %
Mild persistent	≤2×/week; <1X/day Exacerbations may affect activity	>2×/month	FEV ≥ 80 % predicted PEF variability 20–30 %
Moderate persistent	Daily Daily use of rescue $ß_2$ agonist; exacerbations affect activity ≥2×/week	>1×/week	FEV >60 % but <80 % predicted PEF variability >30 %
Severe persistent	Continual Limited physical activity Frequent exacerbations	Frequent	FEV ≤ 60 predicted PEF variability >30 %

National Heart, Lung, and Blood Institute/National Asthma Education and Prevention Program, Expert Panel Report II: Guidelines for the Diagnosis and Management of Asthma: Full Report. Publication # 97-4051. NIH Publication 97-4051, 1997 [11]

asthma or treatment requiring hospitalization within 6 weeks of the treatment date precludes elective dental treatment.

Evaluating the Cardiovascular System

Children with moderate to severe cardiovascular conditions are generally not candidates for dental treatment under sedation in an outpatient setting. Hence, it is important that the dentist is capable of completing a basic cardiovascular examination in order to triage patients appropriately. For the majority of children who may be candidates for dental treatment under sedation, significant cardiovascular lesions will most likely have been revealed and investigated by 2–3 years of age. However, parents may not have a full understanding of the nature of a cardiovascular condition affecting their child, and it is therefore important that the dentist obtain an accurate history of any cardiovascular condition; investigations which have been completed; ongoing treatment, if any; and precautions that may have been recommended by the physician managing the child's cardiac condition. Questions pertaining to the child's energy level, exercise or activity tolerance, squatting when tired, hypoxic spells, peripheral cyanosis, unexplained syncope, peripheral edema, respiratory distress, poor weight gain, and excessive perspiration will assist the clinician in gathering information which helps to determine if the cardiovascular condition(s) is/are hemodynamically significant [13–15]. Positive answers to any of these questions require that dental treatment be postponed until further investigations or consultations are completed. It may be prudent to schedule dental treatment under general anesthesia in a hospital setting.

Table 3.12 Normal heart rates (bpm) in children

Age	Awake rate	Mean	Sleeping rate
Newborn to 3 months	85–205	140	80–160
3 months–2 years	100–190	130	75–160
2–10 years	60–140	80	60–90
>10 years	60–100	75	50–90

Goldbloom, Richard C. *Pediatric Clinical Skills*, Chapter 10, Table 10-2, page 186, 3rd edition, Elsevier Science-Saunders, Philadelphia [15]

Examination of the cardiovascular system begins with a measurement of vital signs such as heart rate, blood pressure, and oxygen saturation [16]. Normal values vary with age, gender, weight, and height, and it is important to have a working knowledge of normal values (Tables 3.12 and 3.13). It is not uncommon in the preschool child who is crying or combative during either the preoperative assessment or during treatment to achieve heart rates around 200 beats per minute for short periods of time. Furthermore, if the heart rate is elevated and the child is struggling, blood pressure will also increase dramatically.

By far the most common problem clinicians face is the interpretation of heart sounds and murmurs, especially the systolic murmur. Auscultation of the heart is a difficult skill to acquire and to become proficient requires many hours of listening to hearts. There are numerous publications and computer-based materials which provide in-depth instruction in heart sound interpretation [14]. Being able to identify abnormal from normal is essential to provide safe sedation experiences to children in need. To do so, the dentist must have a good understanding of the normal cardiac cycle. It is important to follow a systematic procedure for listening to heart sounds and murmurs in children. Figure 3.5 shows the various listening points on the child's chest as well normal and abnormal sounds for each listening area. Auscultation should not occur through clothing. The child should be examined in the supine position in a quiet room without TV or radio distractions so that the clinician can discern the different heart sounds.

Table 3.13 Normal blood pressures in children

Age	Systolic (mmHg)	Diastolic (mmHg)
Birth	50–70	25–45
Neonate (96 h)	60–90	20–60
Infant (6 months)	87–105	53–66
Toddler (2 years)	95–105	53–66
School age (7 years)	97–112	57–71
Adolescent (15 years)	112–128	66–80

Hazinski [16]

Chest auscultation during the cardiovascular assessment may identify the presence of a previously undetected murmur. This can be a vexing problem for the dentist. Parents should be queried as to whether or not the murmur has been previously detected by any of the child's medical caregivers and if a cardiac evaluation has been completed. If the murmur has not been previously detected, the dentist must decide whether

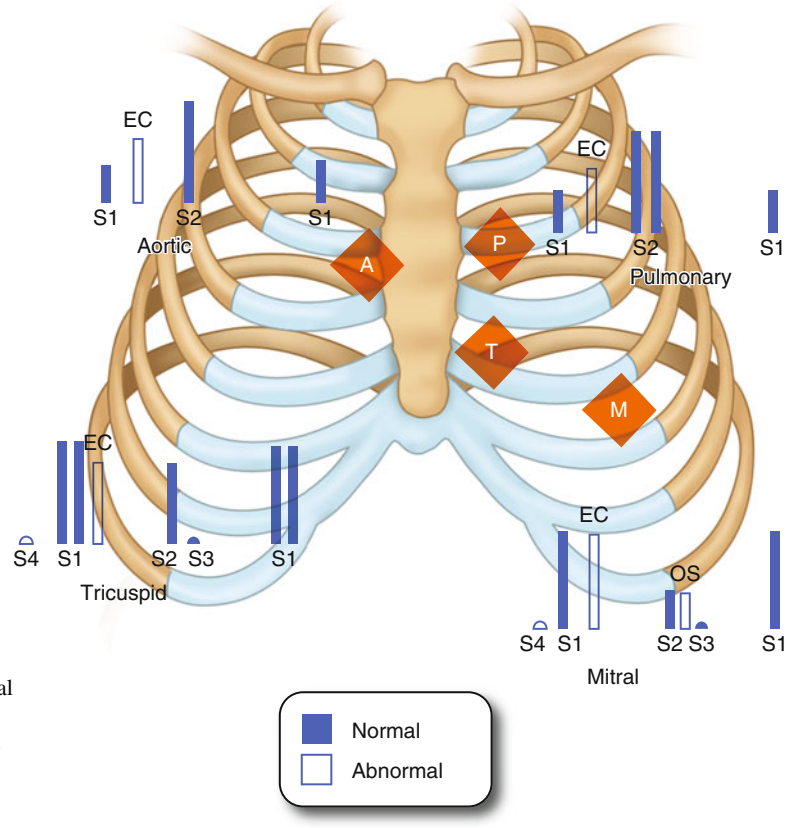

Fig. 3.5 Auscultation points over the child's cardiac valves are indicated by the triangular areas marked *A* aortic, *P* pulmonary, *T* tricuspid, and *M* mitral. The bars represent normal (black) and abnormal (open) sounds each of the conventional auscultation areas. *EC* ejection click, *OS* opening snap [13].

Table 3.14 Medical history – CNS/neuromuscular

Seizure disorders
Swallowing incoordination – dysphagia
Ventricular shunts
Abnormal level of consciousness
Neuropathy
Myopathy
Cerebral palsy
ADD/ADHD
Emotional/behavioral disorders
Psychiatric disorders

to continue with treatment or cancel treatment pending a cardiology consultation to determine the cause of the murmur. The vast majority of murmurs in otherwise healthy children can be classified as innocent flow murmurs. These are usually not louder than II/VI, are usually vibratory in nature, and occur in systole over the pulmonary or mitral valve areas of the chest wall. Murmurs which sound like a breath sound are not innocent murmurs. Sounds which occur at the opening of any valve usually indicate a problem. If these characteristics are not present or if there are other findings relevant to the cardiovascular system in the history or physical examination, a cardiology consultation should be obtained.

Central Nervous System

The neurologic system is the third major system of interest in the preoperative evaluation as this system is most directly and profoundly affected by sedative agents with the primary effect being a reduction in the level of consciousness. This is a very complex area with numerous conditions and diseases that have wide variations both in clinical presentation and management. Hence, each case must be assessed thoroughly on its own merits including consultation with the physician responsible for the child's care or an anesthesiologist. Table 3.14 lists examples of common conditions which the pediatric dentist may encounter.

Children with a neurological, developmental, or psychiatric disorder are often difficult to sedate for the following reasons. The level of sedation is often difficult to assess due to an already altered level of awareness or altered perception of surroundings and people. This group of children is also more likely to experience a paradoxical reaction to sedative medications, an increased incidence of interactions with other centrally acting medications, and an increased metabolism of sedative drugs if already taking anticonvulsants. In addition, lack of coordination of various muscle groups such as those associated with swallowing may place a child at risk for aspiration when sedated. Should the decision be made to proceed with sedation, it is recommended that only anxiolysis or minimal levels of sedation be produced in a dental office setting. Deeper levels of sedation require that treatment be provided in a hospital setting.

Preoperative Fasting

Ensuring that feeding instructions have been followed preoperatively is an important component of the preoperative assessment. Multiple studies have shown that clear fluids are rapidly emptied from the stomach regardless of chronological age. Studies from the pediatric anesthesia literature show that children of all ages who ingest clear fluids up to 2 h prior to induction of anesthesia have a similar gastric volume and pH as those who have fasted for much longer periods. There is no known association between the volume and pH of gastric contents and the risk of pulmonary aspiration. Similarly, there is no consensus as to the maximal amount of clear fluids that can be ingested within currently accepted feeding guidelines. The general consensus now is that children may consume unlimited amounts of clear fluids up to two hours before administration of sedative agents, breast milk may be consumed up to 4 h prior, and nonhuman milk up to 6 h before administration of sedative agents [17]. Solid foods should be restricted for a minimum of 8 h before sedative agents are administered. Clinicians should question parents to verify that nonhuman milk and solid foods have been restricted for 6–8 h preoperatively as these will delay gastric emptying and that feeding instructions for clear fluids have been followed.

Summary

This review has discussed the process of completing a preoperative assessment and review of systems for a child who is to receive sedation for completion of dental treatment. It is essential that this is done well to ensure that a child requiring dental treatment under sedation can be treated safely without complication. This component of the sedation appointment is all about identifying risks and taking the appropriate steps to mitigate them. Readers are encouraged to continue to develop their physical diagnosis skills.

Protocol for Preoperative Assessment and Review of Systems

Child's name, age (years and months), weight (kilograms)
Accompanied by whom? Two adults present?
Last food and fluid intake – within feeding guidelines?
Last voided?
Review medical history with parent(s)
Current medications including herbal medications
Medical conditions and current status/treatment
Allergies?
Review of systems – respiratory, CVS, CNS, GI, GU, musculoskeletal
Behavioral assessment – interaction, cooperation
Respiratory examination – anatomic abnormalities
- Mouth opening
- Tonsil/adenoid assessment
- Habitual breathing pattern
- Recent URI? Current status
- Sleep history – snoring and frequency, apnea, nightmares
- Chest auscultation
- Respiratory rate

Cardiovascular examination – heart sounds
- Heart rate
- Blood pressure
- Oxygen saturation

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Sedative and Anxiolytic Agents

4

Steven I. Ganzberg and Stephen Wilson

Abstract

This chapter outlines sedatives and anxiolytic agents commonly used and administered orally to sedate children for dental procedures. The salient features of nitrous oxide, chloral hydrate, meperidine, midazolam, antihistamines, and ketamine are discussed in relation to sedating children for dental procedures. Nitrous oxide is most frequently used and can be administered alone or with the other agents. Midazolam is the most frequently used oral sedative in children. Most of these agents can be used in various combinations when sedating children; however, caution must be taken when using two or more of these agents at a single appointment to decrease the likelihood of adverse events. Summary tables of the drug characteristics are also provided.

This chapter outlines sedatives and anxiolytic agents commonly used to sedate children for dental procedures. Rarely are these agents used alone in children; thus, combinations of two or more sedatives are common. Caution is advised whenever two or more agents are used in combination in children. Adherence to therapeutic doses of all drugs, including local anesthetics, is essential in minimizing the likelihood of adverse events in children. The pharmacology of the sedatives agents will be discussed followed by clinical applications of sedative agents in the dental setting.

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Common Sedatives for Pediatric Dental Patients: Pharmacology

Nitrous Oxide

Nitrous oxide is the most commonly used sedative in the pediatric dentistry practice [1–3]. It is an inhalation agent that rapidly affects the central nervous system (CNS) causing mild sedation,

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anxiolysis, and analgesia; it also has properties mediating mild affective and perceptual changes. Its mechanism of action is not fully appreciated but likely interacts with several receptors (e.g., gamma-aminobutyric acid [$GABA_a$]) in the CNS, influencing ion channel activity. One of the transmembrane receptor complexes of which nitrous oxide may affect is the activity of the N-methyl-D-aspartate receptor (NMDAR), a glutamate receptor, which is involved with learning and neuronal plasticity.

Nitrous oxide, a liquid in a pressurized cylinder that vaporizes and is available for inhalation, is an inorganic gas that is colorless, nonirritating, and essentially odorless. It has very low solubility in blood, and equilibrium between alveolar and arterial tensions is rapidly established. When inhaled, it rapidly diffuses into the blood stream and begins to influence the CNS within minutes. Likewise, in reverse format, when cessation of nitrous oxide administration occurs, it rapidly diffuses out of the blood and is exhaled within minutes. Thus, its onset and termination process takes only 2–3 min. Nitrous oxide is not metabolized in the body and is essentially eliminated through the respiratory system. Nitrous oxide may be one of the safest agents available in dentistry and is the most frequently used agents for children when delivered via an open system in the dental setting.

The dental delivery system is considered as an "open system" allowing the individual to entrain room air along with the nitrous oxide via the nasal hood and mouth (Fig. 4.1). Evidence suggests that the concentration entering the hypopharynx and nasopharynx is significantly reduced from that set at the manifold of a dental delivery system. The reduction in nitrous oxide concentration can be as much as 63 % [4]. This delivery system contrasts with a "closed system" wherein the patient is intubated and receives the nitrous oxide with minimal or no entrainment of room air.

Clinical

Nitrous oxide is an excellent tool for aiding children who are mildly to moderately anxious in the dental chair. Normally, the concentration of nitrous oxide for wary or mildly fearful pediatric patients ranges from 25 to 50 %. It is the author's opinion that the 35–45 % range works best for most children. Moderately fearful children may require higher concentrations of nitrous oxide initially, but once benefitting from its effects, the concentration can be lowered and still maintains its effectiveness.

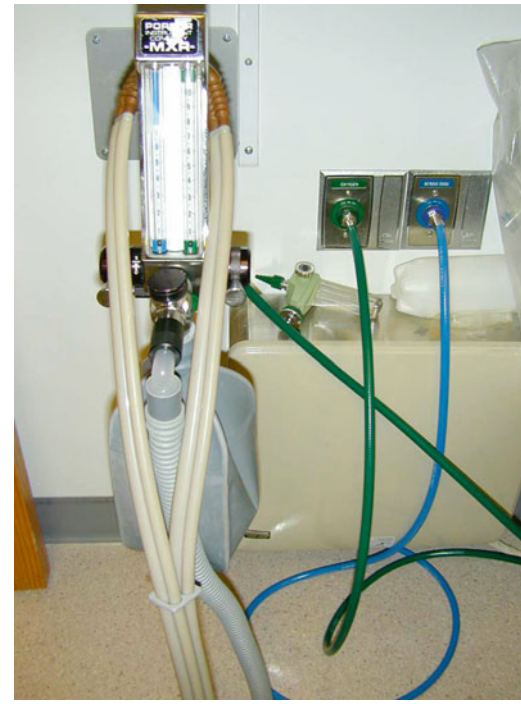

Fig. 4.1 Dental delivery system for nitrous oxide administration

Like all tools for guiding patient's behaviors and responsiveness, the effectiveness of nitrous oxide is greatly dependent on the talents of the dentist who must have good "bedside" manners, a calming disposition, in-depth working knowledge of behavioral guidance techniques, and confidence in his/her skills of behavior guidance. One of the first steps, other than gaining the patient's trust, in the successful use of nitrous oxide is introducing the child to the hood in a way that maximizes his/her curiosity and acceptance and minimizes the child's anxieties about personal intrusiveness or fears of suffocation.

Ideally the child will accept the nasal hood. If this is the case, the dentist can begin the most frequently used technique of administering nitrous oxide which is referred to as titration. Titration is

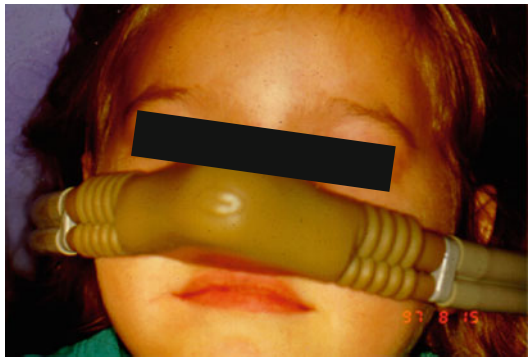

Fig. 4.2 Patient receiving nitrous oxide. Note slight smile and faraway stare as if "look at the stars"

the process of slowly increasing the concentration of nitrous oxide in small steps wherein until the child exhibits, characteristically, ideal clinical signs and symptoms. For example, the patient may be started with a concentration of 15 % nitrous oxide and oxygen and allowed to inhale this mixture for a period of a minute or two, then the concentration is increased by 5 or 10 %, and again the patient inhales this mixture for another minute or two. At each step or change in concentration, the dentist is observing the patient for positive signs such as staring ahead into space and body posturing of quietness, relaxation, and warm, opened hands as well as querying the patient about how they feel (Fig. 4.2) or possibly suggesting what they should be feeling. If the concentration becomes too high, the patient may become agitated, have more spontaneous movement, clench their jaws, and even panic and quickly pull the nasal hood off their nose. Usually the idea concentration of nitrous oxide for children is between 35 and 50 %. Higher levels can be used under certain circumstances as will be explained shortly.

Some children will not readily accept the hood or already be in such a state of agitation and disruptiveness that normal placement and titration of nitrous oxide is impossible. A second means of administering nitrous oxide is possibly now indicated. This technique is referred to as the rapid technique of administration of nitrous oxide. It should be noted that this is an aggressive technique usually involving the dentist and dental assistant but is surprisingly a success on many children. The rapid technique involves the dentist placing the hood and tubing between the thumb and first finger of each hand and with the palms of the hands placed on the sides of the child's face, holding the nitrous oxide slightly off the face but covering the nose and mouth area of the face (Fig. 4.3). Remember the child will be struggling and want to move the head from side to side as well as turn away and/or raise their hands to grab the dentist's hands and nasal hood. The dentist simply follows the head movements using his cupped palms which are gently touching the sides of the child's face. During this phase, the dentist is constantly informing the child that everything will be OK. Simultaneously and in concert, the dental assistant now comes into play by leaning protectively over the top of the child's body near his/her waistline and holding the child's hands. Sometimes the parent, if present, is willing to do the same; alternatively, the child may be restrained in a passive device (e.g., Papoose board) if a decision is made to try this rapid-induction technique.

It should be noted that the nitrous oxide concentration is turned to 70 % immediately before the beginning of the rapid-induction technique. If the child does not settle down within 6–10 min at this concentration, then the technique should be abandoned and another alternative treatment should be considered (e.g., general anesthesia). If the child does begin to calm down (and this doesn't happen like the flip of a switch) and appears to be "listening" to the dentist, then the concentration should be turned down to 50 %. Talking with the child and giving positive verbal feedback is also helpful at this time. As mentioned previously, this technique surprisingly works frequently especially with preschoolers.

Although beyond the scope of the purposes of this writing, nitrous oxide hygiene should be briefly mentioned. For patient and possibly more for the dental team, good nitrous oxide hygiene should always be practiced. This includes minimizing nitrous oxide in the ambient air by using a well-designed scavenging system, use of fans, and rapid turnover of room air circulation. It should be noted that children who are too talkative or cry throughout the dental

Fig. 4.3 Administration of high concentration of nitrous oxide to patient in rapid-induction technique. While the patient typically moves head from side to side (**b** and **c**), the dentist uses hands to stabilize the hood slightly off the face and over the nose and mouth of the patient (**a**)

procedure, thus poorly benefitting from its use, tend to breathe or shunt more of the nitrous oxide into the ambient air of the operatory. Hence, for these children, the practitioner should probably terminate its delivery and use other techniques including rescheduling for a sedation appointment.

The nitrous delivery system should be checked daily for leaks in the ventilation bag as well as the tubing leading from the manifold to the patient. The bag should be changed on a regular basis as the gases tend to dry out the bag causing tiny cracks particularly along crease lines in the bag. Additionally, it is advisable to have periodic testing of the dental operatories by an independent service and make every effort to keep the concentration of nitrous oxide in the ambient air at 25 ppm or less. Compliance with state dental regulations related to nitrous oxide use in the office is also a must for every practitioner who uses nitrous oxide in their offices.

Benzodiazepines

We may know more about benzodiazepines than any other sedatives (e.g., chloral hydrate) despite their shorter clinical history. Benzodiazepines are sedative agents that characteristically have properties causing variable degrees of skeletal motor inhibition, sedation, hypnotic effects (sleep-inducing), anticonvulsant, anxiolytic, and some amnesia. The properties of the benzodiazepines are such that each benzodiazepine may possess some or all of the common effects

usually attributable to this class of drugs but expressed in variable and pronounced ways allowing selections of benzodiazepines to address specified clinical needs.

Benzodiazepines are thought to act primarily in the CNS as agonists affecting a specific subtype of γ-aminobutyric acid receptor complex called $GABA_A$. $GABA_A$ mediates postsynaptic inhibitory activity on other systems of the CNS through control of Cl^- gates in neurons. GABA, a neurotransmitter, acts on Cl^- gates in neurons causing an opening for Cl^- ions to flow into the neuron hyperpolarizing it. Thus, GABA receptors which are actually large macromolecules capable of being activated by various substances are thought to have dominant inhibitory effects within the CNS. The other subtype of GABA receptor complex is a G-protein-linked receptor that apparently does not clinically respond to benzodiazepines. There are actually several benzodiazepine "receptors" within the GABA receptor complex mostly found in the CNS that may be responsible, to some degree, in causing the different benzodiazepine effects (e.g., sleep-inducing). However, this may be a simplistic view of the myriad of benzodiazepine profiles. Benzodiazepines may influence other neurotransmitter receptors other than GABA complexes (e.g., 5-hydroxytryptamine), and the interactive complexities may orchestrate in a way in producing clinically recognized effects.

Benzodiazepines are metabolized via the hepatic microsomal enzyme system and primarily excreted through the kidneys. The different benzodiazepines are metabolized differentially, and many of these agents are metabolized into other benzodiazepine derivatives which may also cause some minor clinical effects. Likewise, variations in lipid solubility, rates of protein binding, and distribution in fatty tissues account for differences in onset, duration of action, and elimination from the body. Care must be exercised to prevent possible adverse situations whenever benzodiazepines are administered in the presence of other agents or substances that interact with the hepatic microsomal enzyme system (e.g., grapefruit juice).

Clinical

By far, the most common benzodiazepines used for pediatric sedation is midazolam. It has a rapid onset and short duration of action, but contains no analgesic properties. Depending on the dose administered, typical behaviors can be observed after its oral administration. Typically, changes in patient behaviors can be perceived in less than 10 min. Generally, the child is less active and slightly more introverted or quiet. Relaxation of the limbs and even less mobility shortly becomes apparent. Eventually the child may become clinically limp and unable to stand or sit unaided, but still maintains eye contact. Respiration and cardiovascular parameters usually remain within appropriate clinical ranges for the patient's age. Hiccups are occasionally witnessed and will disappear within 15–30 min in most cases. Any movements or verbalizations associated with initial procedural events are present, but blunted for a period of 15–25 min; however, after this time frame, in many cases impatience and intense reactivity to procedures become growing prominent.

Benzodiazepines can cause drowsiness, respiratory depression, allergies, and, probably most important for pediatric sedation, paradoxically reactions. During paradoxically reactions associated with midazolam, the patient actually becomes excited rather than calm and relaxed; notable clinical changes include agitation, irritability, hyperactivity, rage, and hostility even toward the caregiver. The delayed paradoxical reaction typically becomes apparent within 30–40 min after its administration and lasts 1–3 h.

Midazolam is a good agent for short dental procedures such as a simple primary tooth extraction, but longer procedures may not be tolerated well by the child and disruptive behaviors may dominate. In a minority of cases, the disruptive behavior progresses to frank agitation and expressions of anger directed at anyone near the child including the parent as mentioned previously. This drug-related response has been called by various names, but may be characterized as the "angry child response" [5]. No definitive evidence is available for the number of children

sedated with midazolam that exhibit this state, and likewise, little documentation for the duration of this response is readily available. It is the author's opinion that this angry child response occurs in approximately 20 % and lasts for 1–2 h. There is some evidence that this response tends to be inversely related to the age of the child (e.g., more frequent in 2-year-olds) [6]. Also, some evidence exists to suggest that flumazenil will reverse the paradoxical reaction [7]. Another infrequent finding associated with midazolam when used alone is the presence of hiccups. The hiccups are not clinically significant and tend to disappear along with other effects as the drug is metabolized.

Diazepam and triazolam are also two other benzodiazepines used with children. Little evidence exists to suggest significant differences in the occurrence of sedated behaviors as a function of these agents. However, subtle timing differences suggest that the onset and length of working time may be slightly enhanced for diazepam and triazolam compared to midazolam. Hence, for longer dental procedures in older preschoolers and school-aged children, it is possible that diazepam and triazolam may be preferred over midazolam. Bouts of agitation can also occur with these two agents similar to that of midazolam. Some benzodiazepines come in a single-dose oral formulation (Fig. 4.4).

Flumazenil is a benzodiazepine receptor antagonist. Flumazenil which is approved for intravenous administration only can reverse therapeutic doses of benzodiazepine effects including sedation within a minute or so. If flumazenil is administered by another parenteral route (e.g., submucosal), the duration required for reversal effect onset will be longer and may require intermediate, adjunctive interventions in an adverse situation (e.g., bag valve mask for respiratory depression or apnea). Furthermore, flumazenil apparently may not last as long as the benzodiazepine is being reversed; hence re-sedation effects can occur. Because of the possibility of re-sedation following reversal in hospital settings, administration of reversal agents generally requires a longer postoperative care monitoring period before discharge occurs. Flumazenil can also reverse some paradoxical reactions to benzodiazepines [8].

Fig. 4.4 Example of single dose delivery package of diazepam

Meperidine

Meperidine is a synthetic opioid agonist with analgesic and atropine-like properties that has been popular among pediatric dentists for years. The gold standard for opioid agonists is morphine. Apparently there is no difference in behaviors in children sedated for dental procedures comparing morphine to meperidine [9]. Meperidine is approximately 1/10th the potency of morphine; however, it is equivalent to morphine in terms of the degree of sedation and respiratory depression. The duration of action of meperidine is less than that of morphine, and its oral effectiveness is significantly reduced compared to parenteral doses due to its first pass through the liver.

Meperidine administered in high doses can cause CNS tremors and convulsions. This effect is due to normeperidine, produced by demethylation of meperidine in the liver. In fact there is some evidence that high doses of meperidine interacting with local anesthetic doses that are high or exceed therapeutic values can induce

seizures followed by respiratory depression and coma [10]. Meperidine is metabolized in the liver and excreted through the kidneys. As an opioid agonist, meperidine is thought to function by binding to opioid receptors in the CNS, primarily mu (μ) and k (κ) to inhibit ascending pain messages and modify affect related to pain.

Clinical

Meperidine when used to sedate children in the dental setting is usually administered by the oral route. Onset of effects can be appreciated in 20–30 min, and working time may extend upwards to 45 min to an hour assuming good behavior guidance is also applied.

Another route that is less popular is that of the submucosal injection similar to the infiltration of local anesthesia in the maxillary buccal vestibule adjacent to the first or second primary molar. The onset via this route is faster (i.e., 10–15 min), and the working time is essential the same as when given orally. Care must be exercised when administering submucosally, as sudden hypotension and respiratory depression can occur rapidly if inadvertently injected into the pterygoid plexus behind the maxillary tuberosity in children.

Meperidine can cause localized release of histamine when injected submucosally causing redness and itching over the malar area. It is thought that meperidine when administered orally may cause itching in and around the facial area; thus occasional rubbing of that area by the dentist in a restrained patient is recommended. Opioids, including meperidine, directly stimulate the chemoreceptor trigger zone in the medulla causing nausea and emesis which are not beneficial as a single agent in sedating children. Because of this side effect, hydroxyzine which has antiemetic effects is often administered with meperidine. Precaution is advised though as this combination of agents, like most, may increase the depth of sedation.

Clinically, the advantages of meperidine for sedating children during dental procedures are best appreciated as mediating mood changes and providing mild analgesia. The mood changes typically are euphoric-like in the majority of patients; however, a small proportion of children may have the opposite effect of dysphoric mood changes that compromise the outcome of sedation procedures. One must always be vigilant of the amount of local anesthetic used during sedations especially when multiple sedative agents are used. Since meperidine can add to the analgesic effect of local anesthesia, it is possible to use little or no anesthetic for doing simple and shallow class I preparations on primary molars.

Combining meperidine with midazolam can be beneficial in that the primary effects of each may produce a better clinical outcome. Anxiolysis, relaxation, a mellow mood, and increased analgesic effects may be possible when the doses of each agent are appropriate. Increased effectiveness has been suggested in one study when this combination is compared to midazolam alone [11]. It is important to note that higher doses of this combination can cause somnolence or deep sedation potentially compromising functional airway competency and endangering patient safety. Meperidine and midazolam can both be reversed with naloxone and flumazenil, respectively, with intramuscular administrations in the patient's thigh. Advanced management of a compromised airway though may be necessary under these circumstances because of the longer onset of action associated with the intramuscular versus intravenous administration of the reversal agents.

Meperidine can also be administered with other sedatives to complement effects. For instance, a very effective combination of agents for older preschoolers (i.e., 3–5 years) is a low dose of chloral hydrate (10–20 mg/kg), meperidine (1–2 mg/kg), and hydroxyzine (1 mg/kg). This "triple" combination produces moderate sedation in most children of this age wherein ptosis or closure of the eyelids occurs, but the child remains responsive to verbal commands or very light physical stimulation. Some children may enter into deep sedation with this combination, and thus appropriate monitoring and management via training is required. Higher doses of chloral hydrate in this combination can rapidly lead to deep levels of sedation, and caution in its use is highly advised as the only reversible agent is meperidine.

Chloral Hydrate

Chloral hydrate is one of the oldest sedatives used for dental sedation. It has been very popular in pediatric dentistry since the mid-1950s. Chloral hydrate is classified as a sedative-hypnotic and is known to induce sleep in children. Chloral hydrate is rapidly absorbed following oral administration and is converted through its first pass in the liver to trichloroethanol, its active form. Trichloroethanol is conjugated in the liver and excreted in the urine. Like other agents that are metabolized in the liver, chloral hydrate may interact with other drugs, herbs, or foods resulting in clinically significant alterations of the agents (e.g., warfarin).

Trichloroethanol is a CNS depressant. Its mechanism of action is not fully understood; however, studies have shown that chloral hydrate, α-chlorose, and trichloroethanol interact with the GABA receptor complex, specifically the $GABA_A$ subunit which is also activated by benzodiazepines [12]. Hyperpolarization occurs as a result of increased Cl^- conductance; hence inhibitory action is noted. Again, like the benzodiazepines, it is possible that chloral hydrate affects other neurotransmitter activating complexes, and the range of clinical effects witnessed may be expressed through the configurations of active receptor complexes throughout the CNS.

Chloral hydrate is a mucosal and gastric irritant. Its used is contraindicated in patients with esophagitis, gastritis, and duodenal inflammation. Choral hydrate has also caused laryngospasms and cardiorespiratory arrest after its aspiration [13]. Care must be taken that choral hydrate is not splashed into the eyes of the child or the individual administering chloral hydrate. In higher doses, chloral hydrate has been known to cause cardiac arrhythmias requiring immediate medical intervention. Chloral hydrate when administered with other sedative agents produces deeper levels of sedation than when either is used alone.

Clinical

Clinically in therapeutic doses (20–50 mg/kg), one typically sees a slight or even prominent hyperexcitability stage within 20–30 min after the administration of chloral hydrate. The hyperexcitability in children is manifested as hyperactivity, talkativeness, and frank change from shyness to friendliness. This stage usually lasts 20–30 min, before sleepiness begins to dominate, especially when higher doses of chloral hydrate are used (i.e., 40–50 mg/kg). Sometimes the hyperexcitability stage does not wane and makes the performance of dentistry challenging if not impossible.

Chloral hydrate is rarely administered alone anymore to children who undergo dental procedures. It is usually mixed with hydroxyzine which aids in minimizing vomiting and to deepen the level of sedation. Another popular "cocktail" is chloral hydrate with meperidine and an antiemetic such as hydroxyzine. This "triple" cocktail can readily produce deep levels of sedation and caution is advised. A "light" triple cocktail involves very low doses of chloral hydrate (10–20 mg/kg). This lighter version significantly lessens the depth of sedation, but still can cause unconsciousness in some children. In fact, whenever any sedative agent is combined with another, it is advisable to decrease the therapeutic dose of each agent.

The production of the oral solution of chloral hydrate was discontinued in 2012, limiting its availability. Compound pharmacists can still make a compounded solution of chloral hydrate but not on a volume basis (i.e., has to be prescribed and compounded, individually, for each patient).

It is thought that chloral hydrate does not have a reversal agent. Nonetheless, one clinical report did indicate that flumazenil reversed respiratory depression and hypotension in a chloral hydrate overdose situation involving a young man [14]. Regardless, one should never rely on this possibility in preplanning sedations with chloral hydrate.

Antihistamines

Some antihistamines had been used for sedation in children. The most popular antihistamine is hydroxyzine, although promethazine and diphenhydramine are sometimes used in sedative combinations. These antihistamines have other properties including antiemetic effects. Hydroxyzine used in combination with other sedatives may reduce the incidence of nausea or vomiting. They also have some anticholinergic properties.

Antihistamines can also be used as a singular sedative agent; however, the amount of sedation achieved in therapeutic doses is minimal especially under challenging conditions associated with dental procedures. The use of communicative behavior guidance techniques, antihistamines, and nitrous oxide can produce amazingly good results for children who have mild anxiety.

Hydroxyzine has some other benefits that suggest its use as an adjunct with other sedatives including bronchodilatation, antiarrhythmic properties, very mild analgesia, and drowsiness. Its mechanism of action is not fully appreciated, but the primary target appears to be subcortical portions of the CNS. Hydroxyzine is rapidly absorbed from the gut with noted effects within 15–30 min. It is metabolized in the liver and excreted through the kidney.

Ketamine

Ketamine is a dissociative anesthetic which has been used infrequently as an orally administered sedative in children for at least a decade. When used intramuscularly or intravenously, it has impressive effects especially when used on uncooperative, combative patients. Furthermore, it provides analgesia and spares the cardiovascular system from any depressive effects. In fact, cardiovascular parameters (e.g., heart rate and blood pressure) are minimally stimulated. It also produces a dissociative state in which communication with the patient is impossible. Some annoying side effects include increased salivation, adverse emergence phenomenon (e.g., nightmares), and vomiting. Under these circumstances, the provider should have a general anesthetic permit or work with another professional (e.g., dental anesthesiologist) who is trained and experienced with the use of anesthetic agents.

Studies using ketamine administered orally have resulted in mixed results. Onset time averages 20 min. Although annoying side effects (e.g., hallucinations and vomiting) can occur [15, 16], it appears that the incidence of vomiting, one of the adverse side effects of ketamine, is reduced when used in lower doses with other sedatives (e.g., promethazine) [17, 18]. One study examined the effects of ketamine administered intranasally. They concluded that ketamine administered as a mist was significantly better than drops (both intranasally) for behavioral measures as well as onset and recovery periods. However, vomiting was an issue for both types of intranasal administration of ketamine [19].

The side effects, cautions, and pharmacotherapeutics of the agents described in this chapter are shown in Table 4.1. Other agents such as morphine have been used to sedate children for dental care [9]; however, their use and supporting literature is rare and thus will not be reviewed in this textbook.

Table 4.1 Characteristics of drugs used for oral sedation

Chloral hydrate						
Usually one's sedation goals are the first two depths of sedation of the American Academy of Pediatric Dentistry guidelines (i.e., minimal and moderate sedation). However, in small uncooperative children, the optimal level of sedation is that of very light sleep from which one can be easily aroused with minimal verbal or tactile stimulation. The therapeutic dose range that usually produces this type of effect, when used alone, in the majority of children is 30–50 mg/kg of body weight. This dose also can cause hypotonicity of the muscles of the tongue causing it to fall backward against the posterior oropharyngeal structures. Appropriate patient monitoring (pulse oximetry and capnography) is necessary because of the possibility that airway compromise due to hypotonicity of glossal muscles, deep sleep, and/or some respiratory depression may occur.						
Dose: oral route	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
10–50 mg/kg when used alone 10–25 mg/kg if used with other agents such as meperidine and hydroxyzine	Central nervous system depressant effects are primarily due to its active metabolite trichloroethanol, mechanism unknown	Onset of action, 10–20 min Maximum effect: within 30–60 min Duration, 4–8 h Mean half-life, 10 h Elimination: metabolites excreted in the urine; small amounts excreted in feces via bile	Sensitive to light; exposure to air causes volatilization; store in light-resistant, airtight container at room temperature; do not refrigerate	Hypersensitivity to chloral hydrate or any component; hepatic or renal impairment; severe cardiac disease Oral forms are also contraindicated in patients with gastritis, esophagitis, or gastric or duodenal ulcers	Deaths and permanent neurologic injury from respiratory compromise have been reported in children sedated with chloral hydrate; respiratory obstruction may occur in children with tonsillar and adenoidal hypertrophy, obstructive sleep apnea, and Leigh's encephalopathy and in ASA class III children; depressed levels of consciousness may occur; chloral hydrate should *not* be administered for sedation by nonmedical personnel or in a non-supervised medical environment; sedation with chloral hydrate requires careful patient monitoring (Cote, 2000); animal studies suggest that chloral hydrate may depress the genioglossus muscle and other airway-maintaining muscles in patients who are already at risk for life-threatening airway obstruction (e.g., obstructive sleep apnea)	Central nervous system: disorientation, sedation, excitement (paradoxical), dizziness, fever, headache, ataxia Dermatologic: rash, urticaria Gastrointestinal: gastric irritation, nausea, vomiting, diarrhea, flatulence Hematologic: leukopenia, eosinophilia Respiratory: respiratory depression when combined with other sedatives or narcotics

Meperidine (*Demerol*)

A major drawback to this agent is its likelihood to cause respiratory depression and hypotension. This is particularly true when administered parenterally with a lessened risk anticipated when delivered via the oral route. Its use in combination with other sedatives should be carefully assessed because of the additive or synergistic properties of sedative agents.

Narcotics, including Demerol, should be used with caution with local anesthetics. The threshold level for seizures apparently is lowered when both are used in combination.

Dose: **oral route**	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
1–2 mg/kg	Binds to opiate receptors in the CNS, causing inhibition of ascending pain pathways, altering the perception of and response to pain; produces generalized CNS depression	Onset of action: oral, within 10–15 min Duration, 2–4 h Metabolism: in the liver Half-life, 3 h Elimination: in the urine	Incompatible with aminophylline, heparin, phenobarbital, phenytoin, and sodium bicarbonate	Hypersensitivity to meperidine or any component; use of MAO inhibitors within 14 days (potentially fatal reactions may occur)	CNS and respiratory depression may occur. Use with great caution (and only if essential) in patients with head injury, increased ICP, or other intercranial lesions (potential to depress respiration and increase ICP may be greatly exaggerated in these patients). Use with extreme caution in patients with COPD, cor pulmonale, acute asthmatic attacks, hypoxia, hypercapnia, and preexisting respiratory depression significantly decreased respiratory reserve. Severe hypotension may occur; use with caution in postoperative patients, in patients with hypovolemia or in those receiving drugs which may exaggerate hypotensive effects (including phenothiazines or general anesthetics). Meperidine may be given IV, but should be administered very slowly and as a diluted solution; rapid IV administration may result in increased adverse effects including severe respiratory depression, apnea, hypotension, peripheral circulatory collapse, or cardiac arrest; do not administer IV unless a narcotic antagonist and respiratory support are immediately available	Cardiovascular: palpitations, hypotension, bradycardia, peripheral vasodilation, tachycardia, syncope, orthostatic hypotension Central nervous system: CNS depression, dizziness, drowsiness, light-headedness, sedation, intracranial pressure elevated, headache, euphoria, dysphoria, agitation, transient hallucinations, disorientation; active metabolite (normeperidine) may precipitate twitches, tremors, or seizures Dermatologic: pruritus, rash, urticaria Endocrine and metabolic: antidiuretic hormone release Gastrointestinal: nausea, vomiting, constipation, biliary tract spasm, xerostomia Genitourinary: urinary tract spasm, urinary retention Local: pain at injection site; phlebitis, wheal, and flare over the vein (with IV use); induration, irritation (repeated SubQ use) Neuromuscular and skeletal: tremor, weakness, uncoordinated muscle movements Ocular: miosis, visual disturbances Respiratory: respiratory depression, respiratory arrest Miscellaneous: physical and psychological dependence, histamine release, anaphylaxis, hypersensitivity reactions, diaphoresis

(continued)

Table 4.1 (continued)

Midazolam (*Versed*)						
The major risks associated with high doses are hypoventilation and associated hypoxemia. There are interactive effects when used in patients who are on other types of drugs such as erythromycin (producing unconsciousness) and thus should be used very cautiously under such circumstances.						
In therapeutic doses, its effect on the cardiovascular system is negligible; however, higher doses produce decreased blood pressure and cardiac output.						
Occasionally in children, the expected sedation does not occur, but rather, a paradoxical hyperactivity occurs and is called the "angry response."						
Dose: oral route	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
0.25–1.0 mg/kg	Depresses all levels of the CNS, including the limbic and reticular formation, by binding to the benzodiazepine site on the gamma-aminobutyric acid (GABA) receptor complex and modulating GABA, which is a major inhibitory neurotransmitter in the brain	Onset of action: oral, within 10–20 min Metabolism: cytochrome P450 CYP3A4 enzyme Half-life, children: syrup, 2.2–6.8 h Elimination, 63–80 % excreted in the urine	Store at 15 °C to 30 °C (59 °F to 86 °F)	Hypersensitivity to midazolam, any component, or cherries (syrup); cross-sensitivity with other benzodiazepines may occur; narrow-angle glaucoma	Midazolam may cause respiratory depression/arrest; deaths and hypoxic encephalopathy have resulted when these were not promptly recognized and treated appropriately; dose must be individualized and patients must be appropriately monitored; serious respiratory adverse events occur most often when midazolam is used in combination with other CNS depressants; severe hypotension and seizures have been reported; risk may be increased with concomitant fentanyl use. Paradoxical reactions, including hyperactive or aggressive behavior, have been reported in both adult and pediatric patients	Cardiovascular: bradycardia, cardiac arrest, hypotension Central nervous system: amnesia, ataxia, combativeness, dizziness, drowsiness, headache, hyperactivity, nystagmus, paradoxical excitement, rhythmic myoclonic jerking in preterm infants (~8 % incidence), sedation Gastrointestinal: nausea, vomiting Local: IM, IV; pain and local reactions at injection site (severity less than diazepam) Nasal: burning, discomfort, irritation Neuromuscular & skeletal: muscle tremor, tonic/clonic movements Ocular: blurred vision, diplopia, lacrimation Respiratory: apnea, bronchospasm, cough, laryngospasm, oxygen desaturation, respiratory depression Miscellaneous: hiccups, physical and psychological dependence with prolonged use

Diazepam (*Valium*)

In therapeutic doses, its effect on the cardiovascular system is negligible; however, higher doses produce decreases in blood pressure and cardiac output.

Respiratory depression occurs with increased dosages (or repeated doses) or when diazepam is used in combination with other sedative agents (e.g., opioids); otherwise, respiratory effect is little. Occasionally in children, the expected sedation does not occur, but rather, a paradoxical hyperactivity occurs. This may be accompanied with rage, hostility, and nightmares.

Dose: **oral route**	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
0.25–0.3 mg/kg	Depresses all levels of the CNS, including the limbic and reticular formation, by binding to the benzodiazepine site on the gamma-aminobutyric acid (GABA) receptor complex and modulating GABA, which is a major inhibitory neurotransmitter in the brain	Onset of action, 15–60 min Metabolism: in the liver Half-life, 15–21 h Elimination: in the urine	Oral solution: store at 25 °C (77 °F); excursions permitted to 15 °C to 30 °C (59 °F to 86 °F); dispense in light-resistant, tightly closed container Tabs: store at 15 °C to 30 °C (59 °F to 86 °F); dispense in tightly closed, light-resistant container	Hypersensitivity to diazepam or any component; possible cross-sensitivity with other benzodiazepines; do not use in a comatose patient, in those with preexisting CNS depression, respiratory depression, acute narrow-angle glaucoma, severe uncontrolled pain, myasthenia gravis, severe respiratory insufficiency, severe hepatic insufficiency, or sleep apnea syndrome	Abrupt discontinuation may cause withdrawal symptoms or seizures. Rapid IV push may cause sudden respiratory depression, apnea, hypotension, or cardiac arrest. Appropriate resuscitative equipment and qualified personnel should be available during parenteral administration with appropriate monitoring. Do not administer injection to patients in coma, shock, or acute ethanol intoxication with depression of vital signs. Tonic status epilepticus may occur in patients with petit mal status or petit mal variant status who are treated with diazepam. Administration of rectal gel should only be performed by individuals trained to recognize characteristic seizure activity for which the product is indicated and who are capable of monitoring patient's response to determine need for additional medical intervention. Psychiatric and paradoxical reactions, including hyperactive or aggressive behavior, hallucinations, and psychoses, have been reported with benzodiazepines, particularly in adolescent/pediatric or elderly patients	Cardiovascular: bradycardia, cardiac arrest, cardiovascular collapse, hypotension Central nervous system: amnesia, ataxia, confusion, depression, dizziness, drowsiness, fatigue, headache, hypoactivity, incoordination, paradoxical reactions (e.g., acute hyperexcited states, anxiety, hallucinations, increased muscle spasms, insomnia, rage, sleep disturbances, stimulation), slurred speech, somnolence, syncope, vertigo Dermatologic: dermatitis, rash, urticaria Gastrointestinal: constipation, diarrhea, GI disturbances, nausea, salivation changes Genitourinary: incontinence, urinary retention Hematological: neutropenia (rare) Hepatic: jaundice, liver enzymes increased Local: pain with injection, thrombophlebitis, and tissue necrosis may occur following extravasation Neuromuscular & skeletal: dysarthria, tremor, weakness Ocular: blurred vision, diplopia, nystagmus Respiratory: apnea, decrease in respiratory rate, laryngospasm Miscellaneous: hiccups, physical and psychological dependence with prolonged use

(continued)

Table 4.1 (continued)

Triazolam (*Halcion*)						
Dose: oral route	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
Children <18 years: dosage not established; investigational doses of 0.02 mg/kg given as an elixir have been used in children ($n=20$) for sedation prior to dental procedures	Depresses all levels of the CNS, including the limbic and reticular formation, by binding to the benzodiazepine site on the gamma-aminobutyric acid (GABA) receptor complex and modulating GABA, which is a major inhibitory neurotransmitter in the brain	Onset of action: within 15–30 min Duration, 6–7 h Metabolism: extensive in the liver Half-life: adults, 1.5–5.5 h Elimination: in the urine as unchanged drug (minor amounts) and metabolites	Store at room temperature, between 68 and 77° F (20 and 25° C). Store away from heat, moisture, and light	Hypersensitivity to triazolam or any component; cross-sensitivity with other benzodiazepines may occur; severe uncontrolled pain; preexisting CNS depression; narrow-angle glaucoma; pregnancy; concomitant use with ketoconazole, itraconazole, or nefazodone	Evaluate patient carefully for medical or psychiatric causes of insomnia prior to initiation of drug treatment; failure of triazolam to treat insomnia (after 7–10 days of therapy), a worsening of insomnia, or the emergence of behavioral changes or thinking abnormalities may indicate a medical or psychiatric illness requiring evaluation; these effects also have been reported with triazolam use. Due to possible adverse effects, use lowest effective dose. Abrupt discontinuation after prolonged use may result in withdrawal symptoms or rebound insomnia. Triazolam is a substrate of cytochrome P450 isoenzyme CYP3A4; serious drug interactions may occur. Hypersensitivity reactions including anaphylaxis and angioedema may occur. Hazardous sleep-related activities, such as sleep driving (driving while not fully awake without any recollection of driving), preparing and eating food, and making phone calls while asleep, have also been reported. Effects with other sedative drugs or ethanol may be potentiated	Central nervous system: drowsiness, anterograde amnesia, confusion, bizarre behavior, agitation, dizziness, hallucinations, nightmares, headache, ataxia Gastrointestinal: xerostomia, nausea, vomiting Hepatic: cholestatic jaundice Miscellaneous: physical and psychological dependence; hypersensitivity reactions, anaphylaxis, angioedema; hazardous sleep-related activities

Hydroxyzine (*Atarax or Vistaril*)						
Dose: **oral route**	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
0.6–1.5 mg/kg or 25 mgs delivered as a bolus	Competes with histamine for H_1-receptor sites on effector cells in the GI tract, blood vessels, and respiratory tract	Absorption: oral, well absorbed Metabolism: in the liver, forms metabolites Half-life, 7.1 ± 2.3 h Time to peak serum concentration: oral, 2 h	Protect from light	Hypersensitivity to hydroxyzine or any component; subcutaneous, intravenous, or intra-arterial administration; early pregnancy	Subcutaneous, intra-arterial, and IV administration are *not* recommended under any circumstances since intravascular hemolysis, thrombosis, and digital gangrene can occur; extravasation can result in sterile abscess and marked tissue induration. Hydroxyzine causes sedation; caution must be used when performing tasks which require alertness (e.g., operating machinery or driving). Sedative effects of CNS depressants or ethanol are potentiated. Injection may contain benzyl alcohol which may cause allergic reactions in susceptible individuals; syrup may contain sodium benzoate	Cardiovascular: hypotension, supraventricular tachycardia Central nervous system: ataxia, dizziness, drowsiness, hallucination, headache, seizure Dermatologic: pruritus, rash, urticaria Gastrointestinal: xerostomia Genitourinary: urinary retention Local: pain at injection site Neuromuscular & skeletal: involuntary movements, paresthesia, tremor, weakness Ocular: blurred vision Respiratory: thickening of bronchial secretions Miscellaneous: allergic reaction, anticholinergic effects

(continued)

Table 4.1 (continued)

Promethazine (*Phenergan*)						
Should not be used in children less than 2 years of age due to the possibility of respiratory depression						
Dose: **oral route**	**Mechanism of action**	**Pharmacokinetics**	**Stability**	**Contraindications**	**Warnings**	**Adverse reactions**
0.25–1 mg/kg	Phenothiazine derivative: blocks postsynaptic mesolimbic dopaminergic receptors in the brain, exhibits a strong alpha-adrenergic blocking effect and depresses the release of hypothalamic and hypophyseal hormones, competes with histamine for the H_1-receptor	Onset of action: within 20 min Duration, 4–6 h Half-life, 9–16 h Metabolism: in the liver Elimination: principally as inactive metabolites in the urine and in the feces	Store at 15 °C to 25 °C (59 °F to 77 °F). Protect from light	Hypersensitivity to promethazine or any component (cross-reactivity with other phenothiazines may occur); severe toxic CNS depression or coma; intra-arterial administration; subcutaneous administration; children <2 years; treatment of lower respiratory tract symptoms, including asthma; intra-arterial or subcutaneous Promethazine is contraindicated for use in children <2 years of age due to the potential for severe and potentially fatal respiratory depression	Contraindicated in children <2 years of age due to the potential for severe and potentially fatal respiratory depression A wide range of weight-based doses have resulted in respiratory depression; excessively high doses have been associated with sudden death in children; use with caution and use the lowest effective dose in children ≥2 years of age and avoid concomitant use with other medications having respiratory depressant effects	Cardiovascular: bradycardia, hypertension (slow IV administration), hypotension (rapid IV administration), palpitations, tachycardia Central nervous system: catatonic-like states, confusion, drowsiness, dystonia, excitation (paradoxical), extrapyramidal reactions, fatigue, hallucinations, hysteria, insomnia, NMS, sedation (pronounced), seizures, tardive dyskinesia Dermatologic: angioedema, photosensitivity, rash, urticaria Endocrine & metabolic: weight gain Gastrointestinal: abdominal pain, appetite increased, diarrhea, GI upset, nausea, xerostomia Genitourinary: urinary retention Hematologic: agranulocytosis (rare), leukopenia, thrombocytopenia Hepatic: cholestatic jaundice, hepatitis Local: abscess, distal vessel spasm, gangrene, injection site reactions (burning, edema, erythema, pain), palsies, paralysis, phlebitis, thrombophlebitis, sensory loss, tissue necrosis, venous thrombosis Neuromuscular & skeletal: arthralgia, myalgia, paresthesia, tremor Ocular: blurred vision, diplopia Otic: tinnitus Respiratory: apnea (particularly severe in children), pharyngitis, respiratory depression, and thickening of bronchial secretions Miscellaneous: allergic reactions

Ketamine

Dose: oral route	Mechanism of action	Pharmacokinetics	Stability	Contraindications	Warnings	Adverse reactions
2–6 mg/kg	Produces dissociative anesthesia by direct action on the cortex and limbic system; does not usually impair pharyngeal or laryngeal reflexes	Onset of action: within 30 Metabolism: in the liver	Protect from light; do not mix with barbiturates or diazepam as precipitation may occur	Hypersensitivity to ketamine or any component; patients in whom a significant elevation in blood pressure would be hazardous (e.g., patients with elevated intracranial pressure, hypertension, aneurysms, thyrotoxicosis, CHF, angina, or psychotic disorders)	Use only by or under the direct supervision of physicians experienced in administering general anesthetics. Resuscitative equipment should be available for use; respiratory depression may occur with rapid administration rates or with overdose. Postanesthetic emergence reactions which can manifest as vivid dreams, hallucinations, and/or frank delirium occur in 12 % of patients; these reactions are less common in pediatric patients; emergence reactions may occur up to 24 h postoperatively and may be reduced by minimization of verbal, tactile, and visual patient stimulation during recovery or by pretreatment with a benzodiazepine (using lower recommended doses of ketamine). Severe emergent reactions may require treatment with a small hypnotic dose of a short or ultrashort-acting barbiturate. Prolonged use may cause physical dependence (withdrawal symptoms on discontinuation) and tolerance. Cardiac function should be continuously monitored in patients with hypertension or cardiac decompensation. Animal data suggests that exposure of the developing brain to anesthetics like ketamine (especially during the critical time of synaptogenesis) may result in long-term impairment of cognitive function	Cardiovascular: hypertension, tachycardia, cardiac output increase, paradoxical direct myocardial depression, hypotension, bradycardia, increases cerebral blood flow, arrhythmias Central nervous system: tonic-clonic movements, intracranial pressure elevated, hallucinations Dermatologic: transient erythema, morbilliform rash Endocrine & metabolic: metabolic rate increased Gastrointestinal: hypersalivation, vomiting, postoperative nausea, anorexia Local: pain and exanthema at injection site Neuromuscular & skeletal: skeletal muscle tone increased, tremor, purposeless movement, fasciculations Ocular: diplopia, nystagmus, intraocular pressure elevated Respiratory: airway resistance increased, cough reflex may be depressed, bronchospasm decreased; respiratory depression or apnea with large doses or rapid infusions, laryngospasm; bronchial mucous gland secretion increased Miscellaneous: emergence reactions; anaphylaxis; physical and psychological dependence with prolonged use

Source of some material: Lexicomp Online, Pediatric and Neonatal Lexi-Drugs

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Local Anesthetics

5

Alan Milnes and Stephen Wilson

Abstract

Local anesthetic agents are essential for the provision of safe, high-quality, and pain-free dental treatment. A brief review of the pharmacology and properties of local anesthetic agents is followed by a brief discussion of considerations for avoiding toxic reactions to local anesthesia in children when used concomitantly with sedative agents.

The overwhelming majority of pharmacologic agents used in dentistry are administered to control anxiety and pain. Generally, the elimination of pain sensation in the dental setting requires blocking of pain perception either peripherally using local anesthesia or centrally with general anesthesia. Anxiety is controlled, in part or completely, by using sedation that may involve pharmacologic or non-pharmacologic techniques or both. Anxiety control and pain control in actual clinical practice overlap to a significant degree.

There is no *best* technique for control of anxiety and pain. A practitioner may have a favorite technique, but one technique is not useful for all dental patients in all situations. The prudent and wise dentist has a working knowledge of several techniques and selects, on an individual basis, the one that appears to be the most appropriate for a particular patient. In some cases, this may necessitate referral.

Local Anesthesia

Mechanisms of Action

Pain perception may be altered at the peripheral level by blocking propagation of nerve impulses using local anesthesia. One dimension of the process of pain perception involves production of nerve impulses or action potentials, by a noxious stimulus that activates specific receptors (nociceptors) at nerve endings. The nerve impulses travel along the nerve fibers via a physiochemical process involving ion transport across the neuronal membrane. The

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mechanism of action of local anesthetic agents is thought to be explained by the specific receptor theory. According to the theory, local anesthetic agents penetrate the nerve cell membrane and bind with specific receptor sites located within the sodium channel causing a direct effect of blocking the influx of sodium ions normally associated with membrane depolarization [1, 2]. Nerves in the area of local anesthesia deposition are bathed in a local anesthetic solution blocking many sodium channels along the nerve trunk resulting in decreased or eliminated transmission of signals going to the central nervous system (CNS). In general, small nerve fibers are more susceptible to the onset of action of local anesthetics than large fibers. Accordingly, the sensation of pain is one of the first perceived modalities blocked, followed by cold, warmth, touch, and pressure.

Local anesthetic agents are weak chemical bases and are supplied generally as salts, such as lidocaine hydrochloride. The salts may exist in one of two forms: either the uncharged free base or the charged cation. The free-base form, which is lipid soluble, is capable of penetrating the nerve cell membrane. Penetration of the tissue and cell membrane is necessary for the local anesthetic to have an effect because the receptor sites are located on the inside of the cell membrane. Once the free base has penetrated the cell, it re-equilibrates, and the cation is thought to be the form that then interacts with the receptors to prevent sodium conductance. This explains in part why local anesthetic agents are not as effective in areas of an acute infection where the local tissues are acidic changing the balance between uncharged free base and charged cations in favor of the latter which is less effective in penetrating the cell membrane [3].

Local Anesthetic Agents

Esters

Discovered in 1860, cocaine was the first local anesthetic. Because of the number of adverse side effects associated with cocaine, attempts were made to develop alternatives that retained the local anesthetic properties of cocaine while eliminating the side effects. Several other benzoic acid ester derivatives were developed, including benzocaine, procaine (Novocain), tetracaine (Pontocaine), and chloroprocaine (Nesacaine). The major problem with the ester class of local anesthetics is their propensity for producing allergic reactions, and they are rarely used today for anything other than topical anesthesia.

Amides

The amides were introduced with the synthesis of lidocaine in 1943. These compounds are amide derivatives of diethylaminoacetic acid. They are relatively free from sensitizing reactions. Since lidocaine was synthesized, several other local anesthetics have been introduced and include mepivacaine (Carbocaine), prilocaine (Citanest), bupivacaine (Marcaine), and etidocaine (Duranest). Bupivacaine and etidocaine are very long acting and not recommended for pediatric use. Amides are metabolized in the liver.

Articaine was first synthesized by Rusching in 1969 and brought to the market in Germany. In 1983, it was introduced into the North American market as Ultracaine for dental use. Since Ultracaine's patent protection has expired, new generic versions have been introduced and include Septanest (Septodont), Astracaine (Dentsply), and Zorcaine (Carestream Health/Kodak). Articaine was approved for use in the United States by the FDA in April 2000.

The structure of articaine is similar to that of other amide local anesthetics, but differs by the presence of a thiophene ring instead of a benzene ring. This has significant implications in articaine metabolism. Because the thiophene ring contains an ester group and articaine has an amide linkage, articaine is metabolized both by nonspecific blood esterases [4] and in the liver. Since articaine is hydrolyzed very quickly, the risk of systemic toxicity seems to be lower than with other local anesthetics. For this reason, articaine is a good choice for local anesthetic during pediatric sedation. In fact, some believe that mandibular infiltration with articaine may be a better choice

for children than the standard inferior alveolar block with lidocaine because of its rapid onset and simpler technique of administration [5].

Local Anesthetic Properties

Individual local anesthetic agents differ from each other in their pharmacologic profiles [6]. They vary in their potency, toxicity, onset time, and duration (see Table 5.1). All these characteristics may be clinically important, and all vary as a function of the intrinsic properties of the anesthetic agent itself and the regional anesthetic procedure employed [1]. Furthermore, these characteristics may be modified by the addition of vasoconstrictors.

Potency

The intrinsic potency of a local anesthetic is associated with lipid solubility and the concentration required to achieve the desired effect of nerve blockade. Procaine has the lowest intrinsic potency; lidocaine, prilocaine, and mepivacaine have intermediate potency; tetracaine, bupivacaine, and etidocaine are of high potency; and articaine is slightly more potent than lidocaine but is cleared three times faster from the body. It is important to note that these types of local anesthetics do not necessarily come in the same percent concentration; hence, caution is needed to prevent exceeding toxic doses of local anesthesia, especially when used in combination with other agents affecting the cardiovascular and CNS (e.g., sedatives).

Onset Time

Onset time is the time required for the local anesthetic solution to penetrate the nerve fiber and cause complete conduction blockade. Clinically, it must be understood that conduction blockade requires time for onset; otherwise, unnecessary pain may result from beginning a procedure too soon.

Duration

Duration of anesthesia is one of the most important clinical properties considered when choosing an appropriate local anesthetic agent for a given procedure. A local anesthetic with increased protein-binding capacity and a vasoconstrictor will have a longer duration than an agent with decreased protein binding and no vasoconstrictor. Lidocaine, mepivacaine, articaine and prilocaine have an intermediate duration, whereas bupivacaine and etidocaine have a long duration.

Onset

Local anesthesia of the soft tissues by the infiltration technique occurs almost immediately with all of the local anesthetics. As more tissue penetration becomes necessary, the intrinsic latency of onset previously discussed plays a greater role. Generally, in dentistry, for any given drug, the onset time required is shortest with an infiltration block, longer with a peripheral (minor) nerve block, and longest for topical anesthesia. Onset of action is also affected by the dissociation constant (pKa) and the pH at which two forms of the molecule, charged and uncharged, exist in

Table 5.1 Comparison of local anesthetics commonly used in pediatric dentistry

Drug	pK (% base at pH 7.4)	Onset (min)	Protein binding (%)	Duration[a] (h)	T ½ (min)	Dose (mg/kg)	Relative potency
Lidocaine	7.9 (24 %)	1–3	65	1–2	96	4.5	1.0
Prilocaine	7.9 (24 %)	1–3	55	1–2	93	6	0.8
Mepivacaine	7.6 (36 %)	1–3	75	1.5–3	114	4.5	2.6
Articaine	7.8 (35 %)	1–3	~85	2.4–4	30	5	1.5
Bupivacaine	8.1 (17 %)	2–10	95	4–8	162	1.3	3.6

Adapted from Malamed [2] and Moore and Hersh [6]
Duration – infiltration versus block; volume and concentration injected, vasoconstrictor presence, and tissues assessed

equivalent amounts. In other words when pKa equals pH, half of the anesthetic molecules present will be charged and half uncharged. A lower pKa, closer to a physiologic pH of 7.4, will result in faster diffusion through tissues and into nerve fibers. This is especially important when dealing with an infected tooth where the pH of the surrounding tissues may be lower than the physiologic pH. In these cases, mepivacaine may be the agent of choice given its pKa of 7.6 compared to that of lidocaine at 7.9.

Duration

The duration of anesthesia varies greatly with the regional technique performed. This profile may differ for different agents, depending on their intrinsic pharmacologic properties. For example, lidocaine (1 %) with epinephrine (1:200,000) has a duration of 416 min with infiltration, 178 min with ulnar nerve block, 156 min with epidural anesthesia, and 94 min with spinal block.

Dose

The quality, onset time, and duration of a local anesthetic block may be improved by increasing the dose of the agent by using a higher concentration or greater volume. Increases in dosage must be limited by anesthetic toxicity; however, for consistently effective local anesthetic block, an adequate concentration and volume must be administered as close to the target nerve(s) as possible.

In a survey of local anesthetic usage in pediatric patients by Florida dentists, Cheatham and Primosch found that younger children received much higher dosages of local anesthetics than older children. Frequently, the amount of local anesthetic administered to young children far exceeded the manufacturers' maximum recommended dose [7, 8].

During any dental treatment for children but especially during pediatric sedation, the maximum dose of local anesthetic to be administered to the child must be carefully calculated and recorded prior to its administration. Table 5.1 shows the recommended dosages for each local anesthetic commonly used in pediatric dentistry. Note that the dosages shown are lower than those recommended by the manufacturers. The rationale for these differences will be discussed in a subsequent section of this chapter.

Vasoconstrictors

Onset time, duration, and quality of block are also affected by the addition of vasoconstrictor agents to the local anesthetic solution. Vasoconstrictor agents such as epinephrine decrease the rate of drug absorption by decreasing blood flow to the tissues, prolonging the duration of the anesthesia produced, and increasing the frequency with which adequate anesthesia is attained and maintained. Toxic effects of local anesthetics are reduced as a result of delay in absorption into the circulation. Onset time of anesthesia is sometimes shortened as well.

In pediatric dental patients, a vasoconstrictor is needed because the higher cardiac output, tissue perfusion, and basal metabolic rate tend to remove the local anesthetic solution from the tissues and carry it into the systemic circulation more quickly, thus producing a shorter duration of action and a more rapid accumulation of toxic levels in the blood. Finally, vasoconstrictors produce local hemostasis following local anesthetic infiltration into the operating field. This assists in postoperative hemorrhage control, an advantage in the management of young children undergoing dental extractions.

Vasoconstrictors are all sympathomimetic agents that carry their own intrinsic toxic effects. These include tachycardia, hypertension, headache, anxiety, tremor, and arrhythmias. It has been shown that 2 % lidocaine containing a concentration of 1:250,000 epinephrine is as effective in increasing the depth and duration of local anesthesia block as higher concentrations of epinephrine such as 1:100,000 or 1:50,000 [9]. To avoid vasoconstriction toxicity in children, a concentration of 1:100,000 epinephrine should not be exceeded. The pharmacologic properties of the local anesthetics commonly used in dentistry are summarized in Table 5.1. Bupivacaine use is NOT RECOMMENDED for use in pediatric dentistry because it is extremely potent and produces soft tissue anesthesia for very prolonged

periods of time which, in children, could lead to injury. It is included only for comparison as it is commonly used in adults for extensive restorative dentistry or oral surgery.

Toxicity

The use of local anesthetics is so common in dentistry that the potential for toxicity with these agents can be easily overlooked. Dentists who treat children should always be mindful of local anesthetic toxicity. Toxic reactions to local anesthetics may be due to overdose, accidental intravascular injection, idiosyncratic response, allergic reaction, interactive effects with other agents, and other mechanisms (e.g., sedatives) [10].

The dental practitioner should be familiar with the maximal recommended dose for all local anesthetic agents that are used on a dose-per-body-weight basis (i.e., milligrams per kilogram). Simply knowing a total milligram dose for the average adult is not adequate and may lead to overdose in pediatric patients.

The use of local anesthesia during pediatric sedation is considered an absolute requirement for patient comfort. In fact, profound anesthesia during treatment often improves the outcome of a pediatric sedation appointment. However, clinicians must be aware of the effect of sedative agents on both the action and metabolism of local anesthetic agents. This is especially important when sedative agents are used which could produce respiratory depression. All sedative agents are capable of causing respiratory depression when administered in large enough dosages. However, the agents most likely to cause respiratory depression are opioids as well as sedative techniques which use more than one agent such as the triple cocktail.

Respiratory depression leads to hypoxemia, hypercarbia, and respiratory acidosis manifested as a decreased serum pH. Hypercarbia in turn leads to an increase in cerebral perfusion and further distribution of local anesthetic agent to the brain. This occurs because respiratory acidosis causes a decrease in protein binding in the serum resulting in the further release of a local anesthetic agent into the serum for redistribution to the brain. Moreover, respiratory acidosis further complicates recovery as cardiac arrest is more likely in the presence of worsening hypoxia, respiratory acidosis, and hypercarbia.

Central Nervous System Reactions

Local anesthetic agents cause a biphasic reaction in the CNS as blood levels increase. Although local anesthetics have depressant effects in general, they are thought to selectively depress inhibitory neurons initially, producing a net effect of CNS excitation. Subjective signs and symptoms of early anesthetic toxicity include circumoral numbness or tingling, dizziness, tinnitus (often described as a buzzing or humming sound), cycloplegia (difficulty in focusing), and disorientation. Depressant effects may be evident immediately. These include drowsiness or even transient loss of consciousness. Objective signs may include muscle twitching, tremors, slurred speech, and shivering followed by overt seizure activity. Generalized CNS depression characterizes the second phase of local anesthetic toxicity, accompanied sometimes by respiratory depression. Table 5.2 provides a graphical representation of the effects of an increasing concentration of lidocaine to toxic levels.

Table 5.2 Dose-dependent systemic effects of lidocaine

Plasma concentration (μg/mL)	Effect
1–5	Analgesia
5–10	Lightheadedness
	Numbness of tongue
	Tinnitus
	Muscular twitching
10–15	Seizures
	Unconsciousness
15–25	Coma
	Respiratory depression/arrest
>25	Cardiovascular depression

Adapted from Malamed [2] and Moore and Hersh [6]

Cardiovascular System Reactions

The cardiovascular response to local anesthetic toxicity is also biphasic. During the period of CNS stimulation, the heart rate and blood pressure may increase. When plasma levels of the anesthetic increase, vasodilatation followed by myocardial depression occurs, with a subsequent fall in blood pressure. Bradycardia, cardiovascular collapse, and cardiac arrest may occur at higher levels of the agents. Most local anesthetics used in dentistry cause little cardiovascular alteration even at levels associated with seizure activity. The depressant effect on the myocardium is essentially proportional to the inherent potency of the local anesthetic, with procaine being least toxic, lidocaine and mepivacaine of intermediate toxicity, and bupivacaine and etidocaine the most cardiotoxic.

The use of local anesthetic in pediatric dentistry has changed the quality and quantity of procedures possible as much as any other advances in the field. In children who are properly prepared psychologically, high-quality local anesthesia is usually all that is necessary to eliminate pain completely. One must be ever mindful of the pharmacokinetics of the agents used with children. Because of the higher cardiac output, higher basal metabolic rate, and higher degree of tissue perfusion in children, the agents tend to be absorbed more rapidly from the tissues. The less mature liver enzyme systems in young children may detoxify these chemicals at a slower rate than in adults. Also, the immature central nervous and cardiovascular systems probably are more susceptible to toxicity at lower drug levels than in adults. For these reasons, a precise local anesthetic technique should be used, aspiration techniques should be practiced, a vasoconstrictor is necessary, and a thorough knowledge of the intrinsic properties of local anesthetic agents is essential. Local anesthetics alone or with sedatives used in children, especially those who are 2–4 years of age, have been associated with fatalities, some of which involved local anesthetic overdose [11, 12]. *Above all, the recommended maximal safe dose of local anesthetic should be calculated precisely for each patient and must never be exceeded.*

To avoid a toxic overdose to local anesthesia, adhering to the following suggestions will help to avoid problems:

1. Always calculate the local anesthetic dose to be administered by weight, preferably milligrams per kilogram, based on the figures provided in Table 5.1. Do not exceed the maximum recommended dose.
2. Always use local anesthesia WITH vasopressor.
3. If treating multiple quadrants during one appointment, do not administer all of the local anesthetic at once. Rather, administer local anesthetic in one quadrant, treat the quadrant, and then administer more local anesthetic in the next quadrant to be treated when ready to move to that quadrant.
4. Avoid high concentrations of local anesthetic if at all possible. This is not always possible, and this suggestion contravenes the earlier recommendation of articaine which is available as a 4 % solution.
5. Be very cautious with local anesthesia dosage when the sedation protocol involves respiratory depressants such as opioids or involves sedation polypharmacy.

The future may reveal even easier techniques involving sedation and local anesthesia administration for children. Intranasal administration of local anesthetics in children may be a promising technique [13]. There is already some positive evidence of intranasally administered mist containing the sedative and local anesthetic in children undergoing various painful procedures [14].

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Clinical Sedation Regimens

6

Stephen Wilson

Abstract

Several agents and their combinations, administered orally, have been studied and used in practice. In reality, little substantial body of evidence derived from organized, randomized, well-controlled scientific studies is available to support any one agent or combination of agents over another for sedating children. Often, dentists use sedative regimens with which they are familiar from their training or what "works well in their hands." In this chapter, common sedatives and their combinations that have been popularized in professional journals or through sharing of experiences with colleagues are overviewed. A more complete understanding of the success or failure of these agents is dependent on other key factors that will influence, to some degree, these outcomes. Child temperament, parental influence, and the amount of and required technical skills associated with procedures are some of these important factors. They will be discussed in the context of procedural sedation. The review is admittedly incomplete simply because of complexity of the situation and the limited evidence; however, it gives the reader a good perspective of the common challenge in pediatric dental practice.

Common Sedatives for Pediatric Dental Patients: Practical Use

There are many articles describing the effects of different drugs and dosages and their effect on children's behavior and physiology. However, taken as a whole, they fail to provide a substantial, evidence-based information set and standardized process for selecting orally administered sedative agents to give children of various temperaments and personalities, social circum-

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stances, and dental needs [1]. Until systematic trials can be designed and tested, the clinician usually relies on clinical experiences. The purpose of this chapter is to describe common sedatives that have been used in pediatric dentistry over the years and a model for their selection as represented by the experiences of the author's some 30 plus years of performing and studying sedation and children.

The outcomes of sedation administered via the oral route used for children undergoing dental procedures are not easily predicted because of many factors, some of which are not readily known or manipulative. Nevertheless, there are some key factors to consider when scheduling children for dental procedures. The medical and social histories, cognitive age, emotional and temperamental attributes, physical assessment, and overall risk assessment become salient and important factors. Arguably, the two most critical factors in the decision-making process of which agents to use are child temperament and the amount of dentistry to be accomplished.

In the context of a clinical procedure, children express temperaments that may be clinically classified along a continuum as "easy," "slow-to-warm-up," and "difficult." Obviously, children with difficult, shy, and emotionally labile temperaments are most challenging, regardless of age. These children will often require deep levels of sedation or general anesthesia; otherwise, restraint may become necessary possibly compromising the quality of care and increasing the frustration of the dental team and parents. At the other extreme, easy children with a high degree of approachability and calm demeanor are more likely to respond favorably to lighter levels of sedation and practitioner guidance. Children, who are classified as slow-to-warm-up, fall on a continuum somewhere between the two extremes. Evidence of the impact and importance of temperament in clinical situations continues to grow and seems to highlight the characteristic of shyness as an entity worthy of note.

The other dominant factor is the amount of time of dental procedures that can safely and efficiently be accomplished in one setting while preserving quality care. The effect of this factor comes into play when considering the attention span, distractible tolerance, and activity level of children compared to adults during tedious procedures (e.g., dental procedure) normally requiring minimal movement and expressive communication. Also noteworthy is the amount of local anesthesia that can be effectively and safely administered in a single appointment period.

The author tends to classify dental procedures as ultrashort, short, and long in duration. The ultrashort classification can be exemplified by the procedure of extracting the four maxillary primary incisors. The amount of time it takes to physically extract these four teeth is literally less than a minute, although such an appointment may last 20–30 min to allow the sedative and local anesthetic to reach their greatest effectiveness for the procedure. A short procedure may be characterized as restorations of teeth in a full quadrant of the dental arch such as a pulpotomy and stainless steel crown (SSC) on the mandibular right second primary molar, an SSC on the mandibular right first primary molar, and a distolingual composite on mandibular right primary canine. Besides the 15–20 min conditioning time associated with topical and local anesthesia, the tooth preparation and restorative procedures may require another 20–30 min totaling up to 50 min. A long procedure usually involves two or more quadrants of dentistry and can consume up to 90 min or more of time to accomplish. Multiple, complex procedures in two or more quadrants may best be accomplished using general anesthesia.

Also as briefly noted above is the consideration of the amount of local anesthesia that may be required to comfortably and safely complete the procedures. Local anesthetics in high doses can cause central nervous system (CNS) depression. Furthermore, local anesthetics can interact with sedative agents and deepen sedation and even cause adverse events such as seizures, respiratory depression, and coma. Therefore, it is imperative that, based on body weight in kilograms, only therapeutic doses are administered, and the maximum amount of local anesthesia is never exceeded during sedation appointments in children. It is the author's opinion that a consistently safe dose for local anesthesia in children is

4 mg/kg regardless of the type of "caine" one is using. If more than one type of local anesthetic is used, one must realize the effect is additive; the sum still cannot exceed the maximum dose [2]. So if the maximum dose was 100 mg for a child weighing 25 kg and 60 mg of lidocaine had been administered, then only 40 mg of Septocaine could additionally be administered safely. One may be able to appreciate that multiple injections and the significant amount of time involved in a long procedure may be too overwhelming to tolerate for a 3-year-old child who has a difficult temperament. Furthermore, the use of a single, short-acting agent such as midazolam alone is highly unlikely to afford sufficient efficacy for long procedures in these challenging children. Adherence to this philosophy may require more than one sedation appointment, but only serves to increase the safety for the child. Under these circumstances, either general anesthesia, deep sedation, or multiple short sedation appointments may be the best options, despite the fact that little is known about the beneficial outcomes of the latter in difficult children.

Selecting a single drug or a combination of drugs for an individual child patient is a formidable challenge for any practitioner. A drug used singularly may produce advantageous effects (e.g., drowsiness and analgesia) but may be limited by the length of working time. Thus, one is left with the questionable decision of whether to increase the dose of the drug raising the risk of occurrence of deep sedation and adverse events. The management of adverse events associated with a single drug may be as challenging as a regimen involving polypharmacy; however, since only one drug is involved, the algorithm for rescuing a child may be less daunting.

Another option is to combine drugs, especially two or more drugs whose effects are complementary. Again, the risk of loss of consciousness and adverse events with this option may rise, increasing the level of concern for patient safety. *Care must be taken to downwardly adjust the usual therapeutic dose of a single agent when two or more agents are used in combination. Furthermore, it is highly advisable that a significant amount of appropriate training in the use and management of multi-agent combinations in children be accomplished before embarking in this type of pharmacological management*. Such training is usually only available in advanced training programs of pediatric dentistry; however, not all such programs afford this type of training. Also, the practitioner must be knowledgeable of his/her state dental practice act and requirements for training in order to obtain an appropriate sedation permit. Table 6.1 shows a representative scheme for selecting drugs based on these major factors.

Table 6.1 Scheme for selecting agents based on child temperament and estimated dental treatment

Dental needs	Child temperament	Drugs (all oral administration supplemented with N_2O/O_2)
Ultrashort (e.g., extract of maxillary central incisors)	Easy	Nitrous alone (40–50); midazolam alone (0.5 mg/kg)
	Difficult	Midazolam (1.0 mg/kg) + nitrous (50 %)
Short (e.g., 1 quadrant of pulps/crowns)	Easy	Midazolam (0.5 mg/kg) + meperidine (1.0 mg/kg)
	Difficult	Chloral hydrate (15–20 mg/kg) or midazolam (0.3–0.5 mg/kg) + meperidine (2 mg/kg) + hydroxyzine (0.5–1.0 mg/kg)
Long (e.g., two or more quadrants of dentistry	Easy	Chloral hydrate (15–25 mg/kg) + meperidine (2 mg/kg) + hydroxyzine (0.5–1.5 mg/kg)
	Difficult	Recommend general anesthesia

Single Agents

Characteristics of the agents described below can be seen in Table 6.2. Midazolam may be one of the few agents that are commonly used alone in

Table 6.2 Characteristics of common drug combinations used in pediatric dentistry

Drug combinations	Individual drug Dose – oral (mg/kg) *Combo dose:*	Characteristics	Warnings	Sedation considerations (timing)[a]	Likelihood of unconsciousness +++ – high ++ – medium + – low	Reversibility
Choral hydrate + hydroxyzine	CH (15–50) H (1–2) *Combo dose:* CH (20–40) H (1–2)	Hyperexcitable Agitation Drowsiness Sleep	Loss of consciousness *AIRWAY blockage*!!!!!	Onset: 20 min Separation time: 45 min Work: 1–1.5 h	+++	None
Chloral hydrate + meperidine + hydroxyzine (called "triple" combo)	CH (15–50) M (1–2) H (1–2) *Combo doses:* "Low dose" CH (15–25) M (2) H (2)	Euphoric Mellow Dysphoric Agitated Drowsiness Sleep	*AIRWAY blockage*!!!!! Deep sedation possible Respiratory depression	Onset: 20 min Separation time: 45 min Work: 1–1.5 h	++	Only M is reversible in these combinations Narcan (0.1 mg/kg)
	"High dose" CH (40–50) M (1) H (1)				+++	
Meperidine + hydroxyzine	*Combo dose:* M (1–2) H (1–2)	Euphoria Dysphoria More sensitive to stimuli than "triple" combo	Respiratory depression, rare	Onset: 20–30 min Separation time: 30 min Work: 1 h???	+	Only M Narcan (0.1 mg/kg)
Meperidine + midazolam	*Combo dose:* M (1–1.5) Mid (0.3–0.5)	Same as above Angry child reaction Fussy	Respiratory depression; loss of head right reflex	Onset: 20–30 min Separation time: 30 min Work: 1 h???	++	Both M and mid are reversible
Meperidine + hydroxyzine + midazolam	*Combo dose:* M (1) H (1) Mid (0.3–0.5)	Initially relaxation; Same as above	Same as above	Onset: 20–30 min Separation time: 30 min Work: 1 h???	+++	Only H is not reversible
Midazolam + hydroxyzine	*Combo dose:* Mid (0.3–0.7) H (1–2)	Initial relaxation; Same as above	Respiratory depression; loss of head right reflex	Onset: 10 min Separation time: 20 min Work: 30–45 min???	+	Only mid flumazenil (0.01 mg/kg)

[a]For best results with any combination: "Settle" child with nitrous oxide (40–70 %) 5–10 min before proceeding. *Remember to reset your nitrous to lower concentration after child is settled.* If nitrous fails, expect poor sedation results. Inject local anesthesia very, very slowly

children. Furthermore, it is the most frequently used sedative agent in pediatric dentistry (other than nitrous oxide). It is generally indicated for children who require ultrashort or short procedures lasting less than 20 min of working time. It is relatively safe when administered orally in children whose risk status is ASA I. The dose range is from 0.3 to 1.0 mg/kg administered by the oral route. Therapeutic end points (i.e., "low" and "high" ends of therapeutic dose) in dosing can be associated with extremes in temperament (viz., lower doses for "easy" and higher doses for "difficult" children). Hiccups can occur shortly after consumption but usually resolve within 20–30 min after administration. Another prominent effect seen in a smaller proportion of patients is a paradoxical excitement or "angry child syndrome." Anecdotally, the paradoxical excitement or "angry child syndrome" seems to occur more often in higher doses, regardless of temperament. Attempts to reason with the child during this effect are generally fruitless, but the effect can be reversed with a benzodiazepine reversal agent (i.e., Romazicon [flumazenil]). Reversing this hyperexcited state can be done, but the reversal effect is only temporary with reemergence of the state possibly occurring once the child has returned home. Consequently, it is advisable that when a reversal agent is administered, the patient should remain at the facility for a longer period of time to manage any issues associated with reemergence of the sedative agent.

The working time, usually 20–30 min at most, can be increased by adding another agent with sedative properties such as hydroxyzine or meperidine or both; however, the depth of sedation also increases and a reduction in the dose of both agents is necessary. When combining agents, the latency time will usually vary depending on the mix of agents and their properties. For instance, the latency with midazolam alone is usually 10–15 min, hydroxyzine with 15–20 min, and meperidine with 20–25 min. When all three agents are used, latency time varies from 20 to 30 min.

Typically, midazolam initially causes a quieting of the child and obvious relaxation. The child must be watched carefully once relaxation occurs; otherwise, a traumatic fall could occur because of imbalance and weakness of the limbs. The child temporarily responds to distraction, storytelling, and quiet activities such as coloring during the first 15 min after its administration. Provoking or painful stimulation (e.g., injections) after the first 20–25 min following its administration can elicit disruptive behaviors and even initiate the angry child syndrome. Once these behaviors are "unleashed," they are hard to control and "retrieve" the child back into a state of cooperation.

When administered by parenteral routes (e.g., intranasal), the dose must be decreased compared to the oral dose (0.2–0.3 mg/kg versus 0.5–1.0 mg/kg, respectively). The onset is slightly more rapid, but the long-term effects on behavior via this route are not much different than that of the oral route. Sometimes, delivery of midazolam by the intranasal route provokes the child causing agitation, but this usually diminishes in intensity as the child succumbs to the sedative's effects.

Antihistamines such as hydroxyzine are very popular for mild sedation when used alone and tend to be relatively safe for children [3, 4]. Next to nitrous oxide, they are the most frequently used adjuncts to oral sedative agents during sedations for pediatric patients undergoing dental procedures. They have beneficial effects including antiemetic and drying properties, mild sedation adding slightly to the effects of other agents, and prolongation of the sedation working time. Onset time usually occurs in 15–30 min, and working time varies considerably depending on the child's age and other characteristics (e.g., temperament).

Studies evaluating the addition of hydroxyzine with other sedatives have shown mixed results [5–9]. This inconsistency may be due to differences in methodology in the studies (e.g., dose). Nonetheless, it remains a popular agent whether beneficial or not.

Meperidine or chloral hydrate may be used as independent, single agents. Meperidine does not appear to cause as much sedation in the dental clinic, but can impact the mood of the child. If the mood change is beneficial which is often the case, this effect is referred to as euphoria. If, like can occur with midazolam, agitation dominates, the

effect is known as dysphoria. The euphoric effect dominates in the majority of cases, in the author's opinion, particularly when meperidine is mixed with midazolam, hydroxyzine, or chloral hydrate.

Meperidine has a bitter taste typical of narcotics and, like most other agents, requires some masking with a flavoring agent. The onset time is 20–30 min with a working time approximating 45 min to an hour. The submucosal route is another popular means of administering meperidine [6, 10–13]. It is necessary to reduce the dose whenever any parenteral route is used (compared to the dose of the oral route). Its onset time is usually 10–15 min. Usually, the effect noted (after an initial expression of agitation, crying, and momentary struggling at the time of its administration) is more quietness, euphoric mood change, and increased likelihood of positive interaction between the patient and dental team.

In terms of behavioral management, there does not appear to be any differences based on the route of administration [13]. As stated, the time of onset of meperidine effects when administered submucosally is less compared to oral administrations. One drawback of the submucosal administration of meperidine is that it can cause itching over the facial area where the injection was given, and often a reddening and slight swelling of the skin is seen (i.e., wheal). These effects are caused by the histamine release from local mast cells and even direct vascular effects when exposed to meperidine [14–16].

Another potential side effect of administering meperidine submucosally is the possibility of injecting meperidine into a large venous complex (i.e., pterygoid plexus) which exists just distal to the maxillary tuberosity in children. When appropriately administered via this route, the patient becomes sedate and ready for the start of dental procedures within 10–15 min. Working time is usually 30–45 min. Nonetheless, meperidine causes a sharp, intense sting when administered immediately eliciting struggling and crying behaviors in most children. Often in aiding to minimize the intensity of the disruptive behaviors, the child is sedated with hydroxyzine given orally approximately 30 min before the meperidine injection. It should be noted that the rapid, almost IV-like administration of meperidine into the venous supply can cause a rapid onset of hypotension. Advanced airway management and knowledge of reversal agent therapy (i.e., naloxone) are highly recommended if using this route of administration.

Considering these issues, it seems more prudent to administer meperidine in therapeutic doses via the oral route which tends to eliminate the occurrence of the submucosal effects. Another serious concern is potential interaction between local anesthetics and some narcotics including meperidine which when either or both are used in excessive amounts can result in seizures and/or death [17].

Chloral hydrate when used alone is unpredictable. Paradoxical reactions resulting in hyperactivity and disruptive behaviors can occur after its administration in children. In low doses, this reaction may predominate as the primary behavior in the dental setting, whereas in higher doses, the reaction may only be temporary before sleep is induced when the child is not stimulated.

The normal sequence of observed behaviors after the administration of chloral hydrate is as follows. Typically, disinhibition or excitement occurs in 15–25 min after the oral administration of chloral hydrate. Signs of this disinhibition which is similar to consumption of alcohol in some individuals include increased social interaction and talkativeness, exploratory hyperactivity in the environment, general silliness, but occasionally frank agitation. This phase is usually followed by drowsiness or sleepiness and can result in sleep itself. One must be cautioned however that this early phase of apparent sleep is not generally sufficient to begin the patient separation from the parent to start dental procedures. Thus, the immediate phases of apparent sleep should not lure the practitioner into thinking the patient is ready for dental procedures, *but does require confirmation of airway patency and careful and appropriate monitoring depending on the growing depth of sedation*. In other words, it is best to wait approximately 45 min to allow the attainment of adequate blood levels of chloral hydrate during which time the child must be monitored for airway and respiratory sufficiency. Starting too quickly can result in a highly agitated

child who is hard to console (i.e., similar to a "bad" drunk). If one does start too early with the separation and procedural process and significant relentless agitation occurs, one can stop the process (i.e., a failed sedation) and return the child to the parent. In more cases than not, the child will return to a comfortable sleep in the arms of the parent and should be monitored appropriately. It is highly advisable that one does not reattempt to start the procedure again even if the child looks well sedated as experience shows the agitation will likely return frustrating the parent and dental team.

The working time, depending on whether other drugs are used in combination; the patient's level of fatigue which can be increased if struggling occurs in the early phase of treatment; and child characteristics such as temperament and cognitive development is usually 60 or more minutes.

Anderson reported in 1960 on the use of chloral hydrate for 300 of his child patients. Other studies using chloral hydrate as the single agent or with nitrous oxide have also been reported [18–21]. Most of the studies indicate that chloral hydrate produces good to excellent sedations. However, chloral hydrate currently is rarely used as a single agent for children during dental procedures.

At least 20 studies have documented the use of choral hydrate in combination with other sedatives, particularly antihistamines. The dosage range used in these studies for chloral hydrate and hydroxyzine is 40–75 mg/kg and 1–2 mg/kg, respectively. There is some support to the expectation that the addition of hydroxyzine to chloral hydrate improves patient behavior compared to chloral hydrate alone [5]; on the contrary, others have found no improvement in this comparison [22].

Combinations of Agents

Many of the "common" agents such as midazolam, chloral hydrate, meperidine, hydroxyzine, and other antihistamines can and are often combined in various combinations. Studies support these combinations for somewhat effective clinical alternatives to standard non-pharmacological behavioral guidance techniques; however, there are no systematic studies to aid in selecting definitive outcomes when combinations are used. Combinations of agents can be seen in Table 6.2.

Midazolam and meperidine with or without nitrous oxide may be considered as a combination. This combination produces both sedation and adds some analgesia into the mix based on the characteristics of the two drugs. One prospective study suggests that little difference in behavior is seen comparing midazolam at a higher dose to midazolam in a lower dose and combined with meperidine [23]. Hiccups occurred less frequently with the combination than when midazolam was used alone. Another retrospective study indicated different behavioral effects occurred by varying the doses of the two drugs [24]. Although this may be a useful combination, more prospective, randomized, and controlled dosage studies involving a much larger sample size may be beneficial in discriminating optimal dose ranges for children of different temperamental styles.

This combination may prolong the working time. Furthermore, both can increase the depth of sedation possibly changing monitoring requirements as well as affect the mood of the patient. Nitrous oxide initially may be helpful with this combination especially during "settling" of the child early in the procedural process (see Chap. 8), but if and once the child becomes agitated and behaviorally noncompliant, its effectiveness is minimal at best. It is conceivable that midazolam could be used in combination with chloral hydrate, but caution is advised due to the increased likelihood of unconsciousness.

Given orally with the characteristic slower onset of action of the drugs and in downwardly modified therapeutic doses, there is less likelihood of adverse events occurring. However, if respiratory depression or unconsciousness occurs, both agents are reversible (i.e., midazolam-flumazenil and meperidine-naloxone). Should this situation occur, the question becomes which agent should first be reversed. There is no definitive answer based on evidence, but empirically meperidine, as a narcotic, is likely to cause respiratory depression and thus would logically be reversed first. Either way, the primary means of managing any

respiratory depression before the onset of effects of reversal agents is via an open airway, a bag-valve-mask, and 100 % oxygen.

Chloral hydrate is rarely used alone or even in combination today in dental practices primarily due to its lack of availability in large volumes from a manufacturer. However, it can be made available by individual dose per a prescription via a compounding pharmacist. It can be combined with almost any other common agent. But its effects of causing sleep and unconsciousness as well as hypotonia of the tongue and increased likelihood of airway blockage must be weighed carefully before using it in combinations. Certainly, appropriate training to include advanced airway management techniques is indicated whenever it is used.

Chloral hydrate combined with meperidine and hydroxyzine has been shown to be an effective combination, especially when longer working times are desirable [25–28]. This "triple" combination can be partitioned either into a "high" chloral hydrate or "low" chloral hydrate combination. The likelihood of unconsciousness or deep sedation is great in the former and less likely in the latter. Typically, the dose of the "high" triple when administered orally is 40–50 mg/kg, 1 mg/kg, and 1–2 mg/kg or less of chloral hydrate, meperidine, and hydroxyzine, respectively. Deep sedation can occur and may be more notable when nitrous oxide is used with this combination.

The best "low-dose" triple combination is 10–20 mg/kg, 2 mg/kg, and 1–2 mg/kg or less of chloral hydrate, meperidine, and hydroxyzine, respectively. The low-dose triple usually causes moderate sedation but occasionally can also induce deep sedation. The latency time for this combination is usually 40–50 min, but the working time typically is 60 min or longer assuming good local anesthetic technique. Unfortunately, only one of the three agents (i.e., meperidine) is reversible. A frequent and interesting observation of the low-dose triple combination is the rapid rate of alertness and apparent readiness to be discharged immediately following dental procedures. Nonetheless, sleep can occur fairly often once the patient is home and in a less challenging setting. This napping can occur with other sedatives as well.

Another triple combination is one that substitutes midazolam for chloral hydrate. The "midazolam" triple combination (midazolam, meperidine, and hydroxyzine) also could use variable dosages for each agent. Examples might include a dose range of 0.3–0.75, 1.0–1.5, and 1.0 mg/kg of midazolam, meperidine, and hydroxyzine, respectively. One study compared the two "high-dose" triple combinations (i.e., chloral versus midazolam) and found little difference in behaviors [29]. Yet the rate of quiet behaviors was relatively high suggesting a good sedation outcome. Desaturation did occur in the triple combination involving chloral hydrate in two patients that was resolved by a chin lift procedure, but this maneuver emphasizes that deep sedation occurred. This triple combination also has an advantage in that it contains two of the three sedatives that can be reversed (i.e., midazolam and meperidine with flumazenil and naloxone, respectively) compared to the chloral hydrate triple which only has one reversible agent (i.e., meperidine).

Nitrous oxide can be used with any of these sedatives or combinations given orally. The effect of nitrous oxide can be adjusted via altering the concentration that is inhaled, so it is the only agent in these oral inhalation combinations that can be titrated. *Higher concentrations of nitrous oxide (*i.e., *40 % and higher) can deepen the level of sedation; thus, caution is advised.* Likewise, a patient who is more deeply sedated can be stimulated and the nitrous oxide reduced or shut off allowing the patient to drift into lighter levels of sedation.

In the future, other agents are likely to become popularized should any of the current commonly used agents fade in popularity, cease to be produced, or taken off the market by regulatory agencies. For example, should the marketplace not support continued production of meperidine as the primary narcotic used as a sedative for children during dental procedures, fentanyl may emerge as a possible front-runner when administered nasally or submucosally, despite its potent respiratory depressing properties. Tables 6.3 and 6.4 summarize relatively recent and older representative studies, respectively, showing different routes and combinations of agents.

Table 6.3 Recent studies involving multiple agents

Routes and agents		Routes
Oral versus submucosal	Meperidine, midazolam, and hydroxyzine	Toomarian, L., et al. (2013). "Assessing the sedative effect of oral vs. submucosal meperidine in pediatric dental patients." *Dent Res J (Isfahan)* **10**(2): 173-179 PURPOSE: Compare behavioral and physiological effects of three sedative drug regimens: oral meperidine (OM), submucosal meperidine (SM), and oral midazolam (M) in healthy pediatric patients METHODS: This study sample consisted of 30 children aged 24–72 months (mean = 41.1) exhibiting definitely negative behavior. Three sedative regimens: oral meperidine/hydroxyzine, oral midazolam/hydroxyzine, and submucosal meperidine/oral hydroxyzine were administered randomly during three consecutive appointments with a crossover design. Houpt behavioral scale was employed for evaluating the sedation effect of each regimen by a calibrated independent pediatric dentist. Physiological parameters were also recorded including blood oxygen saturation and pulse rate. Data was analyzed using Wilcoxon signed-rank test, Mc-Nemar, GEE Logistic regression, Friedman, Fisher exact, and Cochran tests for significance RESULTS: Overall success rates were 50, 46.7, and 26.7 % for submucosal meperidine, oral meperidine, and oral midazolam, respectively ($p = 0.03$). The probability of achieving a success in behavior control was more in 48–72 month olds. Child's age and drug type were the two main predictors of altered behavior. Evaluating the differences between the effects of three tested regimens on recorded physiological parameters showed no significant differences CONCLUSION: All three regimens were proved safe within the limits of the current study. Meperidine sedation in both routes was considered to be more effective. Although there was less sleep and more head/oral resistance in midazolam group, the difference between groups was not significant
Oral versus submucosal route	Meperidine and hydroxyzine	Cathers, J. W., et al. (2005). "A comparison of two meperidine/hydroxyzine sedation regimens for the uncooperative pediatric dental patient." *Pediatr Dent* **27**(5): 395-400 PURPOSE: The purpose of this study was to compare the safety and efficacy of submucosal-administered meperidine (SM) and oral-administered meperidine (OM). Both regimens were used in conjunction with oral hydroxyzine for the sedation of children for dental treatment METHODS: Twenty preschool-age children, with previous histories of uncooperative behavior, were randomly assigned to first receive a sedation regimen of either SM (0.5 mg/lb), or OM (1 mg/lb), both with oral hydroxyzine (0.5 mg/lb). A crossover design was utilized so that each child received both regimens. Safety was monitored through vital signs and side effects. Efficacy was measured with Houpt and Frankl behavior ratings RESULTS: Vital signs remained stable during both treatments. Differences noted were clinically insignificant. The major side effects reported during submucosal injection included pain (58 %) and edema (26 %). All blinded behavior ratings, in both sedation regimens, significantly improved from presedation Frankl ratings. No significant differences existed between treatments. Success was 63 % in the SM group and 80 % in the OM group. The percentages were not statistically significant ($p = .219$) CONCLUSIONS: Both methods of administration were found to be safe and effective for sedating uncooperative pediatric dental patients. Neither was significantly more effective or safer than the other

(continued)

Table 6.3 (continued)

Routes and agents		Routes
Intranasal	Midazolam and lidocaine	Chiaretti, A., et al. (2011). "Intranasal lidocaine and midazolam for procedural sedation in children." *Arch Dis Child* **96**(2): 160-163 PURPOSE: To evaluate the safety and efficacy of a sedation protocol based on intranasal lidocaine spray and midazolam (INM) in children who are anxious and uncooperative when undergoing minor painful or diagnostic procedures, such as peripheral line insertion, venipuncture, intramuscular injection, echocardiogram, CT scan, audiometry testing, and dental examination and extractions METHOD: Forty-six children, aged 5–50 months, received INM (0.5 mg/kg) via a mucosal atomizer device. To avoid any nasal discomfort, a puff of lidocaine spray (10 mg/puff) was administered before INM. The child's degree of sedation was scored using a modified Ramsay sedation scale. A questionnaire was designed to evaluate the parents' and doctors' opinions on the efficacy of the sedation. Statistical analysis was used to compare sedation times with children's age and weight RESULTS: The degree of sedation achieved by INM enabled all procedures to be completed without additional drugs. Premedication with lidocaine spray prevented any nasal discomfort related to the INM. The mean duration of sedation was 23.1 min. The depth of sedation was 1 on the modified Ramsay scale. The questionnaire revealed high levels of satisfaction by both doctors and parents. Sedation start and end times were significantly correlated with age only. No side effects were recorded in the cohort of children studied CONCLUSIONS: This study has shown that the combined use of lidocaine spray and atomized INM appears to be a safe and effective method to achieve short-term sedation in children to facilitate medical care and procedures
Oral versus intranasal	Midazolam	Johnson, E., et al. (2010). "The physiologic and behavioral effects of oral and intranasal midazolam in pediatric dental patients." *Pediatr Dent* **32**(3): 229-238 PURPOSE: The purpose of this study was to compare the safety and effectiveness of oral and intranasal midazolam in healthy children by evaluating their physiological and behavioral responses METHODS: Regimen A patients received 0.5 mg/kg oral midazolam with an intranasal saline spray placebo at their first appointment and 03 mg/kg intranasal midazolam with an oral midazolam placebo at their second appointment. Regimen B patients received the medications in the reverse order at each appointment. Physiological parameters and behavioral ratings were recorded RESULTS: There were no significant differences in physiological parameters in the two treatment groups, except for significantly lower oxygen saturation in the oral group at t = 20 min ($p = .03$) The oral group showed significantly lower crying scores at $t = 5$ min ($p = .02$) and lower overall behavioral scores at $t =$ papoose and $t = 5$ min ($p = .04$ and .03, respectively). Oral sedations were given ratings by providers of "effective" and "very effective" significantly more than intranasal sedations ($p < .05$) CONCLUSIONS: Both regimens have similar behavioral outcomes, with the oral group having improved crying and overall behavior early in the appointment. Oral sedations were considered to be more effective by providers than intranasal sedations. Clinically significant desaturations occur in both regimens, indicating the need for operators to recognize and respond to the need for airway correction according to American Academy of Pediatric Dentistry guidelines

Table 6.3 (continued)

Routes and agents		Routes
Oral versus nasal	Midazolam	Lee-Kim, S. J., et al. (2004). "Nasal versus oral midazolam sedation for pediatric dental patients." *J Dent Child (Chic)* **71**(2): 126-130 PURPOSE: The purpose of this study was to evaluate and compare intranasal (IN) and oral (PO) midazolam for effect on behavior, time of onset, maximum working time, efficacy, and safety for patients requiring dental care METHODS: Forty anxious subjects (20 IN, 20 PO, Frankl scale 3 and 4, ages 2–6 years, ASA I and II) were sedated randomly with either IN (0.3 mg/kg) or PO (0.7 mg/kg) midazolam. The dental procedure under sedation was videotaped and rated by a blinded and calibrated evaluator using Houpt's behavioral rating scale RESULTS: There was no statistical difference for overall behavior (F3, 27 = 0.407; $p = .749$). The planned contrasts showed significant interactions between time and route (IN vs. PO) between 25 and 30 min after starting sedation. The time of onset ($p = .000$) and the working time ($p = .007$) were significantly different between IN and PO midazolam. There were no statistically significant differences in vital signs (O2 sat, HR, RR, BP) between PO and IN ($p = .595$). IN subjects showed more movement and less sleep toward the end of the dental procedures and faster onset time but shorter working time than PO. Vital signs were stable throughout the procedures with no significant differences CONCLUSIONS: Mean onset time was approximately three times faster with IN administration compared to PO administration. Mean working time was approximately 10 min longer with PO administration than it was with IN administration. Overall behavior under PO and IN was similar. However, more movement and less sleep were shown in subjects under IN than those under PO toward the end of the dental session. All vital signs were stable throughout the procedures and showed no significant differences between PO and IN administration
Oral versus intravenous	Midazolam and diazepam	Tyagi, P., et al. (2013). "Sedative effects of oral midazolam, intravenous midazolam and oral diazepam in the dental treatment of children." *J Clin Pediatr Dent* **37**(3): 301-305 PURPOSE: To evaluate and compare the behavioral changes and effect of sedative techniques in pediatric dental patients using oral midazolam, intravenous midazolam, and oral diazepam as sedative agents METHOD: Triple blind randomized control trial with 40 patients aged between 2 and 10 years, exhibiting definitely negative behavior was considered. Patients were randomly assigned to one of the four treatment groups. Group I received midazolam 0.5 mg/kg orally, group II received 0.5 mg/kg diazepam orally, group III received 0.06 mg/kg midazolam intravenously, and group IV received oral placebo. Behavioral changes (sleep, crying, movement, and overall behavior) and effect of sedative techniques on pediatric patients were assessed RESULTS: All the patients in group III were significantly better in post-administrative behavior, viz., sleep, crying, and movement. Overall behavioral scores for group III patients were significantly better than other three groups ($p < 0.001$). Positive behavior of patients in group II and III did not show significant difference, but positive behavior in group III was significantly ($p < 0.05$) more than group II. Placebo group showed the highest negative behavior CONCLUSION: Sedative effects of oral midazolam and oral diazepam were comparable, whereas intravenous midazolam produced more sedation. Anxiolysis was found to be more in both the midazolam groups than the diazepam group. Most number of positive changes were observed in midazolam groups as compared to diazepam group

(continued)

Table 6.3 (continued)

Routes and agents		Routes
		Single and combination studies
Single agent	Triazolam	Raadal, M., et al. (1999). "A randomized clinical trial of triazolam in 3- to 5-year-olds." *J Dent Res* **78**(6): 1197-1203 PURPOSE: Triazolam has shown promise as a sedative agent for use in pediatric dentistry. However, the efficacy of triazolam has not been previously examined in a placebo-controlled study METHOD: The present clinical trial used a two-group, randomized, double-blind study design to compare the efficacy of oral triazolam with that of a placebo. The primary hypothesis tested was that triazolam would reduce negative behaviors of pediatric dental patients compared with a placebo. A secondary hypothesis was that triazolam would increase the efficiency of dental treatment by reducing the need for time-consuming behavioral management by the pediatric dentist. The subjects were 54 3- to 5-year-old children, randomly assigned to the drug and placebo groups. The active drug, 0.03 mg/kg triazolam (Halcion), or lactose placebo, was given orally 30 min before dental treatment. Behavioral management techniques commonly used in pediatric dentistry were used during dental treatment. A single pediatric dentist provided all of the dental treatment. The procedure included an inferior block anesthesia and careful attention to anesthesia effectiveness. All sessions were videotaped and the tapes coded for child and dentist behaviors by an independent observer RESULTS: There were no statistically significant differences between the groups with respect to completion of dental treatment. There were no significant differences found in either the total time or the percent of time that the subjects exhibited disruptive movements, verbal or nonverbal distress. The total use of time in the dental chair was slightly higher in the placebo than in the drug group due to more time spent preparing the child CONCLUSIONS: Contrary to preliminary reports in the literature, this investigation found little or no improvement in child behavior when triazolam was used as a sedative compared with a placebo. However, triazolam did shorten the length of dental treatment, primarily by reducing dentist time in preparing the child for the dental procedure (e.g., establishing rapport and shaping behavior)
Two-agent combination	Placebo, chloral hydrate, and hydroxyzine	da Costa, L. R., et al. (2007). "A randomized double-blinded trial of chloral hydrate with or without hydroxyzine versus placebo for pediatric dental sedation." *Braz Dent J* **18**(4): 334-340 PURPOSE: The aim of this crossover, double-blind study was to evaluate the effect of these drugs compared to a placebo, administered to young children for dental treatment METHODS: Thirty-five dental sedation sessions were carried out on 12 uncooperative ASA I children aged less than 5 years old. In each session, patients were randomly assigned to groups P (placebo), CH (chloral hydrate 75 mg/kg), and CHH (chloral hydrate 50 mg/kg plus hydroxyzine 2.0 mg/kg). Vital signs and behavioral variables were evaluated every 15 min. Comparisons were statistically analyzed using Friedman and Wilcoxon tests. RESULTS: P, CH, and CHH had no differences concerning vital signs, except for breathing rate. All vital signs were in the normal range. CH and CHH promoted more sleep in the first 30 min of treatment. Overall behavior was better in CH and CHH than in P. CH, CHH, and P were effective in 62.5, 61.5, and 11.1 % of the cases, respectively CONCLUSION: Chloral hydrate was safe and relatively effective, causing more satisfactory behavioral and physiological outcomes than a placebo

Table 6.3 (continued)

Routes and agents		Routes
Single versus two combination	Midazolam and hydroxyzine	Shapira, J., et al. (2004). "Comparison of oral midazolam with and without hydroxyzine in the sedation of pediatric dental patients." *Pediatr Dent* **26**(6): 492-496 PURPOSE: The purpose of this study was to compare the effectiveness of midazolam (MDZ) alone to a combination of MDZ and hydroxyzine (MDZH) when sedating young children for dental treatment METHODS: This was a prospective, double-blind, crossover clinical study of young uncooperative children in need of at least two restorative visits. Twenty-eight children, ages 21–56 months, with a mean age of 36.6 months, participated in this study. The subjects were assigned randomly to receive either 0.5 mg/kg of oral MDZ 20 min prior to the beginning of dental treatment or the combination of 0.3 mg/kg oral MDZ with 3.7 mg/kg of hydroxyzine 30 min before treatment. The alternative drug regimen was administered at the second appointment. All subjects also received 50 % nitrous oxide and were restrained with a Papoose board. The child's behavior (quiet or crying, relaxed or moving) was evaluated every 5 min by an experienced pediatric dentist who was unaware of the drug given to the child. At the conclusion of treatment, each session was evaluated for overall effectiveness RESULTS: Regardless of the type of premedication, more patients exhibited quiet behavior at the beginning of treatment, with an increase in crying and movement toward the end of treatment. Regarding movement, a significant difference was observed during the first 20 min between the two regimens. MDZ showed more children exhibiting movement. During the first 30 min of treatment, more children cried in the MDZ group, while MDZH presented more children asleep or quiet. No significant differences were found in behavior as a function of the order the sedative regimens were given. No significant differences between the two regimens regarding overall behavior and success ($t = 0.655$ at 27° of freedom; $p = .518$) were found. CONCLUSIONS: The combination of hydroxyzine (3.7 mg/kg) with MDZ (0.3 mg/kg) administered 30 min before treatment resulted in safe and effective sedation for the dental treatment of young children. This combination's use might be more advantageous when compared to MDZ alone, resulting in less crying and movement during the first 30 and 20 min, respectively
Single versus two combination	Midazolam and ketamine	Cagiran, E., et al. (2010). "Comparison of oral Midazolam and Midazolam-Ketamine as sedative agents in paediatric dentistry." *Eur J Paediatr Dent* **11**(1): 19-22 PURPOSE: We compared the efficacy of sedation with oral midazolam and a combination of oral midazolam and ketamine used as alternatives to general anesthesia during tooth extraction Study Design: Retrospective study METHOD: A total of 30 patients aged between 3 and 9 years, who had elective tooth extraction, were included in the study. Subjects in Group A (n. 15) were given 0.75 mg/kg midazolam orally, while those in Group B (n. 15) were given 0.75 mg/kg midazolam orally + 5 mg/kg ketamine. Acceptance of orally administered drugs, sedation and anxiety scores, and reactions to local anesthetic injection and tooth extraction were assessed RESULTS: Sedation and anxiety scores in Group B were better than in Group A ($p < 0.05$). Reactions to local anesthetic injection and tooth extraction were very significantly less common in Group B ($p < 0.0001$). Requirement for an additional medication was more common in Group A ($p < 0.05$). Side effects were not observed in either group. Statistics: patient demographics and time to discharge were analyzed by Mann-Whitney *U* test, whereas Chi-square test was used to analyze compliance to sedation, anxiety and sedation scores, reaction to tooth extraction, side effects, and additional drug requirement CONCLUSION: Compared to oral midazolam only, a combination of oral midazolam + ketamine resulted in better sedation and surgical comfort in children during a painful procedure such as tooth extraction

(continued)

Table 6.3 (continued)

Routes and agents		Routes
Triple combinations	Chloral hydrate, meperidine, hydroxyzine versus midazolam, meperidine, hydroxyzine	Sheroan, M. M., et al. (2006). "A prospective study of two sedation regimens in children: chloral hydrate, meperidine, and hydroxyzine versus midazolam, meperidine, and hydroxyzine." *Anesth Prog* **53**(3): 83-90 PURPOSE: The aim of this study was to compare both the behavioral and physiological effects of two drug regimens in children: chloral hydrate (CH), meperidine (M), and hydroxyzine (H) (regimen A) versus midazolam (MZ), M, and H (regimen B) METHODS: Patients between 24 and 54 months of age were examined by crossover study design. Behavior was analyzed objectively by the North Carolina Behavior Rating System and subjectively through an operator and monitor success scale. Physiological data were recorded every 5 min and at critical points throughout the appointment RESULTS: Sixteen patients completed this study. No significant differences in behavior were noted by the North Carolina Behavior Rating System or the operator and monitor success scale. A quiet or annoyed behavior was observed 93 and 90 % of the time for regimen A and regimen B, respectively. Using the operator and monitor success scale, 63 % of regimen A and 56 % of regimen B sedations were successful. No statistically significant differences were noted in any of the physiological parameters between the two regimens. Ten episodes of hemoglobin desaturation were detected with regimen A sedations CONCLUSIONS: There were no differences between the sedative drug regimens CH/M/H and MZ/M/H for behavioral outcomes or physiological parameters

Table 6.4 Representative "older" studies

Authors	Year	Drugs	Res design	# Children/age	Primary emphasis: behavior, physiology or both	Results
Nathan and West	1987	Combo of chloral hydrate, hydroxyzine with or without meperidine	Retrospective Descriptive	135 Mean 34 months (range 18–60 months)	Behavior success scale	Addition of meperidine enhanced sedation success with less restraint needed
Iwasaki, J. Vann, W. F., Jr. Dilley, D. C. Anderson, J. A.	1989	Chloral hydrate (75 mg/kg)	Prospective Descriptive Detect airway compromise and desaturation	10 - Mean age 34 months	Physiology - O2, CO2	Capnography very accurate in detecting obstruction CO2 values not predictive of subsequent desaturations All patients had mild desaturation and 50 % had moderate desaturation
Meyer, M. L. Mourino, A. P. Farrington, F. H.	1990	Triazolam (0.2 mg/kg) vs. chloral hydrate (40 mg/kg) and hydroxyzine (25 mg) N2O (50 %)	Prospective Two groups	20 – triazolam Mean age 44 months (21–74 months) 20 – chloral hydrate Mean age 42 (23–64 months)	Both Houpt scale Degree of sleep, crying, movement, overall behavior O2, HR	No statistical difference in behavior or vital signs
Poorman, T. L. Farrington, F. H. Mourino, A. P.	1990	Combo of chloral hydrate (40 mg/kg) and hydroxyzine (25 mg) Combo of chloral hydrate (40 mg/kg), meperidine (0.5 mg/kg), and hydroxyzine (25 mg) N2O (50 %)	Prospective Two groups	20 (each of two groups) 24–60 months	Both Houpt scale Degree of sleep, crying, movement, overall behavior O2, HR	No statistical difference in behavior or vital signs
Hasty, M. F. Vann, W. F., Jr. Dilley, D. C. Anderson, J. A.	1991	Two combos Combo of chloral hydrate (50 mg/kg), meperidine (1.5 mg/kg), and hydroxyzine (25 mg) Combo of chloral hydrate (50 mg/kg) and hydroxyzine (25 mg)	Prospective Crossover	10 Mean age 37 months	Both HR, O2, CO2	Addition of meperidine improved behavior Addition of meperidine did not increase prevalence of respiratory compromise

(continued)

Table 6.4 (continued)

Author	Year	Drugs	Res design	# children/age	Primary emphasis: behavior, physiology or both	Results
Sams, D. R. Thornton, J. B. Wright, J. T.	1992	Combo of chloral hydrate (50 mg/kg) and promethazine (1 mg/kg) Combo of meperidine (1 mg/kg) and promethazine (1 mg/kg)	Retrospective Descriptive 112 sedations	112 Mean 39 months (range 20–120 months)	Both Modified Barker and Nisbet Scale Degree of sleep, crying, movement, overall behavior O2, HR	48 % experienced mild to moderate hypoxemia occurring even between regimens 6.2 % had emesis No statistical difference between regimens
Roberts, S. M. Wilson, C. F. Seale, N. S. McWhorter, A. G.	1992	Two narcotic regimens Morphine (0.15 mg/kg) and promethazine (1.1 mg/kg) given submucosal Meperidine (2.2 mg/kg) and promethazine (1.1 mg/kg) given orally	Prospective Descriptive Blinded Partial crossover	29 (42 sedations) 2–7 years of age 23 had morphine 11 had meperidine	Both Hr, RR, BP, O2 Success scale	No significant differences in vital signs across time No differences between regimens
Sams, D. R. Cook, E. W. Jackson, J. G. Roebuck, B. L.	1993	Combo of chloral hydrate (50 mg/kg) and promethazine (1 mg/kg) Combo of meperidine (1 mg/kg) and promethazine (1 mg/kg)	Prospective Randomized Double blind Two groups	24 18–48 months	Behavior Houpt Scale Degree of sleep, crying, movement, overall behavior O2, HR	Chloral hydrate/promethazine was statistically better than meperidine/promethazine to cause more sleep, less movement and crying, and overall score No clinical difference between two regimens
Wilson S.	1993	Chloral hydrate used alone but in 3 different doses (25, 50, and 70 mg/kg)	Prospective Randomized Double blind Latin square design	20 Mean age 30.7 ± 4.8 months)	Both O2, HR, EMG amplitude Ohio State University Behavior Rating Scale	Statistically significant difference in EMG, % of quiet and crying behaviors as a function of dose The higher the dose, the more quiet behaviors noted Significant correlations between EMG and % crying and quiet behaviors

Haney, K. L. McWhorter, A. G. Seale, N. S.	1993	Combo of meperidine (1.0 mg/lb) and promethazine (0.5 mg/lb) N2O	Retrospective Descriptive	282 sedations Mean age 6.4 years Medically compromised pts	Behavior simplified success index (3 levels: failure, moderately successful, highly successful	Children taking medications with CNS action were significantly less likely to have successful appointments Children with neurological problems were significantly less likely to have successful appointment 77 % of all sedations successful
Lochary, M. E. Wilson, S. Griffen, A. L. Coury, D. L.	1993	Combo of meperidine (2 mg/kg) and hydroxyzine (2 mg/kg)	Prospective Descriptive	29 Mean age 30±6.2 months	Both HR, O2, CO2 Ohio State University Behavior Rating Scale Evaluated child temperament variables	Approachability and adaptability were found to predict total % of struggling behaviors Approachability predicted total % of all negative behavior
Fukuta, O. Braham, R. L. Yanase, H. Atsumi, N. Kurosu, K.	1993	Midazolam (0.2 mg/kg) given intranasally No drugs	Prospective Descriptive Crossover Mentally disabled patients	21 4–21 years	Both 7-point behavior rating scale	Marked improvement with midazolam
Sanders, B. J. Avery, D. R.	1994	Combo of chloral hydrate 50–60 mg/kg) and hydroxyzine (15–25 mg) N2O (30–50 %)	Prospective Descriptive	30 18–61 months	Behavior Evaluate effect of preoperative sleep on sedation Good to poor scale	Normal or more than normal amount of sleep had better sedation Child older than 3 years had better sedation
Fuks, A. B. Kaufman, E. Ram, D. Hovav, S. Shapira, J.	1994	Two doses of midazolam given intranasally 0.2 mg/kg 0.3 mg/kg N2O (50 %)	Prospective Randomized Blinded Two groups	30 Mean age 32 months	Both Houpt Scale	No statistical difference between dosages No adverse events
Hartgraves and Primosch	1994	Midazolam given either orally or intranasally Oral (0.5 mg/kg) Nasal (0.2 mg/kg) N2O	Prospective Descriptive Two groups	100 1.5–6 years	Behavior Success scale	No difference in success or complications between routes of administration Satisfactory sedation at 66 % of time

(continued)

Table 6.4 (continued)

Author	Year	Drugs	Res design	# children/age	Primary emphasis: behavior, physiology or both	Results
Silver, T. Wilson, C. Webb, M.	1994	Midazolam (two dosages) 0.3 mg/kg 0.5 mg/kg	Prospective Randomized Two groups	31 3–18 years of age	Both	Mixed statistically significant effects on physiology, but none were clinically significant 0.3 mg/kg successful 75 %; 0.5 mg/kg successful 60 %
Croswell, R. J. Dilley, D. C. Lucas, W. J. Vann, W. F., Jr	1995	Combo of chloral hydrate (50 mg/kg), meperidine (0.5 mg/kg), and hydroxyzine (25 mg) Oxygen supplement	Prospective Descriptive, blinded Traditional vs. electronic monitors	39 Mean age 39 months	Physiology O2,CO2,HR	Electronic detected more respiratory compromise than traditional CO2 better than O2 in detecting compromise
McCann, W. Wilson, S. Larsen, P. Stehle, B.	1996	Combo of chloral hydrate (40 mg/kg) and hydroxyzine (2 mg/kg) O2 (100 %) vs. N2O (50 %)	Prospective Randomized Double blind Crossover	20 Mean age 45 ± 5.1 months	Both HR, O2, CO2 Ohio State University Behavior Rating Scale (OSUBRS)	No difference in physiology or behavior as a function of inhalation agent Statistically significant differences in physiology and behavior as a function of procedural events N2O caused less crying and struggling and more quiet behaviors than O2
Haas, D. A. Nenniger, S. A. Yacobi, R. Magathan, J. G. Grad, H. A. Copp, P. E. Charendoff, M. D.	1996	Two regimens Midazolam (0.6 mg/kg) Chloral hydrate (50 mg/kg)	Prospective Randomized Double blind Crossover	23	Both Frankl scale	Patients given midazolam had increased level of sedation prior to local anesthesia No statistical differences in any other parameters
Kupietzky, A. Holan, G. Shapira, J.	1996	Midazolam (0.2 mg/kg) Hydroxyzine (3.7 mg/kg) N2O	Prospective Descriptive Randomized Crossover Two groups	30 24–28 months of age	Behavior and memory Stanford Binet Scale-Memory	Recall in group was 90 % Recall was 71 % for hydroxyzine and 29 % for midazolam Midazolam more effective in causing amnesia

Reeves, S. T. Wiedenfeld, K. R. Wrobleski, J. Hardin, C. L. Pinosky, M. L.	1996	Combo of chloral hydrate (50 mg/kg) and hydroxyzine (25 mg) Midazolam (0.5 mg/kg) and acetaminophen (10 mg/kg)	Prospective Randomized Double blind Two groups		Behavior Houpt Scale	No significant difference between groups for age, weight, sex, length of procedure Chloral hydrate caused more sleep at later time intervals No difference in overall behavior between regimens
Roelofse, J. A. Joubert, J. J. Roelofse, P. G.	1996	Combo of midazolam (0.35 mg/kg) and ketamine (5 mg/kg) rectally Midazolam alone (1 mg/kg) rectally	Prospective Descriptive	100 2–7 years of age	Both - Hr, RR, BP, O2	Satisfactory sedation and anxiolysis achieved with both drugs Excessive salivation in 26 % receiving combo compared to 14 % midazolam alone 14 % with combo had hallucinations compared to 42 % with midazolam
Shapira, J. Holan, G. Botzer, E. Kupieztky, A. Tal, E. Fuks, A. B.	1996	Hydroxyzine nasally Midazolam (0.2 mg/kg) nasally N2O	Prospective Descriptive Crossover	29 2–4 years of age	Both Houpt Scale	No difference in general behavior Midazolam caused better acceptance of face mask
Fishbaugh, D. F. Wilson, S. Preisch, J. W. Weaver, J. M.,	1997	Combo of chloral hydrate (50 mg/kg) and hydroxyzine (2 mg/kg) N2O (50 %)	Prospective Descriptive Attempted to block airway with Moore maneuver	30 age range of 22–40 month	Physiology CO2 and airway blockage studied	Enlarged tonsils (>50 % of airway) blocked airway and decreased CO2 concentration Small or no tonsils did not block airway and CO2 concentration not affected
Rohlfing, G. K. Dilley, D. C. Lucas, W. J. Vann, W. F., Jr.	1998	Combo of chloral hydrate (50 mg/kg), meperidine (1.5 mg/kg), and hydroxyzine (25 mg) O2 supplementation	Prospective Crossover	14 Mean age 42 months	Physiology - HR, O2	Overall risk of desaturation was 29 % with no difference in risk of apnea between O2 vs. non-O2 supplementation O2 was elevated and statistically different in supplemental conditions compared to non-O2
Fraone, G. Wilson, S. Casamassimo, P. S. Weaver, J., 2nd Pulido, A. M.	1999	Midazolam (0.5 mg/kg)	Prospective Three groups (based on age)	61 24–58 months of age	Both	No significant difference among three age groups (3–5 years of age)

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Table 6.4 (continued)

Author	Year	Drugs	Res design	# children/age	Primary emphasis: behavior, physiology or both	Results
Leelataweewud, P. Vann, W. F., Jr. Dilley, D. C. Lucas, W. J.	2000	Combo of chloral hydrate (50 mg/kg), meperidine (1.5 mg/kg), and hydroxyzine (25 mg) O2 supplementation vs. 50 % N2O	Prospective Randomized Double blind Crossover	19 Mean age 41 ±8.6 months	Both - HR, RR, O2, CO2	No difference between inhalation agents Level of sedation deeper with N2O Sedation outcomes better with N2O
Wilson, S. Easton, J. Lamb, K. Orchardson, R. Casamassimo, P.	2000	Three drug regimens (doses varied) Chloral hydrate, meperidine, and hydroxyzine Chloral hydrate and hydroxyzine Midazolam	Retrospective Descriptive	300 (100/drug regimen) 2–5 years of age	Both HR, O2, CO2 Ohio State University Behavior Rating Scale	Significant differences in mean age, weight, and duration of drug regimen Significant differences in % quiet, sleep, and struggling behaviors as a function of drug regimen More sleep with triple combo; more quiet with chloral hydrate and hydroxyzine combo Preoperative cooperative behaviors predictive of intraoperative behaviors Significant difference in HR as a function of drug regimen with chloral hydrate and hydroxyzine causing lower HR
Dallman, J. A. Ignelzi, M. A., Jr. Briskie, D. M.	2001	Midazolam (0.2 mg/kg intranasal) Combo of chloral hydrate (62.5 mg/kg) and promethazine (12.5 mg) N2O (25–50 %)	Prospective Double blind Crossover	31 Mean 41.8 months (range 26–58 months)	Both HR, BP, RR, O2 Houpt rating scale	No clinical difference, but statistical in physiology (BP decreased in combo) No significant differences in behavior; however, combo caused more sleep and longer recovery
Leelataweedwud, P. Vann, W. F., Jr.	2001	Combo of chloral hydrate, meperidine, and hydroxyzine O2 supplementation	Retrospective 195 sedations	111 Mean age 47 months (range 24–48 months)	Both	Adverse events occurred in 3 % of all sedations (they were relatively minor) 72 % satisfactory behaviors, 23 % unsatisfactory, 5 % aborted Sex not a factor

Erlandsson, A. L. Backman, B. Stenstrom, A. Stecksen-Blicks, C.	2001	Midazolam (0.2 mg/kg)	Prospective Descriptive	160 Mean age 6.7 ± 2.6 years	Both Success	Of 250 sessions, 63 % were acceptable and 30 % were doubtfully acceptable
Religa, Z. C. Wilson, S. Ganzberg, S. I. Casamassimo, P. S.	2002	Combo of chloral hydrate (variable), meperidine (2 mg/kg), and hydroxyzine (2 mg/kg) N2O (50 %)	Prospective Descriptive	34 Mean age 46 ± 10 months	Both HR, O2, CO2, BIS (EEG) Ohio State University Behavior Rating Scale	Significant association between patient behaviors, levels of sedation according to AAPD guidelines, and BIS BIS does not appear to be more valid than other physiological variables in determining depth of sedation
Singh, N. Pandey, R. K. Saksena, A. K. Jaiswal, J. N.	2002	Midazolam Triclofos Promethazine	Prospective Three groups	3–9 years of age	Both	Midazolam was best in producing conscious sedation
Nathan and Vargas	2002	Midazolam (0.7–1.0) Combo of midazolam (0.7–1.0 mg/kg) and meperidine (1.0–1.5 mg/kg)	Retrospective Descriptive Six groups	120 24–48 months of age	Both	0.7 mg/kg midazolam used alone caused most agitation 1.0 mg/kg midazolam and meperidine most effective Addition of meperidine increases effectiveness and working time
Lima, A. R. da Costa, L. R. da Costa, P. S.	2003	P (placebo), M (midazolam 1 mg/kg) or MH (midazolam 0.75 mg/kg and hydroxyzine 2.0 mg/kg)	Prospective	37 children Age range 40–59 months	Houpt scale	Overall behavioral analysis showed that group M was significantly better than group P ($p = 0.011$) and group MH ($p = 0.022$) No serious adverse events were observed in the groups; the success rate for each group based solely on overall behavior scores 5 and 6 was 7.7 % (P), 77.0 % (M), and 30.8 % (MH)

(continued)

Table 6.4 (continued)

Author	Year	Drugs	Res design	# children/age	Primary emphasis: behavior, physiology or both	Results
Myers, Maestrello, Mourino, Best,	2003	CH+placebo (50 mg/kg) versus CH+midazolam submucosally (50 and 0.2 mg/kg, respectively	Randomized, double blind, crossover	20 children Age range 32–63 months	OSUBRS Behavior was evaluated every 2.5 min beginning with the start of the dental procedure through 40 min for a total of 17 observations	No serious complications or adverse outcomes The probability of each of the behavioral categories occurrence was dependent upon the drug used and was not dependent on visit number Therefore, the overall decrease in negative behavior and increase of quiet behavior were not due to chance or any effect created by the order of sedation visits and can be directly attributed to the SM midazolam. This data indicates the difference in behavior seen that was not due to differences in wait time or delays after the midazolam/placebo was administered. HR and RR were both elevated for the patients receiving midazolam. HR was different across visit number, while RR was not
Chowdbury Vargas	2005	Chloral hydrate (25 m/k) Meperidine (1 m/k) Hydroxyzine (1 m/k) versus Midazolam (0.6 mg/kg)	Retrospective	66 children sedated, 45 % girls and 55 % (36) boys. Range in age: 24–60 months	Frankl scale	CH+H+M in combination with N2O was more than three times as likely to have a successful outcome as those receiving midazolam Physiology significantly fewer children sedated with CH+H+M experienced elevations of heart rate beyond 130 bpm. No difference in oxygen saturation

Wilson Welbury Girdler	2007	Midazolam (0.2 mg/kg) – buccal mucosal versus Nitrous oxide (30–70 %)	Prospective, randomized, crossover	36 children 26 female, 10 male Mean age: 12.6 years	Houpt scale Vital signs	No significant difference in behavior or physiology associated with extraction of premolar teeth for orthodontia. Buccal administration least preferred because of taste
Faytrouny Okt Kucukyavuz	2007	Hydroxyzine (20 mg – 24 h preoperatively) plus 3.7 mg/kg before sedation procedure versus 3.7 mg/kg before sedation procedure; All received nitrous oxide	Prospective, randomized, operator blinded	30 children 31–120 months (mean 61.9 months)	Houpt scale Oxygen saturation HR	Both groups had 90 % success rate; no difference in behavior. Those without preoperative drug had significantly higher heart rate and lower oxygen saturation, but neither was clinically significant
Gilchrist Cairns Leitch	2007	Midazolam (0.25 mg/kg) Intranasal (mucosal atomization device)	Clinical trial	13 children	Behavior Saturation	Physiological parameters remained stable throughout with no clinically significant episodes of desaturation. One patient vomited at home postoperatively
Pandey Padmanabhan Saksena Chandra	2010	Midazolam (0.5 mg/kg) Fentanyl (3 μg/kg) Placebo	Prospective, randomized, triple blinded	23 children 35–77 months, mean 57.6 months 11 males 12 females	Level of sedation Ease of treatment Vital signs including oxygen saturation	Transient oxygen desaturation was observed in 4 children who were sedated with the combination of oral midazolam and submucosal fentanyl. The overall success was 73.91 % with oral midazolam and submucosal fentanyl regimen and 47.83 % for oral midazolam and submucosal placebo regimen. Submucosal fentanyl appears to improve the short working time associated with oral midazolam. But the oxygen desaturation associated with this regimen necessitates further studies

(continued)

Table 6.4 (continued)

Author	Year	Drugs	Res design	# children/age	Primary emphasis: behavior, physiology or both	Results
Pandey, Behetwar Saksena Chandra	2011	Intranasal ketamine (6 mg/kg) Drops versus atomized spray	Prospective, crossover, randomized	34 children 2–6 years, mean 4.4 years 16 female, 11 male	Behavior – Ohio State Behavior Rating Scale, Level of sedation	This was a two-stage crossover trial, and each child received INK by both modes of administration. Statistically greater acceptance by patients of atomized versus drop administration. Less aversive reaction to atomized. Also, statistically faster onset and shorter recovery with atomized. No difference in vital signs. Vomiting occurred for both types of administration
Chopra Mittal Bansal Chaudhuri	2013	Midazolam (0.25 mg/kg) Intranasal versus buccal spray	Prospective Crossover Blinded	30 children 2–8 years, mean 3.8 years 23 males, 7 females	Behavior – Houpt scale	Acceptance of drug through buccal route was significantly better than the intranasal route ($p<0.05$), but no statistically significant difference was found in the behavior scores for the two routes of administration ($p>0.05$)

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Monitors

7

Stephen Wilson

Abstract

Monitors are an essential part of sedation. The clinician performs clinical monitoring by intermittently observing the patient's breathing, color, and behavior in addition to using other electronic or non-electronic monitors. This chapter discusses the different types of monitors that are useful during oral sedation of children for dental procedures. Pulse oximetry is the gold standard of electronic monitors and will likely be paired with capnography or stethoscopes as standard of care for moderate to deep sedation levels in the future. Monitors are easy to use, and most have alarm systems that can be adjusted as needed for certain clinical circumstances. These features are discussed in this chapter.

Monitoring

Monitoring means to "warn" or "alert." Monitoring of a sedated child enables the clinician to be *alert* to physiological and behavioral changes, some of which may indicate an impending danger, *warning* the clinician to act definitively and swiftly to prevent an adverse event. Monitoring in this sense implies that a professional is always available during a sedation procedure, understands physiological parameters and their implications, is capable of interpreting incoming clinical information, and can act in an appropriate and timely fashion to correct or stabilize an unstable patient state. Therefore, the clinician must be intimately familiar with the normal and abnormal functions and integrity of patient's physiological systems (e.g., respiratory), appropriate parameters and values for each system, and possess knowledge and skill sets associated with necessary interventions to rescue the child from a deteriorating condition (Table 7.1) [1]. A clinician, who lacks knowledge of the systems and does not have appropriate monitors, training, and skill sets, is teetering on the brink of disaster should they decide to sedate a patient for the sake of clinical convenience or in response to other pressures (e.g., parental desires).

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Table 7.1 Normal respiratory and heart rates and blood pressure of child

Normal respiratory rates	
Age	Breaths/min
Infant (<1 year)	30–60
Toddler (1–3 years)	24–40
Preschooler (4–5 years)	22–34
School age (6–12 years)	18–30
Adolescent (13–18 years)	12–18

Normal heart rates		
Age	Awake	Sleeping
Newborn – 3 years	85–205	80–160
3 months – 2 years	100–190	75–160
2–10 years	60–140	60–90
>10 years	60–100	50–90

Normal blood pressure of children				
	50 % of height			
Age	Girls		Boys	
	Systolic	Diastolic	Systolic	Diastolic
1	86	40	85	37
2	88	45	88	42
3	89	49	91	46
4	91	52	93	50
5	93	54	95	53
6	94	56	96	55
7	96	57	97	57
8	98	58	99	59
9	100	59	100	60
10	102	60	102	61
11	103	61	104	61
12	105	62	106	62
13	107	63	108	62
14	109	64	111	63
15	110	65	113	64
16	111	66	116	65
17	111	66	118	67

Source: National Heart, Lung, and Blood Institute; National Institutes of Health; US Department of Health and Human Services

The major systems of interest during a procedure involving oral sedation are respiratory, cardiovascular, central nervous system (CNS), gastrointestinal, and renal. From a monitoring viewpoint, the respiratory, cardiovascular, and CNS are the three main systems of interest potentially affected by sedatives depending on the drug(s) and dosages. For this reason, the clinician will be responsible for closely monitoring ventilation, oxygenation, hemodynamic stability, and CNS functions characteristic of these systems. There are no direct measures typically monitored for the GI and renal system. However, familiarity with their function as it relates to pharmacokinetic and pharmacodynamic management of the sedative agent(s) will be important during clinical procedures and expectations as well as for the process of advisory information and feedback instructions provided by the clinician to the patient or parent.

The act of monitoring can and does, in most cases, involve both a trained professional and assistant, who use clinical observation techniques and various monitoring apparatuses (e.g., precordial stethoscope) according to sedation guidelines [2, 3]. It must be emphasized that reliance only on feedback from monitoring apparatuses during a procedure is not sufficient in promoting optimal patient safety. For instance, a clinician who simply places an oxisensor from a pulse oximeter on the patient knowing the monitor may sound an alarm if oxygen desaturation drops to a certain level and otherwise focuses on the intricacies of the operative procedure is inadequately monitoring the patient (especially if the alarm function has been silenced!).

Monitoring can be both invasive and noninvasive [4, 5]. However, noninvasive monitoring is used for oral sedation involving children because of its convenience, lack of painful stimulation, and usual acceptance by the child once the monitoring is explained or shown to the child in an appropriate fashion.

Monitoring apparatuses can further be divided into non-electronic and electronic monitors (see Table 7.2). Non-electronic monitoring is simple in concept but requires direct clinician-to-patient interaction in order to obtain a measurement (e.g., obtaining respiratory rate with a stethoscope). Automated electronic monitors provide a display of the measures being monitored. They may also provide a printed output that is date-time stamped. The design and sophistication of electronic monitors have increased dramatically since the introduction of microprocessor chips in the 1970s and 1980s. Today, the monitors are relatively small in size and often contain multiple

Table 7.2 Summary of monitors used frequently in sedating pediatric dental patients

Monitor	Measurement	Critical factors affecting signal	Advantages	Disadvantages
Pulse oximeter	Absorption and ration of red an infrared light representing degree of hemoglobin saturation. Also determines heart rate via plethysmography	1. Sensors must be directly opposite each other 2. Patient movement 3. Crying, sobbing, and Valsalva maneuver 4. Pressure on vascular vessels above probe (e.g., blood pressure cuff) 5. Cold limbs	1. Safe and noninvasive 2. Simple to use 3. Information rapidly available for clinical decisions 4. Indirectly and secondarily indicates respiratory exchange	1. Non-reusable probes are expensive 2. Finger probes can be easily dislodged by uncooperative patient. Toes work well with probe taped (gently) in place 3. Emitted light source may cause burning sensation 4. Does not directly determine airway patency
Automated blood pressure cuff	Simultaneously records oscillations and bladder pressure. Also, determines heart rate via plethysmography	1. Cuff size must be appropriate for arm. Too narrow falsely increases absolute parameters; too broad falsely decreases absolute parameters	1. Safe and noninvasive 2. Simple to use 3. Determination time usually less than 30 s	1. Determination time increased with moving uncooperative patient eventually causing discomfort and potential limb paresthesia 2. Because of #1, may decrease patient cooperation
Capnography	Expired carbon dioxide	1. Nasal probe must not be blocked by mucus or physical barrier (e.g., nasal septum or alae)	1. Safe 2. Simple to use 3. Information rapidly available for clinical decisions 4. Indirectly indicates respiratory exchange 5. Directly determines airway patency	1. Temporary block of sample line by mucus 2. May register low CO_2 values when child is crying or probe becomes dislodged for nasal opening
Precordial stethoscope	Sounds of heart and lungs/airway	1. Placement of the bell on the chest wall (best location for determining airway patency with faint heart sounds is over presternal notch below thyroid cartilage) 2. Extraneous sounds (e.g., noise from handpiece) 3. Fixation to chest wall	1. Inexpensive 2. Simple to use 3. Noninvasive 4. Durable	1. Picks up interfering vibratory sounds (e.g., from handpiece) 2. Does not determine degree of airway patency 3. If improperly placed, decreases usefulness in auscultating sounds

measured parameters within a single unit. There are many types of monitors on the market [3]. In dentistry, the pulse oximeter was recently found to be the most frequently used monitor, although others are used as well [6].

Pulse Oximetry

Pulse oximetry is an indirect means of noninvasively measuring the percent of oxygen saturation of hemoglobin molecules in red blood cells

(RBCs) on a continual basis. The percent oxygen saturation of hemoglobin is important during sedation because it gives an indication of how much oxygen is being delivered to metabolically active tissue, especially the brain which requires lots of oxygen to function. Hemoglobin molecules in RBCs become saturated with oxygen (4 oxygen atoms per heme protein) as they pass in the capillary beds surrounding the lungs. The saturated hemoglobin in the RBCs is then pumped throughout the body via the circulation system to metabolically active areas of the body. As the pCO_2 in areas of metabolically active tissue rises, it causes a shift in the tenacity at which hemoglobin binds oxygen resulting in a release of oxygen molecules in the area and a desaturation of the hemoglobin. The RBCs containing the desaturated hemoglobin make their way back to the lungs via the circulatory system to be saturated once again.

If there are any conditions or situations at any step along this saturation-desaturation of hemoglobin process, then clinical problems can arise. For instance, and as it relates to sedation, if the upper airway is blocked and not corrected, oxygen cannot get into the lungs, and the desaturated RBCs passing through the oxygen-depleted lungs cannot pick up oxygen to deliver to already deoxygenated tissues rapidly causing death. In this respect, pulse oximetry is a way to *indirectly* determine if a person is being ventilated and obtaining sufficient oxygen for active tissues. Pulse oximetry does not *directly* measure ventilatory function which in simplistic terms is the movement of air into and out of the lungs.

The functional mechanism of the pulse oximeter monitor can be described as follows. Pulse oximetry is based on the red and infrared light absorption characteristics of oxygenated and deoxygenated hemoglobin. The wavelength of red and infrared light is 660 and 940 nm, respectively. The states of oxygenated and deoxygenated hemoglobin absorb red and infrared light differently. Oxygenated blood absorbs more infrared light and deoxygenated hemoglobin absorbs more red. Conceptually and mnemonically, one could imagine oxygenated blood as appearing bright red with more red light passing through it so we can "see" that it is red (infrared is differentially absorbed). Conversely, deoxygenated blood appears darker (not as bright) and the red light is differentially absorbed.

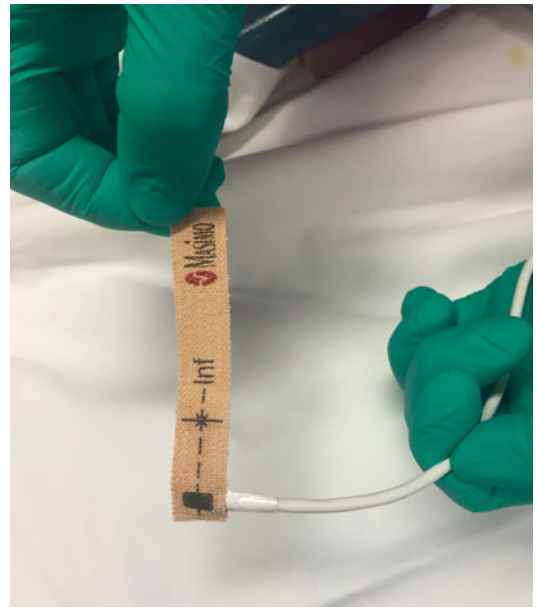

Fig. 7.1 Band-Aid style of oxisensor for pulse oximeter

The pulse oximeter is a monitor that contains a microprocessor and uses a "lead" or oxisensor that affixes to the patient's anatomy (Fig. 7.1). The oxisensor contains two elements: a light-emitting diode (LED) and a photosensitive diode. The LED is capable of emitting red and infrared light at a relative high frequency (i.e., 30 per second). Since the eye does not detect infrared light and cannot discriminate frequencies higher than 20 cycles per second, the LED when lit simply appears as a small red light. The photosensitive diode determines the ratio of the two light waves transmitted and not absorbed. When a tissue bed is placed between the two diodes, the ratio of the two light wavelengths that are not absorbed by the tissue can be measured.

The dimension of the tissue bed changes ever so slightly when an arterial pulse passes through a tissue bed. Because of the dimensional change of the tissue due to the pulse pressure, the transmitted ratio of light travels over a slightly longer distance per unit time. The microchip processor within the pulse oximeter captures this information,

generates, and displays the "signal" as both the heart rate obtained by plethysmography (i.e., change in volume in a tissue bed per unit of time) and the percent of oxygen saturation based on the ratio of the two light wavelengths detected. Thus, the pulse oximeter gives a noninvasive reading of peripheral arterial saturation.

Pulse oximeters not only display information on heart rate and oxygen saturation, they are capable of providing visual and auditory signals as well. Thus, a nice feature of the pulse oximeters is that the audible pitch of each arterial pulse varies with the percent saturation of the hemoglobin. A relatively high pitched sound is heard when the monitor indicates the patient is 100 % saturated (actually, they are slightly less than 100 % saturated at sea level in a normal, healthy adult, but the manufacturers of the pulse oximeter set this value at 100 %). As a patient begins to desaturate, the pitch of the audible sound begins to decrease. In this way, the clinician can not only see what the saturation value is, but does not even have to look up from the patient to know that the saturation level is changing. Also, the frequency rate of the auditory sound indicates whether the heart rate is increasing or decreasing.

Another nice feature of the pulse oximeters is that alarms can be set to sound if the heart rate and/or saturation increases above or below preset values. For instance, most pulse oximeters have a preset heart rate value of 140 and 60 beats per minute for the high and low heart rate thresholds, respectively. Furthermore, for some pulse oximeters, the clinician can reset the high- and low-heart-rate alarm setting at any time when the monitor is turned on and functioning. The same is true for oxygen saturation limits. It is advisable to select oximeters with these features when thinking of purchasing a pulse oximeter.

Clinically, resetting the upper heart rate limit at the beginning of a sedation procedure becomes important for young children (i.e., 4 years or less). They are capable of generating heart rates greater than 140 beats per minute when upset, crying, or having paradoxical responses to the drug. If the upper heart rate limit is not increased above the manufacturer's automated settings, the alarm function of the pulse oximeter may be activated quite frequently during a procedure; this becomes annoying to the dental team and the patient.

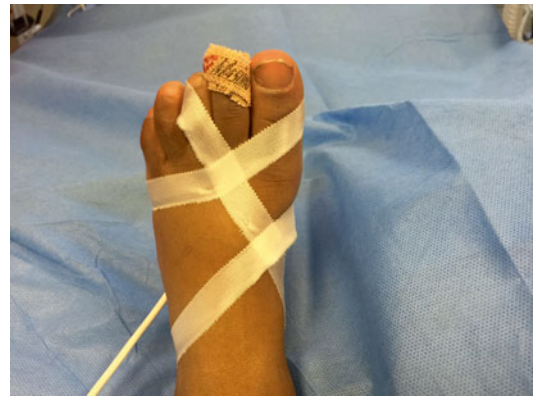

Fig. 7.2 Oxisensor taped to index toe and toes stabilized with tape

For healthy children, the high heart rate is rarely an issue. Depending on the circumstances, a *slow heart rate* in a child who is sedated is a much more disconcerting situation requiring intervention, and thus the lower heart rate limit alarm setting should not be changed.

Clinically, it is important to attach the "lead" or oxisensor to accessible, well-perfused tissue. For older children and teenagers who tolerate and accept the oxisensor, the first finger is usually readily accessible and easy to use. Alternatively, the toe next to the great toe seems best suited in the young toddler. The oxisensor can be placed around the tissue and secured by comfortably taping the great toe, second (on which the oxisensor is placed), and middle toe together as a unit (Fig. 7.2). It is also wise to tape the oxisensor lead wire to the plantar surface of the foot; otherwise, its movement can cause either dislodging of the oxisensor during struggling or electromagnetic (motion) artifacts in the transmitted signal (Fig. 7.3). The earlobe is another convenient site in older children, but again, for toddlers whose head may need to be stabilized for certain procedures (i.e., injections or tooth preparation), this site becomes inconvenient.

The oxisensor must be placed optimally so that the two diodes are directly opposite each other, and the tissue is perpendicular to an imaginary

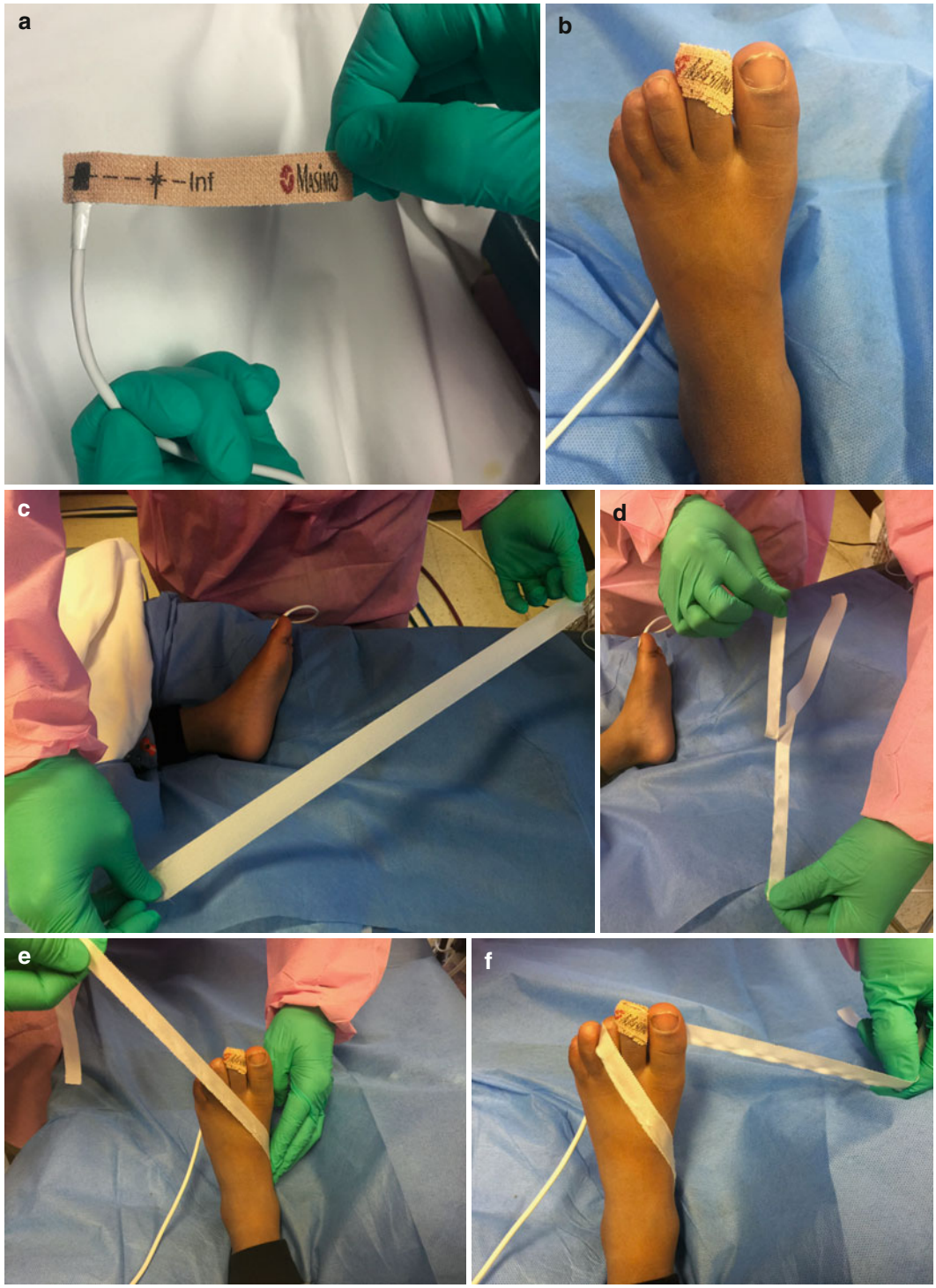

Fig. 7.3 Sequence of photos showing placement of oxisensor on toes. (**a**) Band-Aid style oxisensor. (**b**) Oxisensor is placed on toe. (**c**) Next obtain piece of 1 in. wide silk tape approximately 14 in. long. (**d**) Silk tape is torn in half. (**e**) Start one end on dorsum of foot near ankle and direct silk tape toward toes. (**f**) Take tap between third and fourth toe toward plantar surface of foot and go mesial under great toe, second and third on plantar surface. (**g**) Curve around great toe and over dorsum of foot to lateral side of foot. (**h**) Proceed down and around lateral border of foot and across plantar surface incorporating oxisensor lead. (**i**) Proceed to mesial border of foot and (**j**) up over foot to finish on dorsum of foot. (**k**) Plantar view of final wrap

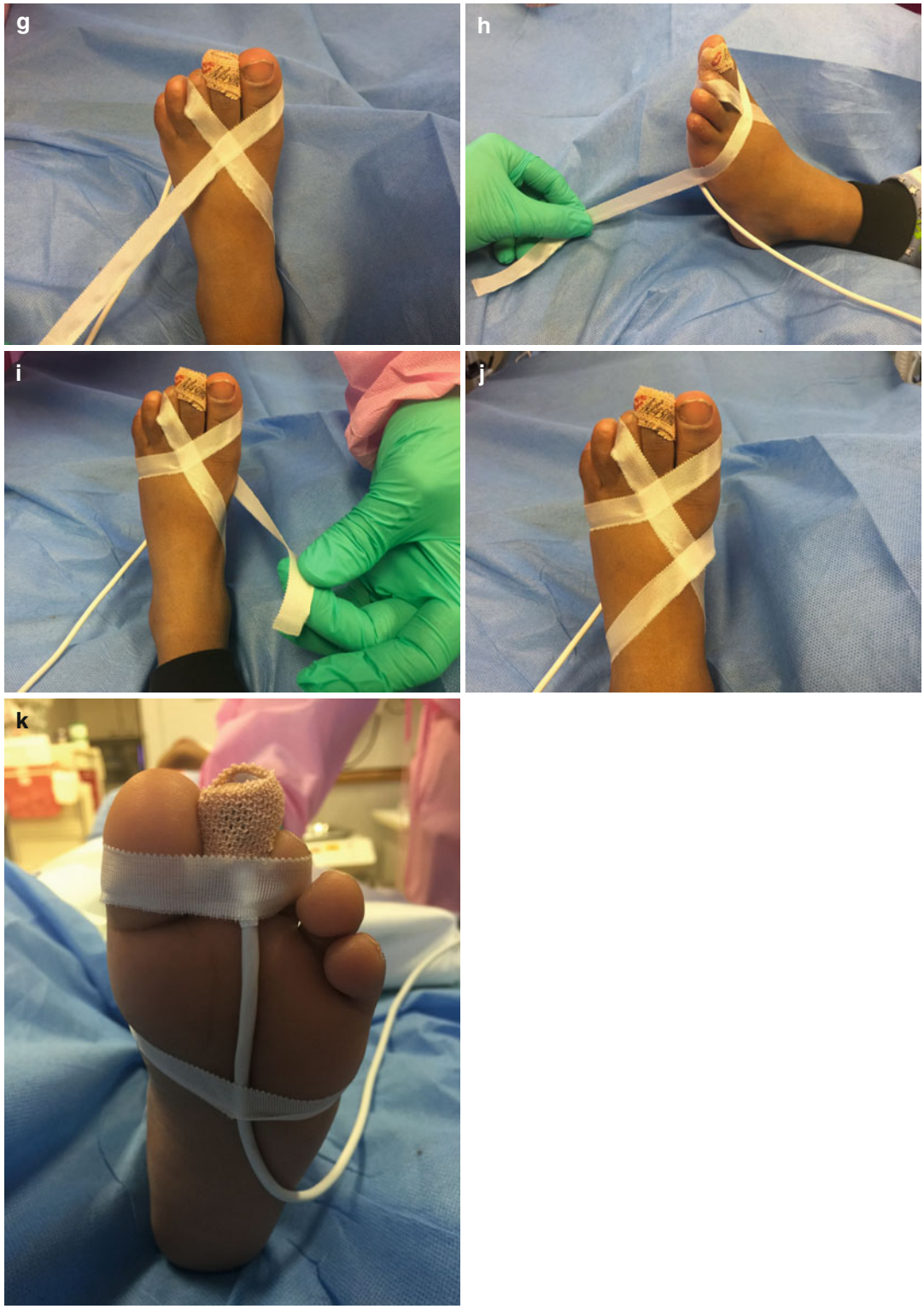

Fig. 7.3 (continued)

straight line connecting the two diodes. As the angle between the two diodes changes (the imaginary line is no longer straight and perpendicular to the tissue), the emitted light is not detected as readily. In such a compromised arrangement, the overhead lighting can even interfere with the monitor's function; hence, the monitor may become less sensitive or create false signals.

Oxisensor function can be impacted due to contaminated oil buildup (i.e., oils from sebaceous glands) on the diodes when they are repeatedly used. This effect can cause erroneous signals. This phenomenon is particularly noticeable with repeated use of disposable oxisensors. They should be discarded after a couple of uses.

Although the first published report on the use of PO in pediatric dentistry was in 1985, almost every article on sedation of the pediatric dental patient published today reports the use of PO. Generally speaking, most reports indicate the oxygen saturation to be very stable during sedations with only an occasional desaturation episode. Unfortunately, these desaturation episodes can be erroneously associated with the sedative agent, including questionable assignment of the agent's purported effects on airway compromise. Other conditions do and have been shown to account for what appears to be temporary "desaturations" that are of no clinical significance.

The clinician needs to be aware that distinct clinical situations can cause bogus signals unrelated to hemoglobin saturation. These are motion artifact; crying that may involve a Valsalva maneuver (airway is momentarily closed while muscular efforts are made to compress air in the lungs – grunting); cold limbs or tissue bed for a brief period shortly after cessation of a prolonged, intense crying bout; some nail polishes; profound tissue pigmentation in some blacks; some hemoglobinopathies; or any condition that reduces blood flow into the tissue bed -(blood pressure cuff inflation or straining against the wraps of a Papoose Board® Olympic Medical Group, Seattle, WA). Interestingly, there have been a few reports suggesting that local anesthetics may cause desaturations in otherwise nonsedated patients, possibly mediated by a temporary methemoglobinemia. This association needs to be confirmed.

Readings of the pulse oximeter can be influenced by patient states or conditions as well as integrity of the monitor. Physiologically, a pulse must be present and detectable via plethysmography and the hemoglobin molecule functional. Several clinical states can affect performance of the monitor but give valuable information about those states.

Box 7.1. Causes of Erroneous or Unusual Oxygenation Readings on Pulse Oximeter

1. Poor perfusion
   (a) Cold limbs
   (b) Occluded limb (from inflated blood pressure cuff)
   (c) Hypotension
2. Physical artifacts
   (a) Violent patient movement
   (b) Bright ambient lights
   (c) Some nail polishes
   (d) Wide angulation between emitting and collecting diodes
3. Patient conditions
   (a) Anemias
   (b) Methemoglobinemia
   (c) Post-prolonged intense crying

Interference with any aspect of the operation of the pulse oximeter or patient status can produce an erroneous reading (see Box 7.1).

Blood Pressure Cuffs

The use of blood pressure cuffs (BPCs) has a longer history than PO in pediatric dentistry. Although manual BPCs can be used and are cheap, the clinician or assistant is required to physically stop and use a stethoscope and the BPC which may compete with performing dental procedures. Functionally, the stethoscope is placed over the artery of a limb (i.e., usually brachial artery in the antecubital area of the arm) and held against the limb with one hand. A small bulb with a one-way valve is squeezed with the other hand blowing up a bladder on the inside of the

cuff. The cuff is inflated to a pressure above expected arterial pressure (usually at 220 mmHg) to occlude the artery. The valve is slowly opened to a point where air gently escapes and the bladder pressure decreases. The clinician listens for the onset and offset of Korotkoff sounds consistent with blood flowing through the previously occluded artery. This process gives an indirect measure of arterial blood pressure. If a stethoscope is placed over the antecubital fossa just below the upper arm and a blood pressure cuff is left uninflated, no sound is heard of blood flowing through the brachial artery as the flow is laminar and not turbulent. Likewise, when the cuff is inflated to a pressure greater than the systolic pressure, no sound is heard. As the pressure is slowly released, the first squirt of blood traveling through the artery will be heard as a "tapping" sound, and this represents the systolic pressure. As the pressure continues to be released, more blood flows into the artery in non-laminar waves producing a more muffled, but staccato-like sound, and finally once the pressure is released to the point where blood flow is again laminar, no sound is heard and this pressure is recorded as the diastolic pressure. Direct arterial blood pressure can be determined but is painful and requires a skilled technician or clinician to access the artery.

Automated BPCs (ABPCs) indirectly indicate the systolic and diastolic blood pressures and mean blood pressure (at 2/3 systolic value) as well as heart rate. Essentially, a similar process occurs in the ABPCs as that of manual BPCs. The ABPC has an internalized pump that produces air pressure causing the bladder in the cuff to inflate to a set pressure value expected to exceed normal arterial pressure and thus occluding the artery. Inside the bladder is a pressure transducer sensitive to oscillatory signals emanating from blood flowing through an artery in various states of occlusion. The transducer changes the oscillatory signal to an electrical signal which is used by the ABPC microprocessor to report appropriate pressures.

In summary, the ABPC inflates the bladder beyond the expected arterial systolic pressure. The inflation pressure is slowly dropped in 2–5 mmHg steps using an algorithm. When the pressure reaches the same level as that of systolic blood pressure, the transducer detects the first oscillatory signals. Usually two signals of the same amplitude have to be detected; otherwise, it is assumed that a spurious or artifactual signal occurred. Once two signals of the same amplitude are first detected, the monitor records and reports this pressure as the systolic pressure. The cuff continues to deflate in steps and the pulse pressure initially increases, then declines, until finally no further change in amplitude of the oscillatory signals is detected, representing diastolic blood pressure. The oscillatory signals are also used to determine heart rate. The time to determine one blood pressure reading with an ABPC is typically 20 s.

ABPCs can be set to cycle on a periodic basis, hence the "automated" function. The range of cycle periods usually spans 1–90 min. The cycle period typically is set for every 5 min when the child is in moderate to deep sedation (Fig. 7.4).

There are a few factors that cause artifact information with ABPCs, including inappropriate-sized cuffs (too large a cuff tends to cause erroneously low blood pressure readings, whereas too small a cuff causes erroneously high blood pressure readings – see Fig. 7.5), air leaks anywhere within the system, and patient movement. The latter is clinically significant and can be especially annoying and even dangerous when blood pressure readings are attempted in an uncooperative child. Under normal circumstances, most automated BPCs require less than 30 s to determine blood pressure. In the disruptive child, the cuff will continue to search for the blood pressure even over a period of a minute or more often using extremely high pressures and eventually the occlusion will cause pain to emanate from the arm thus further aggravating the already disruptive child.

Another clinical situation that is uncomfortable for the child is that in which the child is immobilized in an immobilization device such as a Papoose Board whose torso wrap compresses the child's arm against the body. The cuff is placed on the arm, and when it inflates, it stimulates the child who struggles against the restraint causing erroneous signals and hence

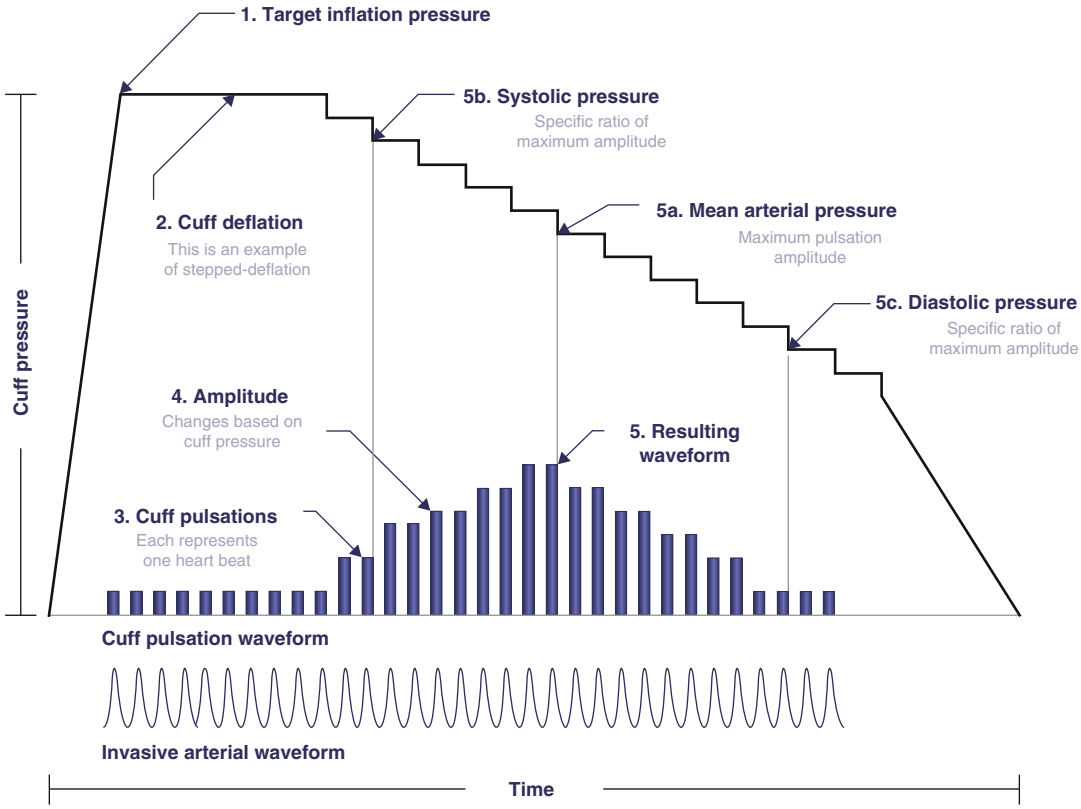

Fig. 7.4 Diagram showing cycle associated with determining blood pressure in automated blood pressure monitor (i.e., Dinamap)

keeping the cuff inflated until pain begins to occur. In a mildly sedated child who is awake and crying and/or struggling in response to fear or anger, either restrained or not, there is no need to take a blood pressure reading. It only aggravates the situation and sometimes produces strange readings (e.g., 140/41 mmHg). Of course, the clinician must record that the patient's behavior at that moment interfered with the normal function of the ABPC.

The usefulness of determining baseline blood pressure readings prior to a sedation in a fully uncooperative patient tugging at the cuff is questionable. A combative or uncooperative child would be expected to have a somewhat elevated blood pressure value, which tends to decrease to normal resting values as the child becomes sedated. If absolutely necessary, another "quick" means of obtaining systolic pressures in a disruptive child is to use a manual BPC. In this situation, one simply elevates the cuff pressure to that greater than the expected arterial pressure while watching the pressure gauge needle which should be non-moving and at an elevated reading (e.g., 220 mmHg). Then, open the valve on the bladder to slowly release air in a slow but steadily decreasing rate until the needle begins to "bounce" back at forth. This can be a coarse estimated of the systolic blood pressure. Regardless, the clinician should indicate in the patient's record that behavior prevented a reliable measure of blood pressure (or any vital sign).

In therapeutic dosages designed to produce mild-moderate sedation, most sedative agents do not cause significant clinical changes in blood pressure from that of the unprovoked, resting child. Deep sedation may cause decreases in heart rate and blood pressure. The clinician should be familiar with blood pressure and heart rate values in children of different ages.

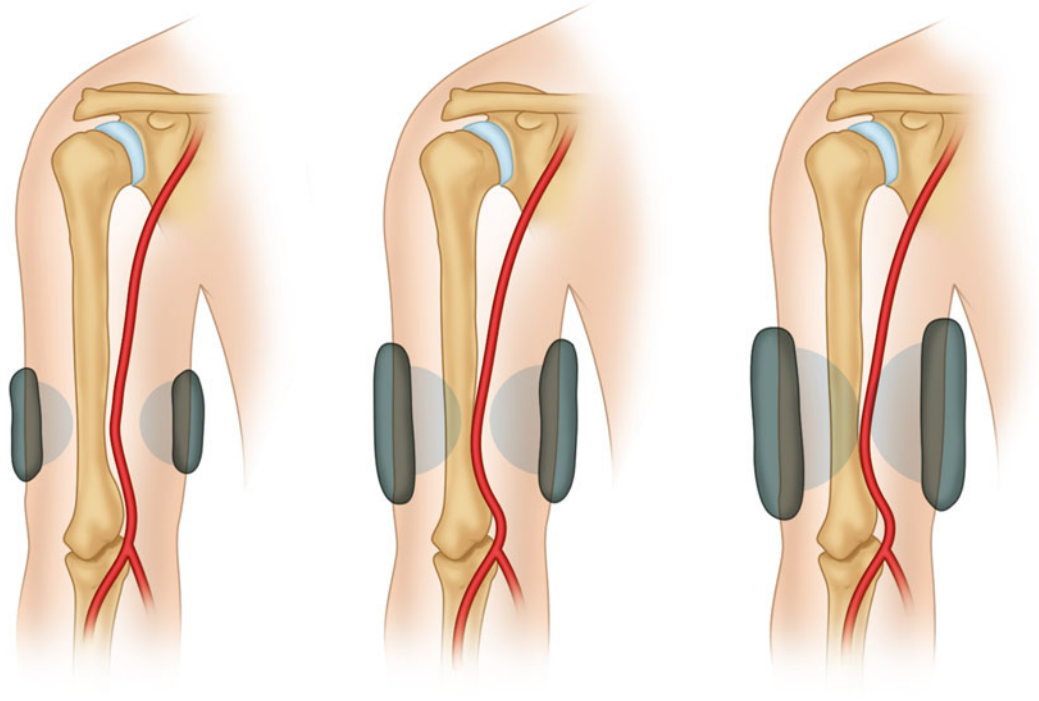

Fig. 7.5 Blood pressure cuff size. A cuff that is narrow compared to the width of the arm (far *left*) results in a spuriously high reading compared to a cuff that is too broad for the arm (far *right*) resulting in a spuriously low blood pressure reading

Capnography

Capnography probably represents one of the least understood and least utilized monitoring techniques in pediatric dentistry, but it is the only monitor on the market that can give an indication of the airway patency and ventilation when used properly. Capnographs measure expired carbon dioxide (CO_2) concentrations in the tidal volume of expired air. A capnograph functions by sucking or vacuuming air from the airway of a patient via a small plastic tubing (called "sampling tube") and travels through a water trap which helps to remove water vapor and into the unit. Inside the unit, the CO_2 is measured using infrared absorption technology. The amount of infrared absorption in the test chamber is compared to a standardized chamber containing a known amount of CO_2. The microchip processor inside the capnograph determines and displays the CO_2 concentration. Capnographs can display single excursions each of which represents the concentration of expired CO_2 of each breath during the expiratory cycle of breathing or ventilation (Fig. 7.6). They are also capable of displaying trended data in which each excursion is compressed and appears as a single vertical line. Capnographs also display respiratory rate. Thus, the capnograph is a means of measuring

Fig. 7.6 Capnograph waveforms associated with normal breathing

ventilation or the movement of air into and out of the lungs.

Capnography or the measurement of expired CO_2 can be classified as either mainstream or sidestream. The mainstream method is used during procedures with intubated patients who are either in deep sedation or general anesthesia. In this case, a tube with a Luer lock on both ends is used. The Luer lock on one end is fastened to a port on the endotracheal tube and the other end of the tube to the inlet of the water trap on the capnograph. Thus, no outside air can be entrained into the tubing.

Sidestream monitoring is appropriate for sedated, non-intubated patients. In this case, the Luer lock on one end of the sampling tube is removed from the tubing. This "free" end of the sampling tubing is placed and secured by tape just below the nostril (Fig. 7.7). It is important to understand that the sampling tube comes from the manufacturer in a rolled fashion producing a curve in the tubing. The curve in the tubing must match the natural contour of the face against which the sampling tube is taped for proper function. Otherwise, the opening of the tube is oriented away from the nostril producing poorer signals. During sidestream monitoring, air is vacuumed or sucked through the open end of the tubing port that is placed in close approximation to the orifice of the nostril or mouth. Sucked air is delivered to a chamber inside the capnograph where the concentration of carbon dioxide can be determined by infrared absorption technology. Finally, capnographs can electronically filter out the wavelength associated with nitrous oxide and other inhalational agents; hence, the *sampling port* can be placed directly under a nitrous hood.

Importantly, most capnographs have alarm capabilities. The two conditions causing an alarm to sound are (a) blockage of the tube leading from the patient to the capnograph (e.g., a mucous plug) and (b) apnea or the lack of detection of CO_2 after a sampling period of 15 s. Children who are crying have an increased tendency to produce nasal discharge of mucous and serous fluids which can block the sampling line. Mucous blockage is one possible clinical situation causing the alarm mechanism to indicate an obstruction.

Individual capnographic displays demonstrating different clinical states can be learned. For instance, crying is a clinical event that causes most of the expired CO_2 to be vented out of the mouth; thus, the capnograph will detect and display a signal that has a lower concentration of expired CO_2 (i.e., the majority was shunted through the mouth leaving proportionately less to be sucked into the port). This phenomenon is also true of predominant mouth breathers. Patients who are moderately to deeply sedated, breathing more slowly, tend to have displayed signals of CO_2 that are taller indicating greater concentration of CO_2. Interestingly, meperidine causes the rise and fall segment of each single excursion to waver slightly because it causes increased tension in the respiratory muscles during expiration. In a nonsedated, calm patient, expiration involves a passive relaxation of elastic tissues and little muscle involvement. When a patient has received a narcotic such as meperidine, the carbon dioxide concentration in the body tends to increase slightly over time due to mild depression of the respiratory centers. Normal carbon dioxide concentrations in awake, calm children range from 33 to 40 mmHg.

The two-pronged tubing system often seen and used in older patients requiring therapeutic oxygen delivery does not always work well in children (Salter tubing; see Fig. 7.8). The prongs are too long (they project too deep into the orifice of the nostrils and are easily clogged) and often too wide to fit the child's nares and need to be trimmed to prevent obstruction of the openings by the inner septal or alar portion of the nostril.

In the future, the capnograph will become one of the most important monitors in the hierarchy of monitors used in sedating children for dental procedures. This opinion is based on extensive clinical experience with the simultaneous use of many monitors – including the capnograph and pulse oximeter. At least one study has demonstrated that the capnograph, with its ability to rapidly detect airway blockage rapidly (<15 s usually) and with appropriate operator response, can prevent desaturations from being displayed by the pulse oximeter.

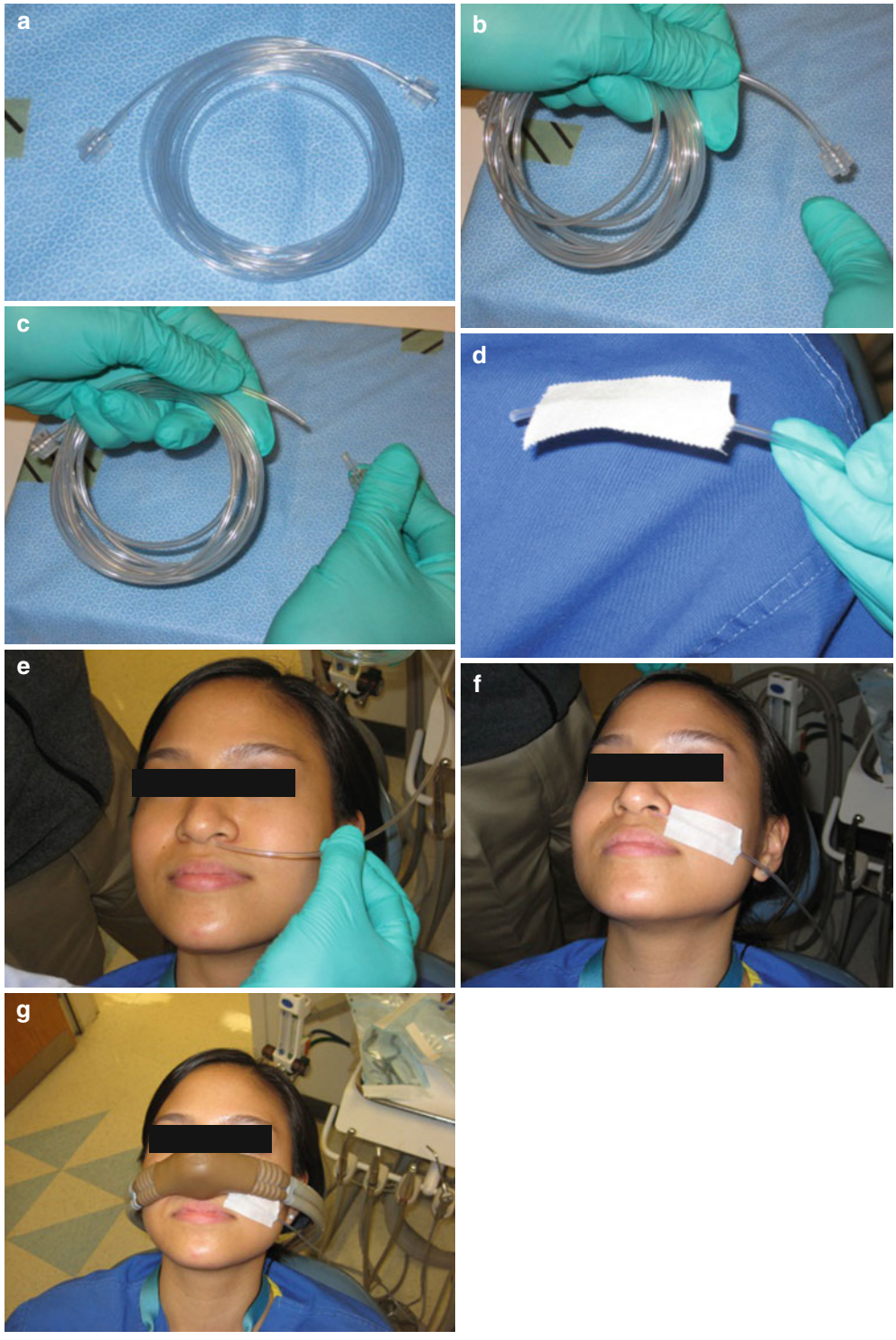

Fig. 7.7 Sequence of steps associated with placement of tubing for obtaining end tidal CO_2 signal with side stream capnography. (**a, b**) Plastic tubing with luer-lock on each end. (**c**) One luer-lock is removed leaving one luer-lock and tubing only. (**d**) Tape is placed on tubing end without luer-lock. (**e**) Tubing end without luer-lock is placed directly below a nares. (**f**) tubing end taped into place. (**g**) Nitrous hood is placed over the taped tubing

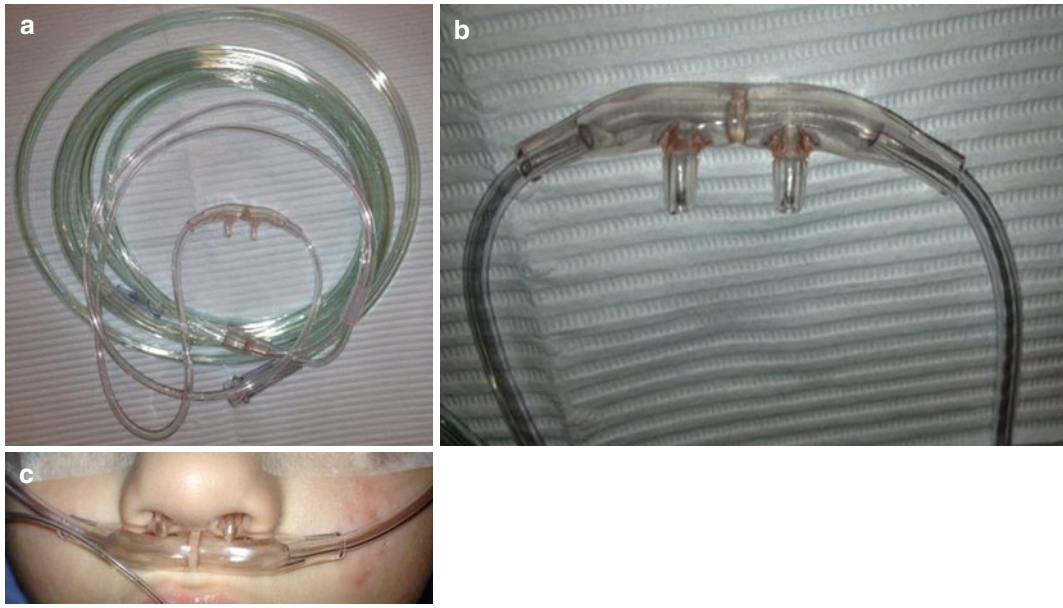

Fig. 7.8 Salter delivery system. (**a**) Salter delivery system taken from package. (**b**) Close up of prongs that fit into nares of patient. (**c**) Prongs shown in nares of patient

Precordial Stethoscopes

Stethoscopes have been available for decades and can obtain heart, respiratory, gastrointestinal, and joint sounds and cardiovascular anomalies (e.g., arteriovenous malformations). They consist of a diaphragm or bell which is placed against a body surface, a connecting tube, and ear pieces for placement into the ear canal of the person listening for sounds (Fig. 7.9). They are particularly useful for monitoring airway and heart sounds during sedations. However, optimizing either the airway or heart sounds is very dependent on the placement of the stethoscope's bell on the chest wall and will determine the dominant sound (i.e., heart versus airway).

To facilitate maximizing airway sounds, an imaginary triangle can be visualized on the child's chest and will be useful to determine which sound will be favored. The base of the triangle is a line joining the patient's nipples with the apex formed by the remaining sides of the triangle each joining the nipple to the precordial notch at the junction of the neck and chest (Fig. 7.10). In a reclined patient, placement of the stethoscope bell at the precordial notch will cause breathing sounds to be loud and dominant compared with the faint sounds of the heart. As the stethoscope bell is moved along the imaginary line connecting the precordial notch to the left nipple, the airway sounds become fainter and the heart's dominate. Airway sounds are more important during sedation, thus the bell should be placed toward the apex of the triangle. Also, the bell should be well attached to the chest wall either with tape or 3M Double-Stick Discs® (3M Medical Device Division, St Paul, MN – see Fig. 7.9).

Competing sounds come from various sources including handpiece noise; a metal rubber dam frame touching the bell of the stethoscope that will conduct sounds when the handpiece contacts the frame; and room noise (e.g., talking or music). Often these sounds can be comparatively loud and drown out the airway sounds, increasing the need for additional monitoring. A study of sedated children undergoing dental care comparing the precordial stethoscope to other monitors of airway patency has not been reported.

Bluetooth technology has recently changed the way in which stethoscopes are used in monitoring sedated patients (Sedation Stethoscope, Sedation Resources, Lone Oak, TX). The Bluetooth stethoscope consists of the bell with a transmitter that is affixed to the patient's chest or

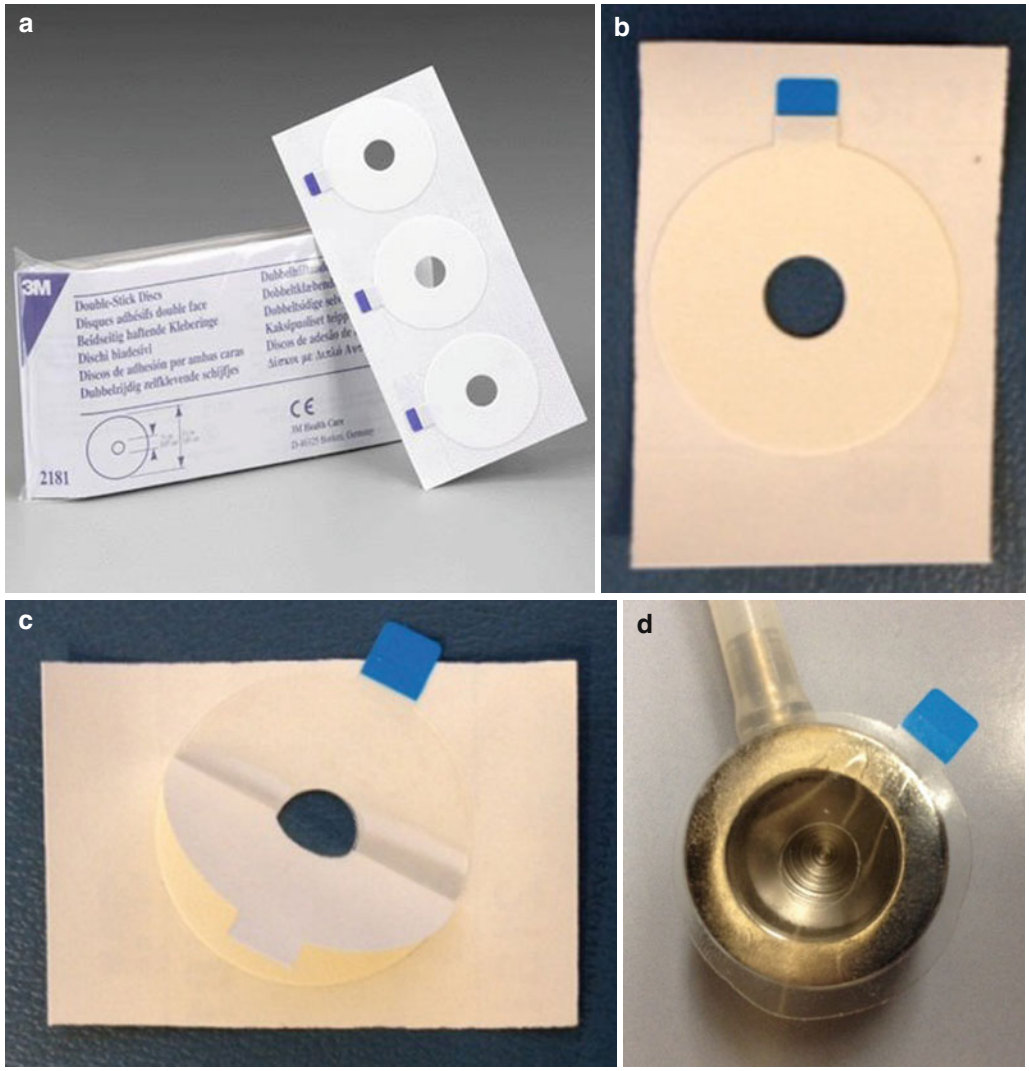

Fig. 7.9 Stethoscope bell and 3M Double Stick Dics. They attach to the stethoscope bell and the patient's chest. (**a**) discs out of package, 3 to a sheet. (**b**) disc on sheet, (**c**) one side of sticky disc lifted and folded, (**d**) clear disc attached to stethoscope bell and ready for placement on patient

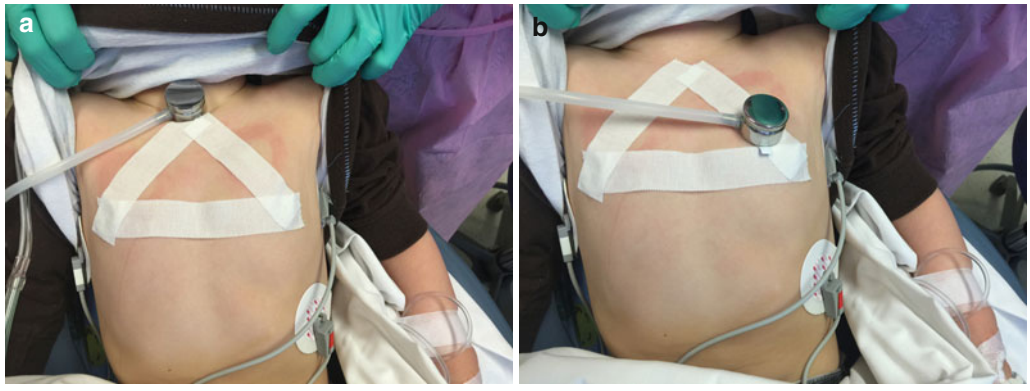

Fig. 7.10 Proper placement of stethoscope bell for maximal amplification of airway sounds (**a**) or heart sounds (**b**)

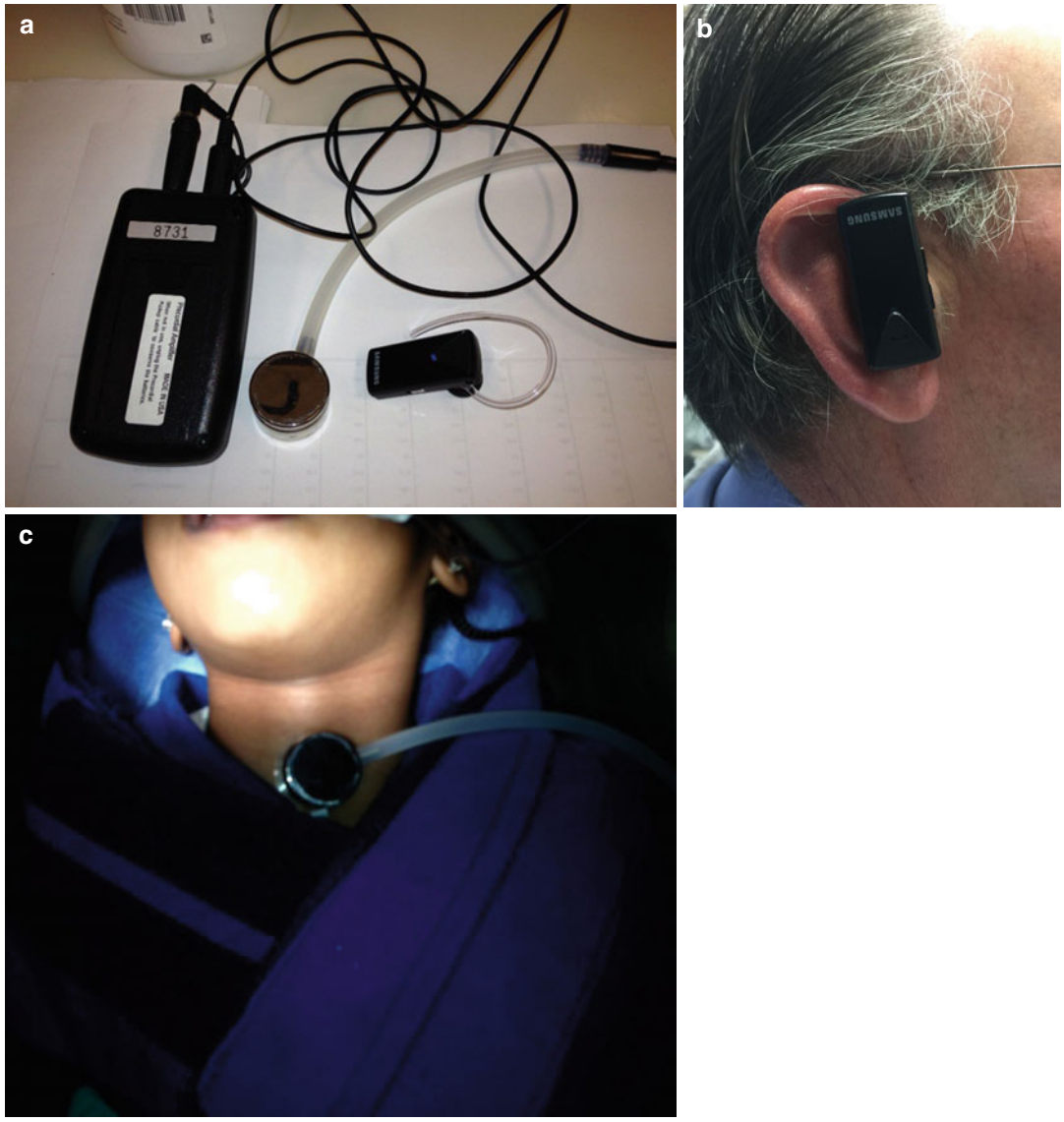

Fig. 7.11 Bluetooth stethoscope. (**a**) Shows earpiece, stethoscope, and transmitter. (**b**) Shows earpiece in place. (**c**) Shows pretracheal stethoscope placed midline on the neck just above the manubrium

neck and a receiver that fits into the ear of the person who is monitoring the sounds of the patient (Fig. 7.11). The airway sounds are transmitted wirelessly over several feet separating the patient from the clinician. This feature is unique in several clinical aspects of monitoring. For instance, a clinician can momentarily step outside of an operatory and still hear the airway and heart sounds of the patient just inside the doorway of the operatory. Also, the signal can be turned off with a simple push of a button on the receiver, and this becomes handy during situations when a child begins crying possibly damaging the ear of the clinician.

Other types of monitors are available including the EKG, temperature probes, and even monitors capable of detecting brain waves (EEG) which give an indirect indication of whether a patient is conscious enough to recall a procedural event (i.e., BIS monitor). These other monitors are generally not necessary during oral sedation of children who are minimally and moderately

Table 7.3 Monitoring as a function of behavior exhibited

Behavior	Clinical signs	Precordial	Pulse ox	Blood pressure	Capnograph
Awake, screaming, or yelling	Little tears Controlled breathing Struggling against wrap	Take earpiece out of ear; replace if patient quiets	Keep it stabilized on foot Set upper heart rate limits to >230 bpm	Keep it stabilized on arm or leg Do not inflate and aggravate already disruptive behaviors	Not needed Use if patient becomes quiet
Mild crying	Tearing variable; eyelids open/some ptosis Sobbing, but controlled Little or no struggling	Same as above, but be ready to insert earpiece if child becomes quiet	Same as above	Keep it stabilized on arm or leg Inflate occasionally during procedure to determine its influence on behavior	Same as above
Quiet, but responsive (moderate)	Eyes closed; opens when requested or mildly stimulated Breathing within normal limits Occasional sobbing	Earpiece in and listening Attentive to gurgling or snoring (adjust head tilt)	Same as above Heightened awareness for incidence of desaturation (pitch)	Set on automatic mode for inflation every 5 min as behavior permits	Place probe Monitor RR
Quiet, not much responsive (deep)	Eyes closed or partial ptosis with possible divergent eyes; does not open upon command Breathing shallow and intermittent or infrequent rate of breathing	Same as above Maximal focus on airway sounds	Same as above Heightened awareness for incidence of desaturation (pitch)	Set on automatic cycle for inflation every 5 min	Be aware of frequency of breathing, expired [conc], and apnea

sedated. In fact, the best means of assessing a patient's mental status during minimal and early stages of moderate levels of sedation are using communication techniques and clinical monitoring.

Most guidelines recommend appropriate monitoring and monitors for various depths of sedation and general anesthesia. Ventilation, oxygenation, and blood pressure are the primary vital signs of sedated children that need to be monitored during minimal, moderate, and even deep levels of sedation. Redundancy in monitoring is never an issue, especially for ventilation, which is the most likely system to be compromised first during a sedation procedure. Ventilation can be measured by clinical observation of the rise and fall of the patient chest, fogging of a mouth mirror, pretracheal/cordial stethoscope, or capnograph. As the patient moves from minimal to moderate to deep sedation, the more the monitors of ventilation used, the better the likelihood of detecting issues with ventilation. Table 7.3 shows a reasonable use of monitors for various levels of sedation in children during dental procedures.

Recordkeeping

Recordkeeping during a sedation procedure involving a child is a must. The record must be detailed, accurate, and complete. Adverse events can and do happen. It is always beneficial to have and will be important in an investigation of such events. Since such incidences can never be predicted, consistency in this process is imperative. Recordkeeping may be done on a form or by freestyle writing in a patient's record. Forms act as a guide to collecting specific pieces of information in a sedation protocol that may otherwise be overlooked in freestyle writing of an operative

note. A time-based record must be included as a part of the form onto which time, events, vital signs, physiologically monitored parameters, behavior, and drugs are recorded.

One of the most complete forms for recording patient information during a dental sedation procedure involving children (Fig. 7.12a, b) can be found in the Resource section of the Policy and Guidelines tab of the American Academy of Pediatric Dentistry's website (www.aapd.org). The content of this record includes information consistent with essentially every "must" statement in their guidelines for procedural sedation (i.e., monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures).

Non-electronic Monitoring

The two types of non-electronic monitors most often used during sedations are the precordial stethoscopes and manual blood pressure cuffs. The precordial (or pretracheal) stethoscope bell is used in sedation primarily for auscultation of the airway sounds and secondarily the heart sounds. The operator's earpiece connected via tubing to the stethoscope bell does not need to be inserted into his/her ear when the child is crying.

BPCs can be placed on either the right or left upper arm area. They should initially be placed snug around the arm, but not tight enough to cause blockage of blood flow in the deflated position. It is best not to place the blood pressure cuff on the same arm as that used to obtain pulse oximetry readings because the readings are intermittently affected by the inflation of the BPC. The cuff can also be placed on the lower portion of the leg just above the ankle in children. The operation of the manual BPC requires dedication of a person for a brief period of time to obtain the blood pressure. Practitioners may not wish to dedicate a person to monitor this physiological parameter during a dental sedation because of the time issue and thus uses automated BPCs.

Electronic Monitoring

The two most important electronic monitors as a first line indicator of patient status and for use with healthy children are the pulse oximeter and capnograph. The pulse oximeter indicates the percent oxygen saturation of hemoglobin or the amount of oxygen being transported to the metabolically active tissue sites. The pulse oximeter has become the most frequently used monitor used in pediatric dental sedation. Since 20 % or more of all behaviors in sedated patients during the dental appointment involve crying and struggling, there is a good likelihood of false alarms (i.e., oxygen desaturations associated with movement).

The capnograph relates information about the patient's ventilation and, therefore, airway blockage. Therefore, it seems prudent and recommended to use both of these monitors as a minimum when a child appears to be sleeping following the administration of sedative agent(s).

Summary

Monitors are a necessary requirement during sedation of children for dental procedures. The array of monitors available is numerous including the clinician. Ventilation and oxygenation are the two primary physiological parameters that should be monitored during sedation of children regardless of the level of sedation, but as the sedation enters into moderate to deep levels, these two parameters must be monitored with heightened vigilance to the point of redundancy. It is impossible to determine the final depth of sedation produced by an orally administered agent in children. Therefore, in the opinion of this author, every clinician who sedates children in their office must have as a minimum a monitor for oxygenation (pulse oximeter), ventilation (stethoscope or capnograph), and cardiovascular function (BPC).

a

Sedation Record

Patient Selection Criteria Date: _____

Patient: _____ ❑ M ❑ F Age: ____yr____mo Weight: _____kg Physician: _____

Indication for sedation:
- ❑ Fearful/anxious patient for whom basic behavior guidance techniques have not been successful
- ❑ Patient unable to cooperate due to lack of psychological or emotional maturity and/or mental, physical, or medical disability
- ❑ To protect patient's developing psyche
- ❑ To reduce patient's medical risk

Medical history/review of systems (ROS)	NONE	YES *	D escribe positive findings: _____
Allergies &/or previous adverse drug reactions	❑	❑	
Current medications (including OTC)	❑	❑	
Relevant diseases, physical/neurologic impairment	❑	❑	
Previous sedation/general anesthetics	❑	❑	
Snoring, obstructive sleep apnea, mouth breathing	❑	❑	
Other significant findings (eg, family history)	❑	❑	

Airway Assessment	NONE	YES *
Obesity	❑	❑
Limited neck mobility	❑	❑
Micro/retrognathia	❑	❑
Macroglossia	❑	❑
Tonsillar obstruction (___%)	❑	❑
Limited oral opening	❑	❑

ASA classification: ❑ I ❑ II ❑ III* ❑ IV* ❑ E * Medical consultation indicated? ❑ NO ❑ YES Date requested: _____

Comments: _____

Is this patient a candidate for in-office sedation? ❑ YES ❑ NO Doctor's signature: _____ Date: _____

Plan	Name/relation to patient	Initials	Date	By
Informed consent obtained from				
Pre-op instructions reviewed with				
Post-op precautions reviewed with				

Assessment on Day of Sedation Date: _____

Accompanied by: _____ Relationship(s) to patient: _____

Medical Hx & ROS update	NO	YES	NPO status	Airway assessment	NO	YES	Checklist
Change in medical hx/ROS	❑	❑	Clear liquids ____hrs	Upper airway clear	❑	❑	❑ Appropriate transportation home
Change in medications	❑	❑	Milk, other liquids,	Lungs clear	❑	❑	❑ Monitors functioning
Recent respiratory illness	❑	❑	&/or foods ____hrs	Tonsillar obstruction (___%)	❑	❑	❑ Emergency kit, suction, & O_2
Weight: _____kg			Medications ____hrs				available

Vital signs (If unable to obtain, check ❑ and document reason: _____)

Blood pressure: _____/_____ mmHg Resp: _____/min Pulse: _____/min Temp: _____°F SpO_2:_____%

Comments: _____

Presedation cooperation level: ❑ Unable/unwilling to cooperate ❑ Rarely follows requests ❑ Cooperates with prompting ❑ Cooperates freely

Behavioral interaction: ❑ Definitively shy and withdrawn ❑ Somewhat shy ❑ Approachable

Guardian was provided an opportunity to ask questions, appeared to understand, and reaffirmed consent for sedation? ❑ YES ❑ NO

Drug Dosage Calculations

Sedatives

Agent _____ Route _____ _____mg/kg X _____kg = _____mg ÷ _____mg/mL = _____mL

Agent _____ Route _____ _____mg/kg X _____kg = _____mg ÷ _____mg/mL = _____mL

Agent _____ Route _____ _____mg/kg X _____kg = _____mg ÷ _____mg/mL = _____mL

Emergency reversal agents

For narcotic: NALOXONE IV, IM, or subQ Dose: 0.1 mg/kg X _____ kg = _____mg (Maximum dose: 2 mg; may repeat)

For benzodiazepine: FLUMAZENIL IV (preferred), IM Dose: 0.01 mg/kg X _____ kg = _____mg (Maximum dose: 0.2 mg; may repeat up to 4 times)

Local anesthetics (maximum dosage based on weight)

Lidocaine 2%	(34 mg/ 1.7 mL cartridge)	4.4 mg/kg X	_____kg = _____mg	(not to exceed 300 mg total dose)
Articaine 4%	(68 mg/ 1.7 mL cartridge)	7 mg/kg X	_____kg = _____mg	(not to exceed 500 mg total dose)
Mepivacaine 3%	(51 mg/ 1.7 mL cartridge)	4.4 mg/kg X	_____kg = _____mg	(not to exceed 300 mg total dose)
Prilocaine 4%	(68 mg/ 1.7 mL cartridge)	6 mg/kg X	_____kg = _____mg	(not to exceed 400 mg total dose)
Bupivacaine 0.5%	(8.5 mg/ 1.7 mL cartridge)	1.3 mg/kg X	_____kg = _____mg	(not to exceed 90 mg total dose)

Fig. 7.12 American Academy of Pediatric Dentistry Sedation Record. (**a**) Front page of record; (**b**) back page of record (Copyright American Academy of Pediatric Dentistry and reproduced with their permission (www.aapd.org))

b

Intraoperative Management and Post-Operative Monitoring EMS telephone number: _____

Monitors: ❑ Observation ❑ Pulse oximeter ❑ Precordial/pretracheal stethoscope ❑ Blood pressure cuff ❑ Capnograph ❑ EKG ❑ Thermometer
Protective stabilization/devices: ❑ Papoose ❑ Head positioner ❑ Manual hold ❑ Neck/shoulder roll ❑ Mouth prop ❑ Rubber dam ❑ _____

TIME	Baseline	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:	:
Sedatives[1]																	
N_2O/O_2 (%)																	
Local[2] (mg)																	
SpO_2																	
Pulse																	
BP																	
Resp																	
CO_2																	
Procedure[3]																	
Comments[4]																	
Sedation level*																	
Behavior†																	

1. Agent _____ Route _____ Dose _____ Time _____ Administered by _____
   Agent _____ Route _____ Dose _____ Time _____ Administered by _____
   Agent _____ Route _____ Dose _____ Time _____ Administered by _____
2. Local anesthetic agent _____
3. Record dental procedure start and completion times, transfer to recovery area, etc.
4. Enter letter on chart and corresponding comments (eg, complications/side effects, airway intervention, reversal agent, analgesic) below:
   A. _____ B. _____
   C. _____ D. _____

Sedation level*
- None (typical response/ cooperation for this patient)
- Mild (anxiolysis)
- Moderate (purposeful response to verbal commands ± light tactile sensation)
- Deep (purposeful response after repeated verbal or painful stimulation
- General Anesthesia (not arousable)

Behavior/ responsiveness to treatment†
- Excellent: quiet and cooperative
- Good: mild objections &/or whimpering but treatment not interrupted
- Fair: crying with minimal disruption to treatment
- Poor: struggling that interfered with operative procedures
- Prohibitive: active resistance and crying; treatment cannot be rendered

Overall effectiveness: ❑ Ineffective ❑ Effective ❑ Very effective ❑ Overly sedated
Additional comments/treatment accomplished: _____

Discharge

Criteria for discharge
- ❑ Cardiovascular function is satisfactory and stable.
- ❑ Airway patency is satisfactory and stable.
- ❑ Patient is easily arousable.
- ❑ Responsiveness is at or very near presedation level (especially if very young or special needs child incapable of the usually expected responses).
- ❑ Protective reflexes are intact.
- ❑ Patient can talk (return to presedation level).
- ❑ Patient can sit up unaided (return to presedation level).
- ❑ State of hydration is adequate.

Discharge vital signs
Pulse: _____/ min
SpO_2: _____%
BP: _____/_____ mmHg
Resp: _____/ min
Temp: _____°F

Discharge process
- ❑ Post-operative instructions reviewed with _____ by _____
  - ❑ Transportation ❑ Airway protection/observation ❑ Activity ❑ Diet ❑ Nausea/vomiting ❑ Fever ❑ Rx ❑ Anesthetized tissues
  - ❑ Dental treatment rendered ❑ Pain ❑ Bleeding ❑ _____ ❑ Emergency contact
- ❑ Next appointment on: _____ for _____

I have received and understand these discharge instructions. The patient is discharged into my care at _____ ❑ AM ❑ PM

Signature: _____ Relationship: _____ After hours number: _____

Operator Signature: _____ Chairside Assistant: _____ Monitoring Personnel signature: _____

Post-op call
Date: _____ Time: _____ By: _____ Spoke to: _____ Comments: _____

Fig. 7.12 (continued)

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Protocol

8

Stephen Wilson

Abstract

The execution of a well-conceived protocol or plan aids in the efficacy, efficiency, and safety of a sedation appointment. The protocol acts like a guide for the clinician to follow in performing a sequence of events aimed at increasing successful outcomes of oral sedations of children in the dental setting. Little has been written on this topic in pediatric dentistry, although protocols for dental procedures are readily learned by dental professionals early in their career. This chapter presents a generalized model in which several considerations and elements associated with a "typical" sedation protocol and process are addressed. Various aspects of patient selection, intraoperative patient guidance, monitoring, and other related procedures are reviewed.

Sedation Protocol

Protocols enable a dental team to work smoothly, efficiently, and effectively during routine patient visits. Unexpected events during sedations can always occur, possibly complicating one's response and effectiveness in managing the situation, especially if one is not prepared. Protocols aid in minimizing and confidently addressing such events particularly when practiced on a regular basis much like routine restorative procedures. Thus, it is highly advisable for any dental office or team to develop and implement various types of clinical protocols including those designed to handle urgent, life-threatening situations. Similarly, following sedation guidelines and structured programs has been shown to benefit sedation outcomes [1].

The purpose of this chapter is to outline a sedation protocol that is designed to minimize risk while increasing the effectiveness of the sedation visit. A patient encounter during which a child is uncooperative, poorly responsive to traditional communicative behavior guidance, and has a need for an invasive dental procedure may be managed pharmacologically. Consultation

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with the parent may confirm their desire for pharmacological management using either sedation or general anesthesia.

Bidirectional and motivational communication with parents concerning the alternatives of pharmacological management of their children is essential because the process may (a) inform the parents of alternatives for treating their child, (b) dispel uncertainty of parental expectations about your practice, (c) mitigate any misleading impressions of the intent of a given technique including its safety, and (d) build a trusting rapport and confidence between the two parties. Parents may have prejudices and beliefs that bias their level of acceptance of certain behavioral guidance techniques including pharmacological management [2–12]. Listening to their concerns and investigating the origins of information that may be ambiguous or frankly incorrect gives the practitioner an opportunity to redirect the parents thinking. And educational materials may be presented to support the pharmacological technique. Likewise, the communication process may aid in reinforcing the parent's beliefs, if accurate, facilitating the development of rapport. For this process to work effectively, however, the practitioner must be well informed of the literature and evidence-based data, adequately trained or experienced in pharmacological techniques, and consistent in describing the range of realities associated with the process and outcomes of their own pharmacological protocol.

The range of child behaviors during sedation may vary significantly based on factors such as the child's cognitive age; his/her child's temperamental orientation and responsiveness; amount, duration, and intensity of dental procedures and stimuli; type and dose of drug or combination of drugs, including nitrous oxide; and resulting depth of sedation. The degree of practitioner effectiveness will depend on the understanding of these factors and intervening in response to behaviors that will be a function of the depth of sedation. For instance, a single agent such as midazolam given orally to an easily approachable 3-year old at a specific dose for a short, minimally discomforting procedure may result in a very effective outcome. Describing these factors to parents may aid in setting their expectations on how their child may respond. It is also helpful to parents to understand exactly how the procedure will be conducted and what efforts will be made to ensure the maximum safety of their child.

Typical Protocol for Sedation

From this point forward, we will assume that the pharmacological technique best suited for the patient is sedation using the oral route of administration. A sedation protocol can be envisioned as a detailed plan involving several major and important steps.

Day of Decision to Sedate

The decision to offer sedation as the preferred means of managing the child for restorative care will likely occur at an appointment on a day prior to a scheduled sedation visit. Acting on this decision will necessitate consideration of patient selection criteria for oral sedation. There are four primary factors associated with patient selection criteria: medical history, airway patency and size of lymphoid tissue (i.e., tonsils), child temperament, and the amount of dental caries present (see Box 8.1).

Box 8.1. Patient Selection Criteria for Oral Sedation

Four primary factors:

- Medical history
  - Healthy or mild systemic dysfunction (e.g., well-controlled seizures)
- Airway patency and lymphoid tissue load (i.e., tonsils)
  - Clear airway
  - Tonsils greater than 50 % of airway – unconsciousness is dangerous
  - Lymphoid tissue changes over time – always check at each sedation
- Child temperament
  - Easy – approachable, interactive, adaptable, and low activity

  - Difficult – shy, withdrawn, cry frequently, high activity, and emotional
- Amount and distribution of dental caries
  - Ultrashort procedure – procedure time is almost equivalent in duration to local anesthesia onset (e.g., extraction of 4 primary incisors)
  - Short procedure – quadrant of dentistry or equivalent
  - Long procedure – 2 or more quadrants of dentistry or equivalent

A thorough medical history and review of systems is a must before scheduling a sedation appointment (see Chap. 3). Detailed questions are needed and designed to investigate any possible concerns arising in discussion with the parent of the patient's medical history and systems (e.g., respiratory). A complete assessment of the child's medical history and review of systems must be done for assignment of the American Society of Anesthesiology (ASA) risk status (see Box 8.2). Only children whose risk status is minimal should be considered candidates for minimal to moderate sedation in the dental office.

Unresolved or unclear medical issues may require a consult with the child's primary care physician or specialist in order to clarify, corroborate, or elaborate on information obtained from the parent. After this information is collected, a discussion can occur with the parent to decide alternatives to behavioral/pharmacological management. The discussion, based on the findings, should also cover topics such as proposed sedatives, depth of sedation, monitoring, and likely outcomes. The goal is to ensure that the patient is healthy or has a minor system condition (i.e., ASA I or mild II). Children with moderate to severe system dysfunction should only be managed in collaboration with other medical specialties, and treatment likely will occur under general anesthesia in a hospital setting where more personnel who are highly skilled and trained in managing such children are present, and sophisticated drugs and equipment for emergency rescue are available.

Box 8.2. American Society of Anesthesiologists (ASA) Physical Status Classification

I. Patient is a completely healthy fit patient.
II. Patient has mild systemic disease.
III. Patient has severe systemic disease that is not incapacitating.
IV. Patient has incapacitating disease that is a constant threat to life.
V. A moribund patient who is not expected to live 24 h with or without surgery.

If the surgery is an emergency, the physical status classification is followed by "E" for emergency (e.g., "3E"). There is a Class VI category for a declared brain-dead person whose organs are removed for donor purposes.

http://www.asahq.org/Home/For-Members/Clinical-Information/ASA-Physical-Status-Classification-System

The airway should be thoroughly assessed. Examination of the mouth from the lips back to the oropharyngeal area where tonsils may be seen needs to be visualized. Tonsil size as it relates to planned depth of sedation is an important consideration. Tonsils should not exceed 50 % of the airway if drugs used can potentially cause loss of consciousness or are known to cause airway blockage (e.g., chloral hydrate) [13]. The airway examination should be done on the day of the initial examination as well as the day of sedation. The size of the lymphoid tissue may change slightly due to changes in the child's health. Also, the parent should be queried as to the history and incidence of patient snoring and other airway issues (e.g., sleep apnea).

Child temperament is recognized as an important predictive factor related to behaviors during sedation [14–17]. Temperament refers to patterns of behavior of children associated with novel settings or strangers. There is good evidence that children who are easygoing, approachable, and

adaptable are easier to treat in the dental operatory, whether sedated or not. However, children who are shy, withdrawn, frown and cry frequently and do not accept change easily tend to be difficult to treat. A "difficult" child may not behave well or respond to behavior guidance unless they are in a deep level of sedation, whereas an "easy" child may do well with behavior guidance at minimal and moderate levels of sedation and rarely need deep sedation.

The complexity of the treatment plan and estimated length of time for procedures should be considered. Treatment may vary from one to four teeth in the maxilla anterior segment of the arch or multiple teeth in all quadrants of the dentition. Children who have significant dental need (i.e., 3 or more quadrants) may require a single long sedation appointment or 2 to 3 shorter sedation visits spread over a couple of weeks depending on the patient's cooperativeness. The drugs and doses may vary depending on the length of the appointment. Possibly a better, more economic consideration for multi-quadrant dentistry is general anesthesia depending on the child's personality, temperament, and coping skills [18]. Also, the location of the carious teeth is an important consideration. Disruptive behaviors in young children are often elicited from the discomfort associated with anesthetizing teeth in the upper anterior segment of the mouth, strongly challenging the behavior guidance abilities and skills of the clinician.

When one puts these four major factors together, it is possible to develop a scheme of selecting sedative agents and their dosages. Table 8.1 is a scheme that has been promoted by this author in recent times.

Table 8.1 Primary factors in selecting drugs and dosages

Dental needs	Child temperament	Drugs (all oral administration supplemented with N_2O/O_2)
Ultrashort (e.g., extract of maxillary central incisors)	Easy	Nitrous alone (40–50); midazolam alone (0.5 mg/kg)
	Difficult	Midazolam (1.0 mg/kg) + nitrous (50 %)
Short (e.g., 1 quadrant of pulps/crowns)	Easy	Midazolam (0.5 mg/kg) + meperidine (1.0 mg/kg)
	Difficult	Chloral hydrate (15–20 mg/kg) or midazolam (0.3–0.5 mg/kg) + meperidine (2 mg/kg) + hydroxyzine (0.5–1.0 mg/kg)
Long (e.g., 2 or more quadrants of dentistry)	Easy	Chloral hydrate (15–25 mg/kg) + meperidine (2 mg/kg) + hydroxyzine (0.5–1.5 mg/kg)
	Difficult	Recommend general anesthesia

It is important to inform the parent about the sedation process. This can be achieved in many ways including informed consent, instructions, packets of information, and frank discussions during the treatment planning phase. It is appropriate to begin the process of informed consent shortly after deciding on sedation as an option. If the sedation procedure is to occur within the next month, then a signed informed consent at the initial visit is recommended. The informed consent process at this visit is indicated because the parent can have the opportunity to (a) ask questions without the stress of the immediacy of the procedure, (b) ponder the procedure and even seek consultation with his/her physician or another dentist, and (c) review the process and other materials (i.e., preoperative instructions) at home without the duress of the clinical environment and situation on the day of the sedation.

The parent should be adequately prepared and advised regarding the events on the day of sedation. It is advisable that the practitioner develops and has a packet of material to give to the parent (see Fig. 8.1). The packet can contain informative material about sedation as an adjunct to dental procedures, the drugs and monitoring techniques used in the practice, pre- and postoperative instructions, and even a statement of the practice and adherence to recognized sedation guidelines (e.g., AAPD-AAP guidelines).

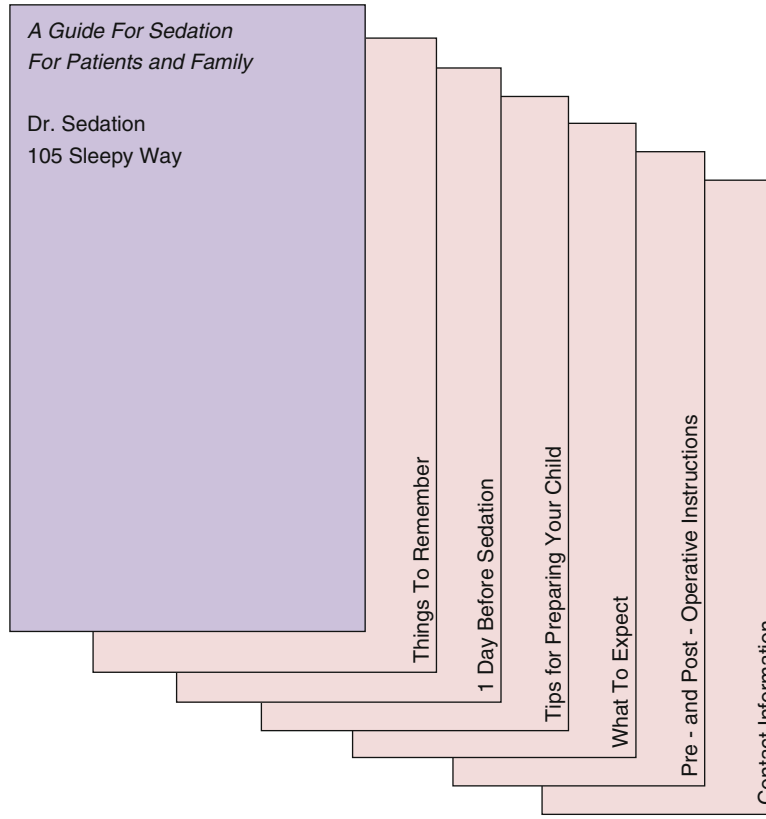

Fig. 8.1 Packet pf material for parent in anticipation of sedation visit

Preoperative instructions are important in facilitating a smooth entry into a sedation appointment. The instructions are meant for the parent/guardian as an explicit listing of details for preparing the patient to safely receive and benefit from the effects of a sedative agent. The instructions should be given verbally at the appointment prior to the sedation appointment date or over the phone the day before the sedation appointment or both. The parent/guardian should also receive a written document containing a listing of the instructions to follow prior to the sedation appointment. The preoperative instructions minimally should contain information on:

- Feeding requirements consistent with published guidelines (e.g., nothing by mouth for a minimum of 6 h prior to the appointment).
- Fluid requirements consistent with published guidelines which usually consist of only clear fluids up to 2–3 h prior to the sedation appointment. Clear fluids are fluids that can be held up to a bright light source and the source is seen through the liquid (e.g., water, apple juice); however, any fluids containing particles are contraindicated (e.g., orange or grapefruit juice).
- Maintaining consistency of normal daily routines including naps, the patient's usual bedtime, waking hours, and playtime on the day before the sedation appointment.
- Dressing the child in comfortable but loosely fitting clothing such as a tee or sweat shirt, blouse, and trousers. The clothing should facilitate access to the anterior chest wall or upper arms as needed for the placement of monitors, IV access, or for monitoring breathing parameters and tissue coloration. Dresses that button in the back or are difficult to remove and expose the chest area or can be soiled by vomitus should not be encouraged.
- Strong encouragement of the parent/guardian to contact your office should the child have conditions that might compromise the child

during a sedative experience. Some of these conditions include recent head trauma (i.e., last 2–4 weeks) in which loss of consciousness, dizziness, vomiting, confusion, or guarded monitoring of the child occurred; cold or flu-like symptoms such as a sore throat, fever, lethargy and malaise, vomiting, or rhinitis within a day or two before the sedation appointment; or any other condition affecting respiratory or cardiac functions.
- Discussion with parent and physician about the daily medications taken for behavioral or other medical conditions, whether they should be taken on the day of the sedation or are contraindicated with the planned sedatives.
- Time of arrival at the clinical facility.
- A listing of the practitioner's telephone numbers including an emergency contact number.
- The date and time of the sedation appointment.

Day of the Sedation Appointment

On the day of the sedation appointment, the first phase of the procedure is not unlike that which occurred on the day when the decision was made to sedate the child. It is very important to follow a standardized, well-established protocol. Part of the protocol involves reviewing the medical history for the purposes of (a) re-familiarizing yourself with the patient's medical history and any specific issues to address before proceeding and (b) looking for change in the medical history since the last visit such as recent colds, influenza, recent head trauma, and vomiting episodes. Also, the major systems (e.g., pulmonary) need to be reviewed for any changes since the last visit. The parent should be queried regarding allergies and current medications including over-the-counter kinds such as Robitussin or liquid acetaminophen, ibuprofen, or herbal medicaments. Any new changes to the medical history should be thoroughly investigated to rule out any contraindications to continuing with the sedation appointment.

The dental assistant must obtain the weight of the child. Dosing of sedative agents for children is based on the patient's weight in kilograms. Observing the interaction between the dental assistant, child, and parent during weighing of the child is an excellent opportunity for the clinician to gain insight into the patient's temperament. Observation of this process and the child's response can be informative and possibly aid in predicting their response in the dental operatory during the sedation process. The procedure of weighing the child can be done in one of two ways depending on the child's behavior (see Fig. 8.2).

If the child is cooperative, the assistant can ask the child to stand quietly on the scale. If the child is not cooperative, the parent and child stand on the scale together, a weight is obtained, and then the child is held by the assistant while the same parent stands on the scale and obtain his/her weight. The difference of the two weights is the weight of the child.

Most children are brought to the clinic or office in clothes including shoes. Therefore, for a more accurate weight of the child, one should subtract 1 kg from the weight of the child. It is standard medical practice for sedation procedures to obtain the patient's weight in kilograms and not pounds. Finally, one should be familiar with the general relationship of weight, height, and age of children. Overly obese children are poor candidates for sedation; those children whose weight is between 50 and 90 % should be carefully evaluated and only receive sedatives in doses based on the average weight and height for a child of their age and not on their own weight. Growth curves showing the relationship and percentiles for children's height and weight by gender are readily available on the web (Fig. 8.3).

Vital signs must be done preoperatively including heart rate, blood pressure, and oxygen saturation. The interaction with the child in collecting vital signs again will give the practitioner a good feeling for the cooperativeness of the patient, and this sometimes may afford an impression of the outcome of the planned sedation.

Tell-show-do should be used in obtaining vital signs. Vital signs can be obtained from most children often with the use of distraction techniques or playing games (e.g., testing "your muscles"). The values obtained may not be accurate in some

Fig. 8.2 Techniques for weighing child before sedation. The child can be asked to step on the scale and remain still, if the child is cooperative (**a**). For an uncooperative child, the parent and child can first be weighed together (**b**), then the parent can be weighed alone (**c**). The difference between the first and second weighing is the weight of the child

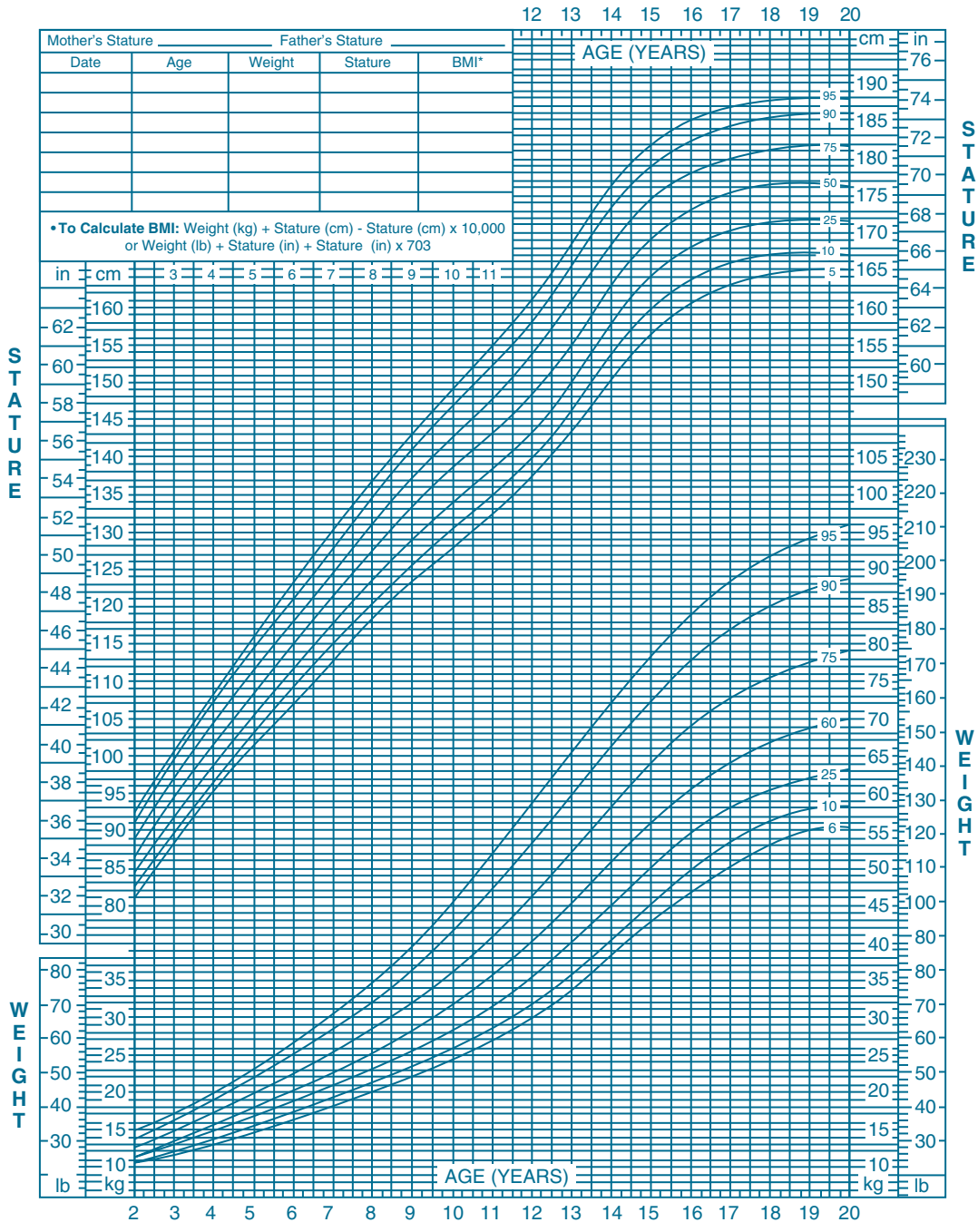

Fig. 8.3 Example of growth curve for boys between 2 and 20 years of age. Source: National Heart, Lung, and Blood Institute; National Institutes of Health; U.S. Department of Health and Human Services

patients due to uncooperative behaviors. For example, children in whom vital signs are difficult to obtain often tend to be poor candidates for light sedation. Individual responses to the process of taking vital signs will vary considerably. Some children may extend their arm for the placement of the blood pressure cuff, whereas others may withdraw their arm compressing it against their chest and screaming at the sight of the cuff. Vital signs should be within normal limits for the age of the child; hence, it is important to know the vital signs of children of varying ages. If the child's behavior makes it impossible to obtain reasonable vital sign data, a note about the behavior preventing or compromising the interpretation of the vital sign values should be placed on the sedation record. Also increased diligence in questioning of the parent about the child's condition, medical history, and related issues is necessary to ensure a greater likelihood that the child is ready for sedation. For instance, a 3-year-old child may have a recorded preoperative resting heart rate of 205 beats per minute. A resting heart rate for a 3-year-old child of 205 beats per minute is abnormal. However, if the child was screaming, kicking, and tugging away from the monitor during the vitals measurements, then such a high heart rate makes sense. Additionally, the automated blood pressure monitor may search for some time for a good signal, and the prolonged inflation of the blood pressure bladder can become painful to the child making behavior even worse.

Next, the practitioner intercedes and begins the process of checking on the child's medical history and physical status. The medical history including any recent incident of head trauma, systems review, changes in medications, or allergy status are updated as children's health and physical status can change rapidly. Any significant change or finding requires attention and the clinician's follow-up. If behavior was an issue during the taking of vital signs, any hint of a potential problem with the patient's physical status and systems should be thoroughly investigated through appropriate questioning of the parent. Furthermore, if the issue cannot be resolved satisfactorily or if questions remain, it is best to postpone the sedation and obtain further consultation with the patient's physician.

The patient should be physically examined to include the head and neck as well as chest auscultation. The general appearance of the child should be appreciated. Attention should be given to symmetry of the head, neck and body, gait, activity, and any unusual clinical findings.

Chest auscultation requires a stethoscope and the tell-show-do technique. The stethoscope should be used to listen to the child's lung fields and heart sounds. The aim of the auscultation is to rule out any abnormal respiratory or heart sounds. Abnormal respiratory sounds include stridor, wheezing, croup, coughing, or any sounds suggesting congestion of the lung fields. Normal heart sounds should be a simple "lub-dub" without any "swish" or tap or other unusual sound. It is recommended that the reader search the World Wide Web for the topic of auditory pediatric heart and lung sounds of which there are several excellent sites for the practitioner to visit and listen (e.g., http://www.easyauscultation.com/).

An airway examination may be one of the most important processes in preparing and planning a sedation appointment as well as ensuring the safety of the child [13]. Dental procedures involve the airway and can potentially compromise efficient and effective ventilation functioning even during non-pharmacological management. This is particularly the case if soft tissue issues and facial structure increase the likelihood of partial airway blockage. For example, individuals who are mouth breathers can find it challenging at times to undergo dental procedures and unfortunately may not even benefit from delivery of nitrous oxide using dental delivery systems. The addition of relatively large lymphatic tissues (i.e., tonsils and adenoids) can further impact the efficiency of ventilation in the awake state. Pharmacological interventions may cause varying degrees of sedation that influences awareness, decreases airway tone and compensatory mechanisms, and increases the likelihood of partial or complete airway blockage. The airway examination is not unlike that of an oral clinical examination, but focus is directed to the size of the tonsils at the oropharyngeal junction. In a supine position, the

Fig. 8.4 Knee-to-knee examination technique used for visualization of the tonsils in an uncooperative child. (**a**) The mother and dentist sit facing each other with their knees touching and laps at approximately the same height from the floor. The mother holds the child who faces her with legs wrapped around her waist. (**b**): The child is lowered onto the dentist's lap. The dentist aids in lowering patient. (**c**) The child lies on the dentist and mother's thighs. The dentist uses his/her hands to stabilize the head and look into the oral cavity. The mother holds the child's hands to prevent grabbing or movement while securing the child's legs around her lap

jaw and tongue will tend to move posteriorly due to the effects of gravity and sedative drugs. The possibility of blockage of the tongue with the tonsils and soft palate should always be considered. The parent should also be asked if the child snores on a regular basis or when greatly fatigued.

In doing this airway examination, the relatively cooperative patient can be asked to open his/her mouth as wide as they can and, while holding the mouth in an open position, protrude the tongue and say "aahhh." For the shy, uncooperative child, it is often necessary to do a knee-to-knee examination (Fig. 8.4). In a knee-to-knee examination, the parent and clinician sit facing each other with their knees touching. The child is placed in the parent's lap facing the parent. The child is reclined onto the legs of the parent and clinician so that the patient's head is resting in the clinician's lap. The patient's legs are wrapped around the waist of the parent who is holding the hands of the patient. Usually the patient is looking up at the clinician facilitating an oral examination.

The mouth is gently opened if the child is quiet. Often the child is crying and the tonsils cannot be easily visualized due to posturing of the tongue "high" in the mouth, and a gag reflex may be elicited. One of the easiest methods to elicit the gag reflex is to slide a mouth mirror along the midline of the tongue toward the posterior 2/3rds of the tongue. (Note: always check the mouth mirror to ensure that the mirror is tightly

attached to the mirror handle.) The patient's tongue naturally positions against the mirror in an attempt to deflect it. Slight pressure and a slow movement of the mirror toward the posterior portion of the tongue will elicit a gag reflex without causing vomiting. The practitioner must watch for and analyze the tonsil size compared to the airway open in the area when not gagging. During the gag reflex, the tonsils move toward the midline and superiorly, thus appearing slightly larger than they are. This procedure must be done very quickly and only once as it agitates the child who must be reassured and consoled.

Attention should be focused on the size of the tonsils compared to the airway [1, 13, 19]. Tonsils greater than 50 % of the airway predispose a patient to possible airway blockage especially when a sedative is used that increases the likelihood of loss of consciousness. For example, chloral hydrate, whose active metabolite is an alcohol, is known to selectively inhibit the muscles of the tongue. When a patient is placed in a supine, relaxed position and the musculature of the tongue loses it tone, it will drop posteriorly to contact the soft palate or pharynx causing partial or full blockage resulting in snoring or alternating chest-stomach rocking indicating attempt to ventilate but lack of movement of air, respectively.

An oral examination should be completed and the dental treatment plan reviewed with the parent. Reviewing the previously obtained and signed informed consent which the parent can resign and date on the day of the sedation is advisable. This is an excellent opportunity to answer any last minute questions or concerns the parent may have prior to the initiation of the sedation process.

The next phase of the sedation protocol is the decision-making process related to the drug or drugs that will be used. The dose of each drug should be calculated based on the child's weight in kilograms, temperament classification (i.e., "easy" or "difficult"), and extent of dentistry to be accomplished. Once a decision on the drug(s) and dose(s) has been made, it is highly advisable that the practitioner recruit a dental assistant or colleague to review the steps of dose calculation and dispensing of the drug(s). The practitioner prepares the drug solution. The assistant or colleague can watch and confirm this process to ensure that a dosing error is not made. The calculations and confirmation of amount dispensed should be noted immediately in the patient's sedation record.

Table 8.2 Agents than can be used for flavoring oral sedative solutions

Agent	Characteristics	Company
Nu-Flavor (alginate flavoring material)	Comes in numerous flavors Two or three drops per 5 ml of solution 2 oz. (57 ml) bottles	Lancer Orthodontics
FLAVORx system	Comes in numerous flavors Comes in kit 30 ml bottles	FLAVORx, Inc.
Children's MOTRIN	Berry flavored 40 mg/ml	McNEIL-PPC, Inc.
Kool-Aid	Comes in numerous flavors Powder	Kraft Foods, Inc.

Once the elixir is prepared, it should be flavored to mask any unpleasant taste of the preparation [20, 21]. The liquid formulations of the most popular sedatives require flavoring to aid with their consumption. The child should be encouraged to drink as fast as possible so that the initial distasteful gustatory effect is minimal. Sipping from medicine cups should be discouraged. Unfortunately once swallowed, the lingering effect of the sedations causes an even worse disagreeable aftertaste. To diminish the lingering aftertaste, a small sip of water can be given (e.g., 3–5 ml). There are several means by which to flavor unpalatable drugs as are seen in Table 8.2.

The next step is the administration of the sedatives as an elixir. There are three ways to administer an oral elixir to a child depending on their behavioral acceptance of the elixir. The child can be given a medicine cup containing the elixir and encouraged to drink the "juice." Many children will drink the elixir readily and rapidly, especially if the process involves a game. For example, the parent is given a medicine cup containing colored/flavored water and the child is challenged

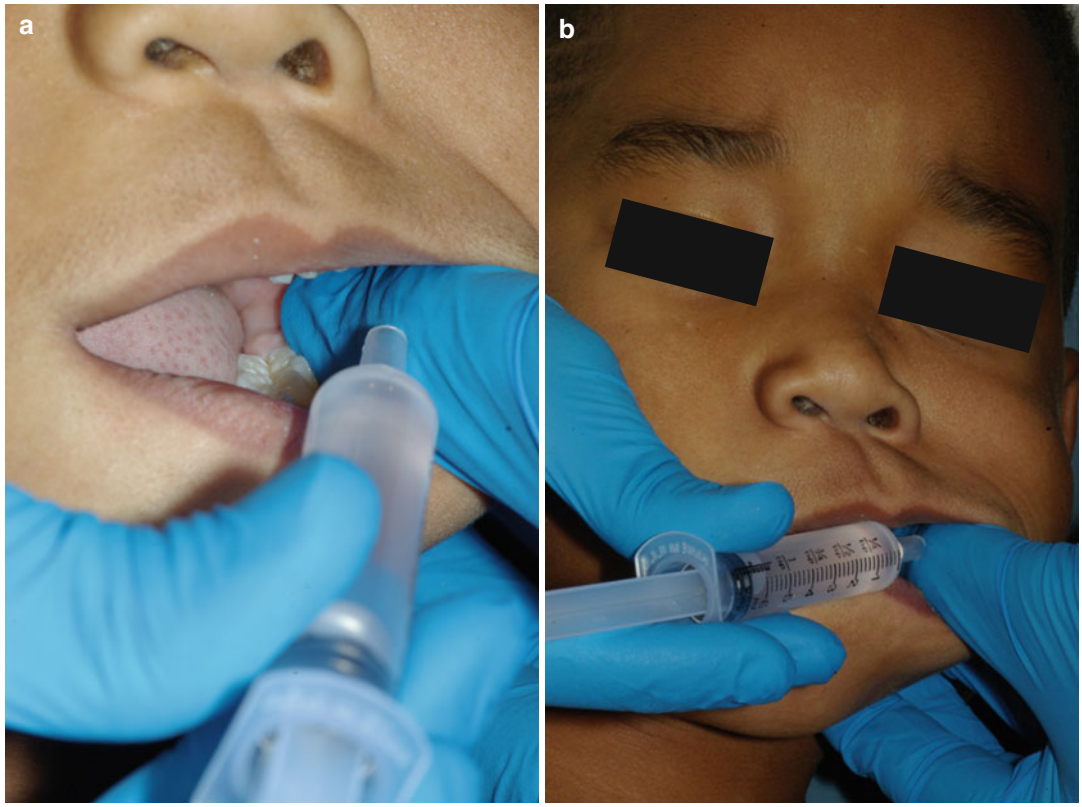

Fig. 8.5 Administration of sedative using a needless syringe. The finger of the nondominant hand is placed on the retromolar pad (seen in **a**). The plunger of the syringe is gently depressed releasing the contents down the finger that is resting on the retromolar pad (**b**)

to "drink the juice faster than Mother on the count of three." If the child sips the elixir and rapidly decides they dislike the juice refusing to drink anymore, then alternatives for administering the elixir should be considered.

One alternative is to have the parent administer the elixir via a needleless syringe. Often the parent will voluntarily report that he/she gives the child medicines at home using a needleless syringe and believe that would be the simplest and most efficient way to get the elixir administered. This technique is fine as long as the practitioner advises the parent to "squirt the liquid" slowly into the mouth and definitely angled toward the cheeks and not the back of the throat. Many parents will "unload" the syringe rapidly and direct toward to back of the throat inducing choking, coughing, gagging, and possible expectoration of the elixir. Since some sedatives are mucosal irritants (e.g., chloral hydrate), this rapid administration and directing of the fluid bolus to the center of the back of the throat is unadvisable.

Another alternative is for the practitioner to administer the elixir via a needleless syringe using a knee-to-knee position with the parent and partial reclining of the patient. The child may cry which is advantageous to the practitioner who can gently reflect the cheek with his nondominant hand placing a finger or thumb on the retromolar pad (Fig. 8.5). He/she can slowly dribble the solution down his/her finger/thumb which flows over the pad and usually induces a swallowing reflex. The same procedure can be done even if the child does not cry, but resists opening the mouth and remains clenched. This is not a problem as the finger or thumb of the nondominant hand can be inserted into the corner of the lip and slowly moved between the clenched teeth

and buccal mucosa to the retromolar pad. Rarely if ever does a child try to bite during this process.

Sometimes the child is not stimulated to swallow and the fluid begins to build in volume in the oropharyngeal area. It is best to stop the administration at this point and ask the parent to help by gently pinching the nose closed. The child will either swallow in order to breathe or expectorate the fluid. The remainder of the elixir in the syringe can then be administered.

If expectoration occurs or vomiting is initiated shortly after this administration procedure, the practitioner should *never* estimate the amount spilled/vomited in order to readminister the estimated amount of sedative. In fact, it is surprising how often the child will sufficiently be sedated with the limited amount of elixir absorbed through the mucosa and partially swallowed, especially when using the adjunct of nitrous oxide and other behavioral guidance tools (e.g., distraction). Much of this spillage/vomiting problem can be avoided if the practitioner decides, based on parental input and whether the drug(s) are parenterally compatible, that a submucosal injection is a better option. This administrative technique is described in Chap. 9 describing alternatives to oral administration of sedatives. This technique has the disadvantage of administering two injections: the sedative elixir and later the local anesthetic. Regardless of what method of administration is used, it is always advisable to have protective eyewear on the child and the administrator of the liquid to prevent spitting of the liquid into eyes. Finally, if any of these alternatives are unacceptable to the parent or uncomfortable for the clinician, then other considerations for managing the patient's behavior should be considered. This may include other routes of sedative administration or even general anesthesia.

The next phase after drug administration is that of latency. In this context, latency refers to the duration of time between the drug administration and the attainment of therapeutic blood levels of the sedative(s) allowing the beginning of the restorative phase of the procedure to begin. Average latency periods for commonly used sedatives vary and have generally been empirically established (see Table 8.3), but the practitioner should recognize that not every child will respond in an "average" fashion. If the practitioner is not using common sedatives, they can seek latency period information by searching on a recognized Web site (e.g., Lexicomp) and find the drug and the pharmacokinetic information for the drug focusing on the time period associated with the "time to peak serum concentration."

Table 8.3 Latency periods for common sedatives and combinations

Drug	Sedation considerations (timing)
Chloral hydrate	Onset: 30–45 min Separation time: 45 min Work: 1–1.5 h
Meperidine	Onset: 30 min Separation time: 30 min Work: 1 h
Midazolam	Onset: 10 min Separation time: 10 min Work: 20 min
Hydroxyzine	Onset: 15 min Separation time: 30 min Work: 45 min
Combinations	
Chloral hydrate + Meperidine + Hydroxyzine	Onset 20–30 min Separation time: 45 min Work: 1–1.5 h
Midazolam + Meperidine + Hydroxyzine	Onset: 5–10 min Separation time: 20–25 min Work: 1 h

As mentioned, the latency periods vary for sedatives. A good example is the latency period for midazolam (Versed) versus that of chloral hydrate. The former is approximately 15–20 min and the latter is usually 45–50 min. It is highly advisable that the practitioner start the separation of the child from the parent at the end of the recommended latency period and not before. Starting prior to the end of the recommended latency period can often cause the child to become agitated and more difficult to settle with behavioral guidance techniques of distraction and tell-show-do.

Monitoring of the child during the latency period is necessary while observing the

behavioral changes associated with the onset of the elixir to prevent the onset of adverse events should the child lose consciousness. Usually a trained auxiliary personnel can monitor the patient continuously but the practitioner should also check the patient once every 3 to 5 min. An Oxisensor from the pulse oximeter should be placed on the patient. Occasionally the patient is initially uncooperative, but if calmness intercedes, then it can be attached. Under any circumstance wherein the child closes his/her eyes or even drifts into a light sleep, more intense clinical vigilance along with monitoring for ventilation becomes necessary. Head tilts or positioning the child in the parent's lap with the airway opened and unobstructed is strongly advisable. Sidestream capnography can also be initiated at this point.

Following the end of the latency period, the patient preparation for and initiation of the intraoperative restorative phase begins. The practitioner should have a policy on whether the parent is allowed to be present in the operatory during the sedation. Like routine restorative visits, there are advantages and disadvantages to parental presence. Nonetheless, the risk of an adverse event increases during a sedation visit especially during deep sedation and its management may be complicated by parental presence in the operatory. Again, policies and procedures can be explained to the parent during the informed consent process to avoid the issue of parental presence or other possible issues (e.g., use of protective stabilization). Should separation of the parent from the child occur, the child may be laid in the reclined dental chair or placed in a restraining device (e.g., papoose board™). The practitioner must decide whether the parent should be asked to leave the operatory for the restorative phase of the sedation appointment. There are few advantages for the parent to stay other than patient support and encouragement if properly guided by the dental team. However, the dental team will focus solely on the child, and the parent's presence may cause distractions, delays, dental team discomfort and apprehension, and interfere with rescue procedures should the child enter into conditions leading to adverse events.

The use of protective stabilization (e.g., papoose board) during sedation is optional. Some individuals feel that it is safer to use the papoose board to prevent any unexpected movement of a sedated child. However, others do not use the papoose board initially because they feel that the use of the papoose board or lack thereof is a measure of sedation success. The child must be properly placed in the papoose board, if used, so that he/she is comfortable and the limbs and joints are not unduly stressed (Fig. 8.6). A properly placed shoulder roll will help ensure an open airway. Other devices are available to aid in opening the airway and stabilize the head as well (Fig. 8.7). If a restraining device is used (this author prefers that the child "earn" the papoose board), it is imperative that the chest restraining flaps of the device not impinge or restrict normal passive breathing of the patient.

The opening of the airway and its continuing maintenance is imperative regardless of the depth of sedation. The maneuvers of head tilt, chin thrust, and the shoulder roll are the simplest and easiest ways to manage the airway (Fig. 8.8). Maintaining a patient airway is a process that occurs not once, but many times during every procedure regardless of depth of sedation. The head up and chin thrust also are excellent maneuvers for optimizing the practitioner's vision of the operating field as well (i.e., the rubber dam and oral tissue areas).

Monitors should be attached to the patient by this time. The monitors may be a pretracheal stethoscope, pulse oximeter, blood pressure cuff, capnograph, temperature, and EKG depending primarily on the depth of sedation, and as regulated by state practice act, and guidelines as well. The monitors should be affixed to the patient shortly after separation from the parent and placement in the dental chair.

Stethoscopes have been available for decades and can obtain heart, respiratory, gastrointestinal, and joint sounds and cardiovascular anomalies (e.g., arteriovenous malformations). They consist of a diaphragm or bell which is placed against a body surface, a connecting tube, and ear pieces for placement into the ear canal of the person listening for sounds (Fig. 8.9). They are particularly

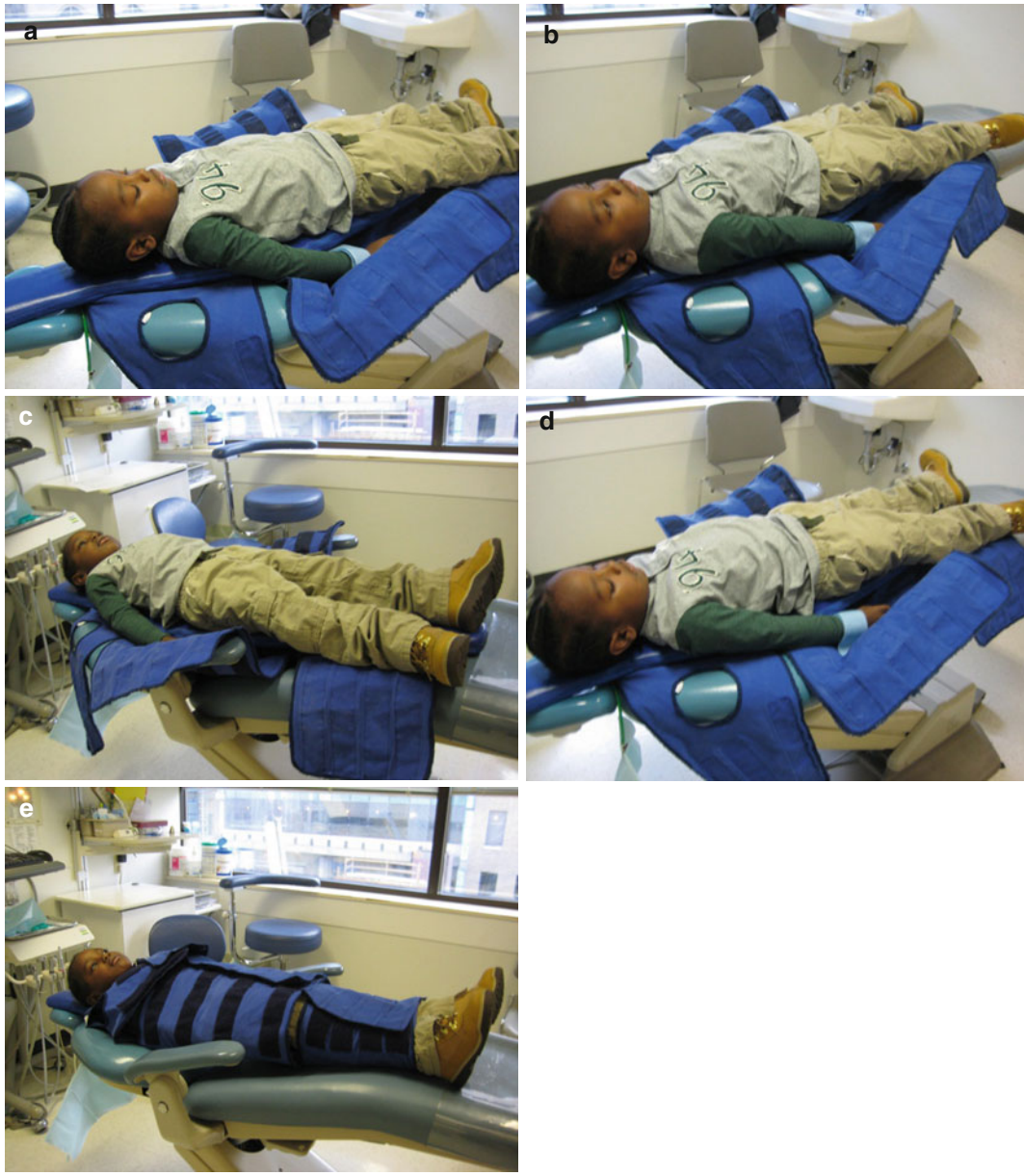

Fig. 8.6 Proper use of passive stabilization immobilization (i.e., papoose Board). Panel (**a**) shows the child whose body is improperly placed too inferiorly in the papoose board. Note that the shoulders are elevated beyond normal shoulder line which can become painful. Panel (**b**) shows the child whose body is improperly placed too superiorly, with the shoulders extended inferiorly again causing pain. Panel (**c**) shows the child resting comfortably on the papoose board with the arms anatomically and naturally extended. Panel (**d**) shows the child properly placed with the shoulders at normal neck line and wrist restraints placed. Panel (**e**) shows the child properly wrapped and comfortable while immobilized

useful for monitoring airway and heart sounds during sedations.

An imaginary triangle can be visualized on the child's chest and used to help determine where to place the stethoscope bell to maximize the hearing of airway sounds. The base of the triangle is a line joining the patient's nipples with the apex formed by the remaining sides of the triangle

each joining the nipple to the precordial notch at the junction of the neck and chest (Fig. 8.10). In a reclined patient, placement of the stethoscope bell at the top of the triangle in the slight depression of the neck just superior to the manubrium of the chest (i.e., the precordial notch) will cause breathing sounds to be loud and dominant compared with the faint sounds of the heart. As the stethoscope bell is moved along the imaginary line connecting the precordial notch to the left nipple, the airway sounds become fainter and the heart's dominate. Airway sounds are more important during sedation, thus the bell should be placed toward the apex of the triangle. Also, the bell should be well sealed when attached to the patient either with tape or 3 M Double-Stick Discs® (3 M Medical Device Division, St Paul, MN – see Fig. 7.9). Care must be taken not to tape the bell too tightly to the patient which can cause partial airway blockage.

Competing ambient sounds to those of the airway come from various sources including handpiece noise, a metal rubber dam frame (i.e., the frame touching the bell of the stethoscope will conduct sounds when the handpiece contacts the frame), and room noise (e.g., talking or music). Often these sounds can be comparatively loud and drown out the airway sounds, increasing the need for additional monitoring. A study of sedated children undergoing dental care comparing the precordial stethoscope to other monitors of airway patency has not been reported.

Bluetooth technology has recently changed the way in which stethoscopes are used in

Fig. 8.7 Styrofoam ramp/pillow to open the airway during sedation. Note how the chin is pointed toward the ceiling, opening the airway

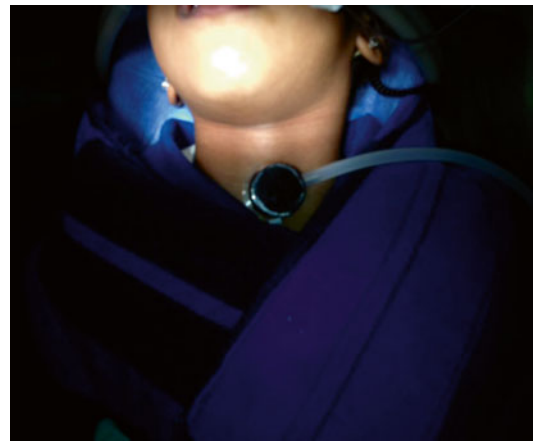

Fig. 8.9 Pretracheal stethoscope bell and tubing leading to the earpiece inserted in the ear of clinician

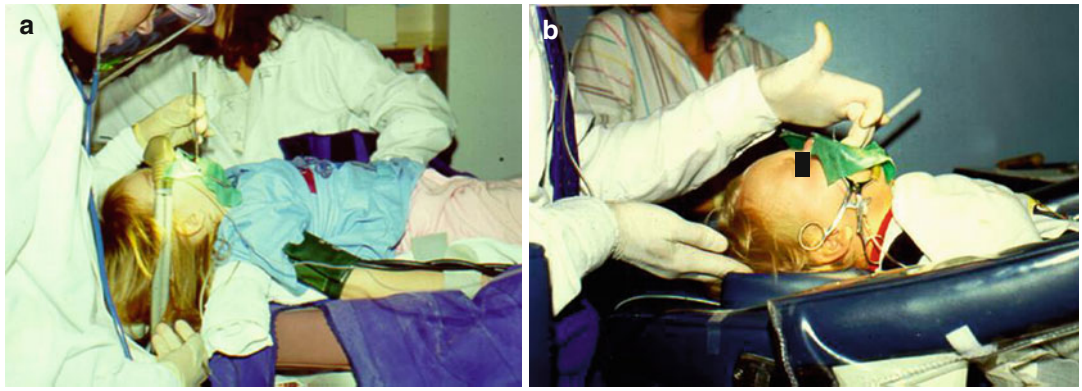

Fig. 8.8 Head Tilt, Chin Thrust, and Shoulder Roll. (**a**) shoulder roll (white rolled towel) and (**b**) demonstration of head tilt

monitoring sedated patients (Sedation Stethoscope, Sedation Resources, Lone Oak, TX). The Bluetooth stethoscope consists of the bell with a transmitter that is affixed to the patient's chest or neck and a receiver that fits into the ear of the person who is monitoring the sounds of the patient. The sounds can be amplified and easily heard over ambient room sounds. The airway sounds also are transmitted wirelessly over several feet separating the patient from the clinician. This feature is unique in several clinical aspects of monitoring. For instance, a clinician can momentarily step outside of an operatory and still hear the airway and heart sounds of the patient just inside the doorway of the operatory. Also, the signal can be turned over with a simple push of a button on the receiver and this becomes handy during situations when a child begins crying possibly damaging the ear of the clinician.

The pulse oximeter probe can be placed on the fingers; however, many very young children or those with extreme fear or defiance will remove the probe shortly after placement. A better location for the oximeter probe is on the toe next to the big toe. The big toe and next 2 toes can be taped together as a unit as is seen in Fig. 7.3. The wire lead connecting to the pulse oximeter's preamplifier can be taped to the plantar or ventral aspect of the foot. If done correctly, the child will be unlikely to remove the probe from his/her toe, despite attempting to do so.

The blood pressure cuff should be selected based on the size of the child's upper limb. The width of the cuff should be approximately 2/3rds of the length of the upper arm. When placed it should be snug, but not too tight and smooth against the skin. The cuff should not be folded or wrinkled in any way when applied so as to prevent damage to the child's arm and peripheral nervous system (e.g., paresthesia).

Automated blood pressure machines usually have mechanisms for setting its operation including how often to take the blood pressure and alarms for low and high limits of blood pressure and heart rate. From a procedural perspective, if the automated blood pressure cuff is set to inflate every 5–10 min, and the noise of the internal pump of the monitor is heard, the assistant can stop and record vital signs on the time-based sedation record. If a nonautomated blood pressure cuff is used, the assistant or practitioner will have to be persistent in watching the clock and taking vital signs on a continual basis.

Sidestream capnography (see Chap. 7) for children has been a controversial topic in the arena of sedation in the dental office. It adds little information when the child is moving, crying, and otherwise is disruptive. However, when the child is quiet and awake or appears sleeping with eyes closed, it is a highly reliable instrument for monitoring ventilation. The capnograph is easy to use and only requires the practitioner or his/her assistant to turn on the instrument and attach the

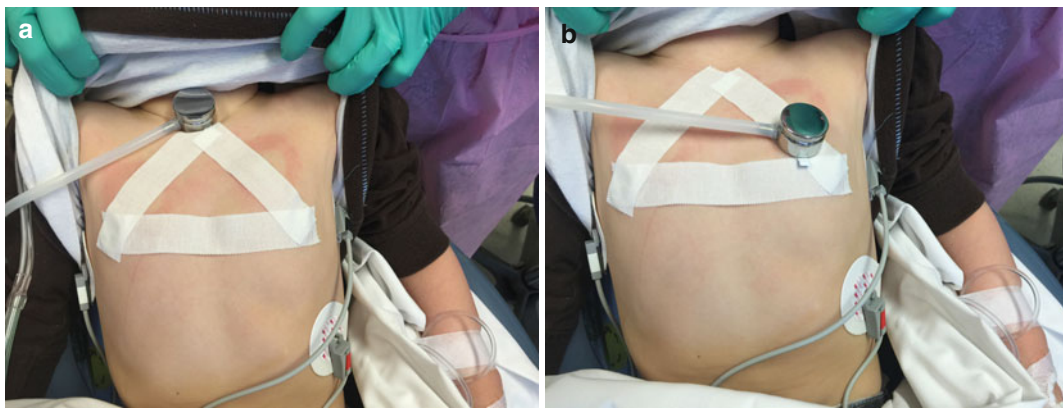

Fig. 8.10 (**a**) Proper placement of stethoscope bell for maximal amplification of airway sounds. (**b**) Placement of stethoscope bell for maximum amplification of heart sounds

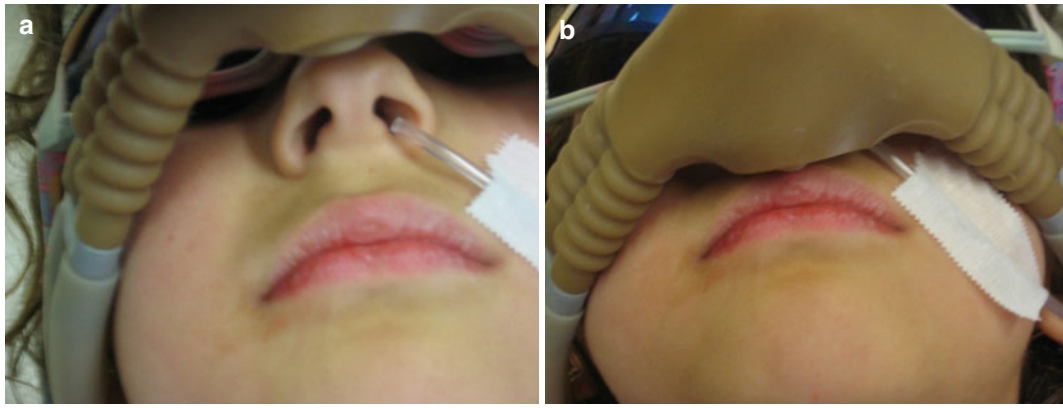

Fig. 8.11 Sidestream capnography with placement and stabilization of open-ended sampling tube below the (**a**) lateral orifice of the nose and (**b**) under nitrous oxide hood resting on the face

probe (usually a small plastic tube) so that the open end of the tube lies immediately below the nares of the nose with a piece of tape (Fig. 8.11). The other end of the plastic tubing attaches to the monitor. This arrangement is one example of so-called "side-stream" capnography.

If nitrous oxide is used, the nasal hood can be placed directly over the top of the nose and plastic tube. Once in place, the plastic tube must be checked on a periodic basis or whenever the height of the capnograph waveform representing the expired CO_2 (or breathing) begins to diminish in height. There are only a few reasons why the height of the waveform is decreasing: (a) the plastic lead has been displaced from the nares opening; (b) the child is breathing/crying through the mouth; or (c) the airway of the patient has become partially blocked. Mucous can also block the plastic tubing causing the monitor to alarm indicating apnea has occurred.

The capnograph complements the precordial stethoscope nicely as long as the stethoscope is placed in the midline of the neck slightly above the bony chest cage. Often times the sound of the high-speed handpiece drowns out the lower-pitched noises associated with breathe sounds.

Continual vigilance and appreciation of the child's mental status is a must throughout the procedure. An awake child who is either quiet or crying requires continuous distraction in the form of constant assurance and stories meant to avert attention to the dental procedures (i.e., *sedation is simply an adjunct to routine communicative behavior management*).

A sleeping child should be carefully monitored to ensure that the vital signs remain within normal limits and the airway is open and clear of debris as determined by a stethoscope and capnography. Stability of vital signs and a patent, protected airway is the key to successful management of a sleeping child. If vital signs begin to trend in an undesirable direction, the dental procedure must be stopped immediately, the situation rapidly assessed, and appropriate responses taken to stabilize the child.

Once the monitors are attached and the patient is comfortable in the chair, the process of "settling" the child is initiated. One of the biggest mistakes made in the art of sedating children that this author has witnessed on numerous occasions is failure of the practitioner to wait for the child to settle down after placing the child in the supine position on the chair. As soon as the child is placed on the chair, a dedicated effort should be made by the dental team to "settle" the child through distraction and by talking calmly to him/her. As a part of this settling period, the practitioner or his assistant should place the nitrous oxide hood using tell-show-do. The practitioner *should wait* for a period of 5 min or more with the nitrous oxide flowing before beginning any other procedure. It is this waiting period during which efforts are made to calm and reassure the child who is receiving nitrous oxide that is referred to as

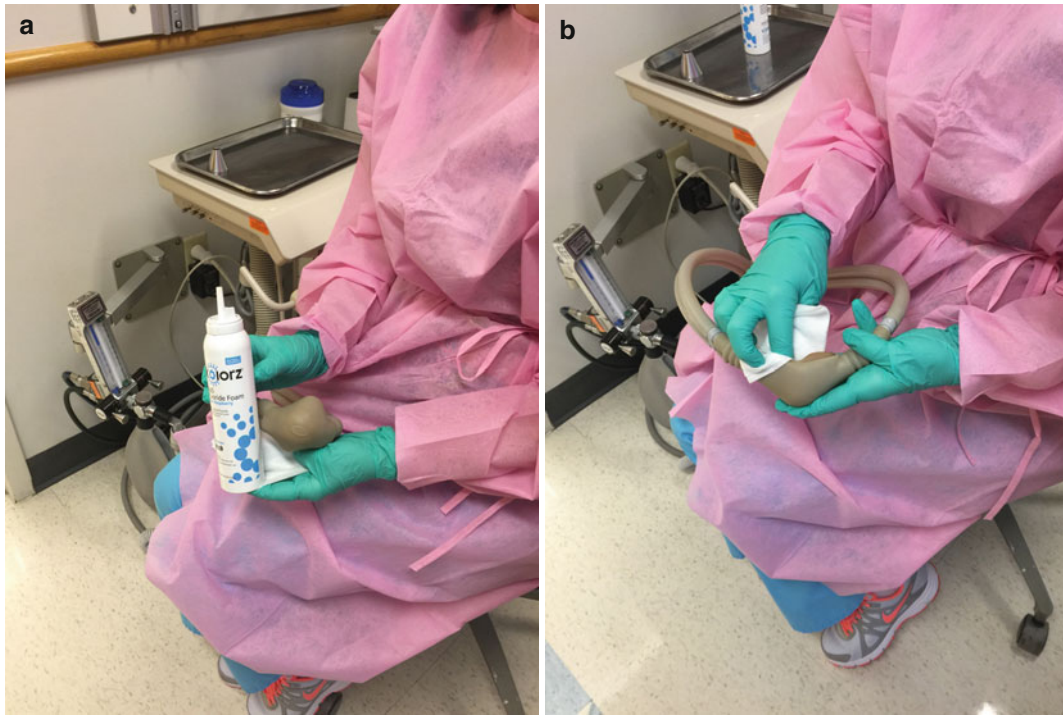

Fig. 8.12 Flavoring the nasal hood with fluoride foam. (**a**) Fluoride foam and a 2 by 2 gauze in the hand. Squirt a small amount of flavored fluoride foam on a 2 by 2 gauze and (**b**) wipe the inside of the nasal hood with foam using the gauze

"settling" of the child. It may be one of the most important periods in the sedation process because it allows the child to calm down and let the sedative produce the desired effect. If the child calms or is already in a peaceful state during settling, the likelihood of a reasonable sedation outcome increases; however, if the child is not settled after 10 min of nitrous oxide exposure, then the outcome of the procedure will likely be poor and frustrating to all involved.

Failure to settle a child and moving directly into the operative procedure is one of the most common mistakes made by practitioners often resulting in an agitated and inconsolable child. The settling can be done at other times during the procedure whenever a child becomes too disruptive or agitated and especially before and after local anesthesia administration.

Nitrous oxide can be administered either via titration or a rapid induction process depending on the patient's behavior at this point in the procedure. One way to minimize the patient's rejection of the nasal hood is to flavor the hood's internal surface and ask the child to smell the flavor. One simple means of flavoring the nasal hood is to express a small amount of flavored fluoride foam onto a 2 by 2 gauze and wipe the inside of the nasal hood (Fig. 8.12). If the patient is calm and accepting of the nasal hood, then the titration method is preferable; however, if the patient is agitated or frankly struggling, then rapid induction is indicated. Rapid induction technique refers to increasing the concentration of nitrous to as much as 70 % holding the hood just slightly off but over the mouth and nose for up to 10 min to determine if the child will "settle." If the child settles within 5–10 min, the concentration should be reduced to 50 % concentration or less.

Titration of nitrous oxide can be done by increasing the concentration of nitrous oxide up to 40–50 % in two or three steps involving a 10 % increase in concentration per step. Each step lasts 20–40 s. The practitioner clinically observes the clinical signs and responses of the patient while querying the patient for their feelings until the child meets an appropriate clinical state (see Table 8.4).

Table 8.4 Nitrous oxide optimal clinical effects

Objective sign	Before nitrous oxide (%)	During nitrous oxide (%)
Eyes open	59 (100)	55 (93)
Tears	3 (5)	0 (0)
Trancelike expression	0 (0)	26 (44)
Smile	0 (0)	39 (66)
Speaking	7 (12)	9 (15)
Laughing	0 (0)	8 (14)
Hands open	32 (54)	53 (90)
Legs limp	13 (22)	48 (81)
Feet abduction	9 (15)	18 (31)

Source: Houpt et al. [22]. Copyright © 2004 American Academy of Pediatric Dentistry and reproduced with their permission

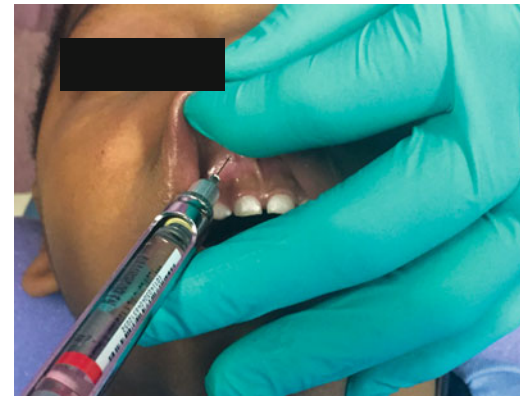

Fig. 8.13 Adequate finger rest on the barrel of the syringe in anticipation of reflex patient movement to injection. Note that the lip is fully lifted. The patient's head is cuddled between the elbow and side of the dentist's body to minimize head movement

The next step in the intraoperative phase is the preparation for and administration of local anesthesia for good pain control. Like all invasive dental procedures, profound local anesthesia is a must in optimizing patient comfort. On the other hand, the clinician *must* have the utmost respect for and adherence to safe therapeutic doses of local anesthesia. Far too often, sedation deaths have been associated with excessive and in some cases frank toxic doses of local anesthesia.

Topical anesthesia can be used. Topical anesthetic must be applied to dry mucosa to be effective. A small dollop of topical anesthesia on a cotton-tipped applicator is usually sufficient to cover multiple sites of mucosa in the mouth. On dry mucosa, the onset of analgesia will begin in less than 2 min. A wet mucosa delays onset and facilitates swallowing which causes paresthesia of the throat frightening some children.

Local anesthesia can now be administered via a syringe. Administration of local anesthesia is the one procedure most likely to agitate and cause disruptive behaviors even when the child was initially well settled. There are some key technical procedures to the administration of local anesthesia that will decrease the likelihood of producing disruptive behaviors.

By gently retracting the lip and lightly applying the topical anesthetic in a smooth fashion, the practitioner will gain a sense of how reactive the child is to procedures. Sometimes it is necessary to use the behavioral technique of distraction during this phase to see how well the child copes or is receptive to distraction. Insertion of the needle must be done accurately and slowly. Vibration or rapid wiggling of the soft tissue appears beneficial. Once the needle penetrates the tissue, it should not be withdrawn even if the child moves slightly. Consequently, when the needle is inserted, a good finger rest and head immobilization is highly advisable in anticipation of reflexive movement, especially in the sedated patient (Fig. 8.13). Reflexive movement should always be anticipated whenever the anesthetic solution is delivered into the mucosa above the maxillary incisors or into any area of the palate – a painful process for any child.

Usually the insertion of the needle is not the stimulus that provokes the child. Rather it is the "pushing" or deposition of the local anesthetic into the tissue. The anesthetic administration must be done extremely slowly and it should take at least 1 min to administer 1 carpule (1.8 mls). A faster administration rate will become painful, and if the child does not have any analgesic in the sedative mix (e.g., meperidine), then vocalization and reflexive movements are likely to occur. If the child moves quickly and excessively (so-called headbanger), the head must cautiously, but firmly, be cradled between the clinician's torso and nondominant arm of the practitioner or held by the dental assistant. Under these circumstances, it

may be advisable to more rapidly inject and remove the needle to otherwise prevent tissue trauma from the needle moving within the tissue. It should be emphasized that excessive stabilization or pressure applied to the head may cause harm to the child's head and neck, and thus, some movement and excellent finger positioning/stabilization of the syringe is critical.

Although the manufacturer recommended dose for each local anesthetic varies, adverse events in children can be prevented by not exceeding the author's "4 mg/kg rule" regardless of the type of "caine" (i.e., local anesthetic). If the child does become agitated, a few minutes of nitrous oxide "settling" and verbal distraction can be initiated again.

A rubber dam should be used for sedated patients. To properly place rubber dam clamps while making the patient comfortable requires judicious use of local anesthesia around the tissues and tooth on which the clamp is placed. Ligatures (dental floss) should be secured to the each side of the clamp in case of breakage along the clamp's bow. Obviously, the deeper the level of sedation induced, the greater the risk for airway reactivity to foreign objects, aerosol, and fluids. The rubber dam is a standard of care for restorative dentistry and aids in protecting the airway during operative procedures. The best and most protective rubber dam technique for sedation procedures is to use a punched hole for every tooth in the quadrant or arch when isolated. Quadrant is generally preferred over arch isolation primarily because the latter may have a tendency to push the tongue posteriorly possibly causing airway blockage. Slit-dam techniques are better than no isolation, but more readily allow fluids to gather behind the rubber dam out of sight of the operative team. The latter technique also permits soft tissue (e.g., tongue) to project beneath the slit portion of the dam increasing the likelihood of soft tissue damage during operative procedures. With good anesthesia, the dam can be placed quickly and effectively without disturbing the patient.

After placement of the dam, it is advisable to do the head tilt-chin thrust maneuver to keep the airway as open as possible. Depending on the depth of sedation, the patency of airway can be appropriately monitored at this point (i.e., crying, protesting clinical observation; calm, interactive pretracheal stethoscope; eyes closed, noninteractive pretracheal + capnograph).

Next, tooth preparation can begin. A good test of the patient's awareness, settled state, and reactivity is to activate the handpiece and hence it is noise without touching the tooth structure. If negative behavior is not elicited, then tooth preparation can begin. A "sensitized" child may begin to cry or react negatively to the noise and need distraction and reassurance through tell-show-do procedures. The operator should keep the chin lifted and head tilted using the nondominant hand during tooth preparation. The same procedure should be done by the operator or assistant when seating crowns or any procedure depressing the mandible which can lower the degree of head tilt. During tooth preparation and restoration, monitoring will continue, and the needed or recommended monitors will be dependent on the depth of sedation (see Table 8.5). Both the dental assistant and operator will need to be vigilant and aware of the monitors during mild-moderate depths of sedation; during deep sedation another assistant or professional trained in clinical monitoring will be necessary just to monitor the patient. The operator may cut wet or dry, but if cutting wet, the amount of water spray should be minimal and excellent high-speed evacuation of fluids performed.

During the intraoperative portion of the procedure, the monitored parameters (e.g., oxygen saturation) should be documented on a routine time basis such as every 5 min or according to sedation guidelines [1]. A good technique for time management involved in recording monitored parameters is to set the automated blood pressure cuff to inflate once every 5 min (or less frequently in a less sedated patient). When the pump of the automated blood pressure machine is activated and begins inflating the cuff, the assistant can be taught to stop when the activated pump is heard and record the parameters. If the child is uncooperative and the treatment is done under unfavorable conditions, the recorded time-based documentation can be done as soon as

Table 8.5 Monitoring as a function of behavior exhibited

Behavior	Clinical signs	Precordial	Pulse ox	Blood pressure	Capnograph
Awake, screaming, or yelling	Little tears Controlled breathing Struggling against wrap	Take earpiece out of ear Replace if patient quiets	Keep it stabilized on foot Set upper heart rate limits to >230 bpm	Keep it stabilized on the arm or leg Do not inflate and aggravate already disruptive behaviors	Not needed Use if patient becomes quiet
Mild crying	Tearing variable; eyelids open/some ptosis Sobbing, but controlled Little or no struggling	Same as above, but be ready to insert earpiece if child becomes quiet	Same as above	Keep it stabilized on the arm or leg Inflate occasionally during the procedure to determine its influence on behavior	Same as above
Quiet, but responsive (moderate)	Eyes closed; opens when requested or mildly stimulated Breathing within normal limits Occasional sobbing	Earpiece in and listening Attentive to gurgling or snoring (adjust head tilt)	Same as above Heightened awareness for incidence of desaturation (pitch)	Set on automatic mode for inflation every 5 min as behavior permits	Place probe Monitor RR
Quiet, not much response (deep)	Eyes closed or partial ptosis with possible divergent eyes; does not open upon command Breathing shallow and intermittent or infrequent rate of breathing	Same as above Maximal focus on airway sounds	Same as above Heightened awareness for incidence of desaturation (pitch)	Set on automatic cycle for inflation every 5 min	Be aware of frequency of breathing, expired [conc], and; apnea

convenient, and "patient behavior" is indicated as the major barrier preventing timely recording of vital sign parameters on the time-based record. The clinician should anticipate that the depth of sedation may increase shortly after a prolonged bout of disruptive behaviors exhausting the child.

After all procedures have been completed and hemorrhage controlled, the operator can stimulate the patient gently if the patient has been quiet until he/she is stable and interactive. For the more alert patient, reassurance that the procedure is finished and reinforcement of good behavior is beneficial. The child is alerted that the mouth has been rinsed of debris and may "feel" funny (due to local anesthesia); the child should be slowly moved from the supine to the sitting position. Too rapid a change to the sitting position may cause orthostatic hypotension and fainting. The child should be consoled and told that his parent is coming.

The operator can then temporarily leave the assistant to monitor the child, once stable, while he/she discusses the treatment with the parent. It is advisable for the operator to discuss the treatment that was accomplished, postoperative instructions, and answer questions of the parent before reunited with the child. If the parent is reunited with the child before this discussion occurs, the parent tends not to listen or remember the information because of the bidirectional emotional response of the child and parent at the time of reuniting. It also allows the parent to think and ask questions. Constant monitoring continues in the operatory or wherever the child is taken in the facility for recovery and until discharge.

In general, postoperative instructions should include how well the child tolerated the procedure, when and what he/she should eat and drink over the next day, type and dose of analgesics for

pain as needed, antibiotics as needed, and how the child should be monitored during transport. Other issues related to the dental procedures can be discussed as well (e.g., bleeding expectations, speech, and esthetic considerations).

Postoperative instructions are extremely important because they instruct the parent/guardian in regard to management of the child during the transport of the child from the treatment facilities to the home and over the next 24 h period. Although the postoperative, transport, and 24-h time period may seem minor and least important in the entire sedation appointment process, it has major implications for patient safety, especially when medical/dental personnel are not immediately available. The postoperative instructions should be given both orally and with written documentation. As a minimum, the instructions should contain information on the following:

- Information concerning the child's behavior over the next 24-h period including possible changes in sleep or napping habits (i.e., they may sleep more in the next 24-h period).
- Feeding and fluid requirements including clear liquids and soft, but favorite foods prepared in small amounts for easy swallowing (e.g., soup, mashed potatoes, scrambled eggs).
- Routine postoperative instructions related to the restorative procedures including information on bleeding from extraction sites, analgesic and antibiotic (if needed) indications, precautionary warnings about paresthesia of lips, cheeks, and tongue associated with local anesthesia.
- The child should be dressed in warm and comfortable clothing for transport.
- The child may be irritable at this point and the parent should tolerate such behavior without compromising important instructions on managing the patient properly.
- Means of carrying or transporting the child home. Ideally, two adults should accompany the child to a sedation appointment. One should manage the child and the other drive the vehicle. The child should be placed in a car seat restraint device. A second adult should pay particular attention to keeping the airway open by lifting the chin/head off the chest should the child wish to sleep on the way home.

Once home, the child should be encouraged to eat a small amount of soft foods and receive clear liquids. If he/she desires to take a nap, it is important that the child sleeps on his/her side and not in the prone or supine position, but some hydration, preferably one having sucrose content (e.g., popsicle), should be accomplished first. Pillows can be strategically placed near the belly and lower part of the back to stabilize the child as he/she lies on his/her side. The parent should monitor the child every 2–5 min for regular breathing patterns and rare vomiting episodes. Emergency telephone/contact numbers of the dentist and EMS should be available. And the parent should know the drugs and dosages that were administered.

Discharge phase does not occur until the child is stable and meets discharge criteria associated with pediatric sedation guidelines [1]. Clinically appropriate discharge criteria include the child being oriented to questions, does not fall asleep frequently and easily in the absence of any stimulation, can consume water or fluids, and vital signs are stable and appropriate for the patient's age.

It is advisable for the clinician to contact the parent later in the day or evening of the sedation appointment to determine how the child is recovering and answer any questions the parent may have. This final process extends the concept of rapport with the parent that was hopefully established on the day the parent and child first visited the office.

Conclusion

A sedation protocol that is well developed, successfully implemented into the daily clinical routine, and consistent with principles outlined in the American Academy of Pediatric Dentistry/American Academy of Pediatrics guidelines for therapeutic procedures will serve the practitioner well in minimizing adverse events in a dental office [1]. It also affords a means of analyzing outcomes for the purposes of continually improving quality assurance and risk analysis for sedation procedures.

Preoperative Instructions for Oral Sedation

As we discussed during our treatment planning conference for your child, we feel an initial, reasonable option is to provide your child with a sedative(s) given by mouth on the day of the procedure. The goal of our sedation appointments is to provide a minimally depressed level of awareness so that we can perform quality care while promoting patient safety and welfare. The sedative(s) usually cause relaxation, mild to moderate sedation, possibly some amnesia, and occasionally changes in the mood of your child. We also may use nitrous oxide (laughing gas) to facilitate the sedative's effects and provide some analgesia. The mild to moderate level of sedation refers to your child being sleepy, but remaining interactive and responsive to our voice and light physical stimulation (e.g., patting his/her shoulder). Generally speaking, these changes will aid your child and his/her interaction with us allowing a higher likelihood that we can accomplish the planned dental procedure. Also recall that mild to moderate sedation is not always successful. If the sedation is not successful, we will talk about alternative means of providing care. Your duties in optimizing the successful outcome of the sedation appointment are to follow the instructions below in preparing your child for their visit.

- Be honest with your child if he/she asks questions about the dental appointment. If you do not know the answers to his/her questions, simply say, "I do not know"…"we will ask the dentist."
  - Do not say anything that will scare your child such as "the dentist is going to give you a shot." You may have good intentions of preparing your child, but the effect may backfire! It is best to let us talk with your child during the visit. We will tell your child everything that will occur, but use language best suited for your child's age and understanding. For instance, we may refer to the shot as a "baby pinch or mosquito bite."
- Make sure your child gets a good night's sleep and is well rested.
- Be sure to tell us if your child takes any daily medication to control their behavior or other medical issues. Most likely and after conversations with you about the daily medications, we may have you give those medications before you come to our office.
- Arrive at our office at the time you were instructed. The actual sedation procedure may be 30 to 60 minutes after you arrive, depending on the sedatives that are used to sedate your child.
- We strongly recommend that you bring another adult with you to the sedation appointment. We feel it is very important for you to take care of your child when he/she is in the child's car seat and the other adult can concentrate on safely driving you home.
- We must focus solely on your child that is being sedated and ask you to do the same. Please make every effort to arrange for care of your other children so that we can attend to your child who is being sedated.
- Please feel free to let your child bring a favorite blanket or stuffed animal to the appointment if he/she is strongly attached to it.
- Dress your child in comfortable clothing, preferably a T-shirt or sweatshirt and pants. We will be attaching monitors, such as a blood pressure cuff to his/her arms. Loosely fitting clothing is preferable for that reason.
- If your child develops a cold, fever, congestion, or the flu at any time and especially 24 hours before the scheduled appointment, please call the office. We will make a decision after talking to you whether to postpone and reschedule the appointment or refer you to your child's physician.
- If your child's health changes, such as being diagnosed with a condition, problem, or disease within a week of the sedation appointment, please call the office. Also call us immediately if your child has had an injury to his/her head causing loss of consciousness, vomiting, or dizziness.
- Please let us know on the day of sedation if, within the last 24 hours, your child has taken any over-the-counter or herbal medications. This is very important to us and to your child safety.

- Make sure your child uses the bathroom before the sedation appointment begins.
- ***MOST IMPORTANT!!!*** Do not give your child any food for at least 6 hours before the scheduled appointment unless advised otherwise. This is extremely important and the child will not be treated if he/she has had any food before the sedation appointment. If the child does vomit during the treatment and has eaten food, we will be unable to complete treatment scheduled for that day and your child may have to be hospitalized.
- Clear liquids such as water, apple juice, gelatin, popsicles, and tea may be given up to 2 hours before the appointment.
- We may use different sedative agents to sedate your child than we had planned, but if you recall, we think the following may be the best sedatives for your child:
  - ☐ Chloral hydrate ☐ Meperidine (Demerol) ☐ Hydroxyzine (Vistaril)
  - ☐ Diazepam (Valium) ☐ Midazolam (Versed) ☐ Other _____
  - ☐ Local anesthetic _____ _____
- If you have any further questions, do not hesitate to call us at the office. We are here to help you with your child. Thank you.
- Our emergency number is (and this is strictly for true emergencies): 501-230-6538

*Note: We use electronic and other monitors that tell us about the oxygenation and breathing patterns of your child. We also follow the American Academy of Pediatric Dentistry guidelines on sedation for dental procedures.

Postoperative Instructions for Sedation

Today, your child received dental treatment including a sedative to help calm him/her during treatment. He/she received the following sedative and/or local anesthetic:

☐ Chloral hydrate ☐ Meperidine (Demerol) ☐ Hydroxyzine (Vistaril)
☐ Diazepam (Valium) ☐ Midazolam (Versed) ☐ Other _____
☐ Local anesthetic _____ _____

The doctor who treated your child today is: _____ _____

Each child is different and responds to sedation in his/her own way. The following guidelines may help you know what to expect after your child's sedation visit while traveling home and during the next 24 hours.

- As you know, we recommended that you bring another adult with you and your child to the sedation appointment. We feel it is very important for you to take care of your child on the way home and when he/she is in the child's car seat.
- It is important that you place your child in a car seat or safety belt during your trip home. Sometimes on the way home your child may wish to take a nap. He/she tends to nod his/her head allowing the chin to touch the chest and blocking his/her airway. Thus, it is also important that you keep your child's chin up and away from his/her chest so he/she can breathe normally. This is why it is important for you to have another adult with you to drive a car.
- When you arrived home, your child may ask to have something to eat. We recommend you start with a light meal involving a soft diet (e.g., Jell-O) or soup. Your child may be numb, and the less chewing done, the less likelihood he/she will bite the tongue or inside of the cheek.
- Give your child clear fluids such as water or apple juice. Your child has been without fluids for a long time, so make sure he/she is well hydrated.
- If your child wishes to take a nap, it is okay. Your child may sleep for two or more hours and may even be irritable for up to 24 hours after a sedation appointment. If you cannot awaken your child, please call us immediately.
- When your child is sleeping, it is important that you place him/her on his/her side. Also check every 3 to 5 minutes to see if he/she is okay and breathing. Do not let him/her lie on

his/her back or stomach. Place pillows to the back and front sides along his/her stomach and back area to keep him/her on his/her side. Do not place the pillow near your child's head.

- If your child vomits, make sure that you move your child away from any vomit and clean out his/her mouth. If your child is not breathing normally after he/she has vomited but is responding to you, call us immediately. If your child has very labored breathing, is not breathing after vomiting, and is not responding, call 911 immediately.
- If your child sleeps longer than four hours, please awaken him/her gently.
- It is best to give your child clear liquids such as water or apple juice when you get home. The first meal at home should be soft foods such as Jell-O or soup. Do not give him/her large portions of food. Do not give him/her fatty foods such as French fries.
- Your child may be unsteady when walking or crawling immediately after the sedation or when you arrive at home. Your child will need your support in protecting him/her from injury. Do not ignore him/her. An adult must be with your child at all times for at least four hours after he/she arrives home.
- We prefer that your child rests and do passive activities like watching television, playing on your iPad or other electronic tablet, or coloring. Make sure that you check on your child every 3 to 5 minutes during the day.
- Your child should not perform any potentially dangerous activities such as riding a bike, unsupervised playing outside, handling sharp objects, working with tools or toys, or climbing stairs until he/she is back to his/her usual alertness and coordination.
- We advise you to keep your child home for the rest of the day. Your child may be able to return to school on the next day.
- The following are reasons for you to call the doctor immediately:
  - You are unable to arouse your child.
  - Your child is unable to eat or drink.
  - Your child experiences excessive vomiting or pain.
  - Your child has developed a rash.
  - Your child has developed a fever.
- In case of a true emergency, call 911. Once the EMS squad is on the way, please call us immediately at the following number (and this is strictly for true emergencies): 230–6538

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Alternatives to Oral Sedation

9

Alan R. Milnes and Stephen Wilson

Abstract

Oral sedation is a wonderful adjunct in the dental treatment of anxious or fearful children. However, it is not always successful, and prudent practitioners will have other sedation techniques available to them when oral sedation fails. This chapter will review alternatives to oral sedation, all of which are within reach of the pediatric dentist. Most of the alternatives involve the administration of sedative medications via routes other than oral, thereby avoiding first-pass metabolism, the Achilles heel of oral sedation. This could include inhalational, intranasal, intramuscular, and intravenous routes of drug administration which, given appropriate didactic and clinical training and permitting by regulatory authorities, is well within the scope of practice of any pediatric dentist. Lastly, should these alternatives fail as well, a brief discussion regarding outpatient general anesthesia is included.

Oral sedation is a technique for healthy children who are anxious, fearful, or unable to cooperate for dental procedures and with no significant medical history. The success of this technique varies considerably and typically averages between 65 and 90 %. Intraoperative disruptive behaviors are key factors in categorizing failures of oral sedation as has been enumerated elsewhere in this book. This chapter offers advice on alternatives to oral sedation primarily for the healthy child.

There are two approaches to behavior guidance of children for dental procedures: (a) traditional communicative and (b) pharmacological techniques. Communicative techniques are still a necessary adjunct for managing children who are in mild to moderate levels of sedation. In this chapter, we assume that traditional communicative approaches during oral sedation have been unsuccessful.

So what are the pharmacological alternatives to an oral sedation that has failed? Alternative

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approaches include performing another oral sedation aiming at the same depth of sedation as the first sedation appointment, doing a second oral sedation increasing the depth of sedation, using another route for administration of sedatives, and performing general anesthesia. Exercising these options may be limited depending on the dentist's education, training, other resources, and licensure regulations.

The first alternative to consider is another oral sedation appointment either using the same regimen or a different regimen but aiming at the same depth of sedation (e.g., minimal sedation). The point to this approach is that the child may respond differently to sedation on another day. There is no evidence to suggest this approach will be more successful than the original failed oral sedation appointment; oddly though, experience has shown that, on occasion, this approach may be beneficial. This observation reinforces the concept that children have "good" and "bad" days under certain circumstances just as adults. Convincing the family of this approach may be difficult because the likelihood of success is unknown and a second failure may be logistically costly and unacceptable to the patient/family. And there are other alternatives.

The first (failed) oral sedation was likely targeting mild or moderate depth of sedation. Because of factors like the child's age, cognitive development, and temperament, the expected outcome may have been poor (viz., patient selection for mild to moderate sedation was probably inappropriate, but one can never predict this outcome using oral sedation). This situation is often encountered in a child who (a) is pre-cooperative (i.e., usually younger than 3 years), (b) with a temperament and personality profile suggestive of incompetence in interacting with strangers (e.g., extreme shyness), (c) moderate to extremely fearful, or (d) hyperactive and non-tolerant of prolonged procedures. In these cases, the next alternative is to consider deeper levels of sedation. *Herein lays a very important caveat. The safe management of planned deep levels of sedation requires a venue with appropriate monitoring, suction, and a well-trained, competent clinician and clinical staff who are quite capable of advanced airway and emergency management.*

Deeper levels of sedation using the oral route can be obtained using the same or other drugs as used in the first failed sedation but at a higher dose. But the oral route of drug administration for deep sedation may be challenging for several reasons including the child's memory of non-palatable taste of the oral solution and other experiences associated with the first sedation. Therefore, deeper levels of sedation may have to be achieved via intranasal (IN), submucosal (SM), intramuscular (IM), or intravenous (IV) routes. Of these routes, the only reliable one that can maintain a stable and deep level of sedation over time is IV. The advantages and disadvantages of each of these routes are described below and are summarized in Table 9.1.

Routes of Drug Administration

The primary routes of administration for sedation are (1) *inhalational*, (2) *enteral* (*e.g., oral or rectal*), *and* (3) *parenteral* (*e.g., IM, SM, IN, or IV*). In reviewing these techniques, only the primary advantages and disadvantages will be discussed briefly.

Inhalational Route: Essentially Nitrous Oxide/Oxygen (N_2O)

Advantages

The primary advantages of N_2O for sedation in pediatric dentistry are as follows.

Rapid Onset and Recovery Time

Because N_2O has very low plasma solubility, it reaches therapeutic levels in the blood rapidly, and conversely, blood levels decrease rapidly when it is discontinued.

Ease of Dose Control (Titration)

The concentration of N_2O is easily controlled as it leaves the hood of a dental inhalation unit, but the concentration of N_2O that the child inhales

Table 9.1 Routes of administration

Route	Advantages	Disadvantages	Comments
Oral	Ease of administration Inexpensive ↓incidence of adverse reactions ↓severity of adverse reactions Almost universal acceptability	Unpredictable effect NO titration Long onset and recovery time Need cooperation ↓bioavailability, first-pass metabolism	Most common in pediatric dentistry Taste issues and GI upset Expect only 70 % success for sedations
Parenteral			
Intranasal	Requires little cooperation Eliminates first-pass metabolism Relatively inexpensive Relaxed fasting requirements	Injury to nose Eyes vulnerable NO titration Liability costs and licensure	Atomizer is recommended Helps w/ obstreperous child Shorter procedures only Considered parenteral route
Intramuscular	Relatively fast absorption Technically easy to do Relatively inexpensive	Onset may be delayed NO titration Trauma to injection site Higher potential for side effects/toxicity Liability costs and licensure	Relatively fast Needle phobia Not commonly used in dentistry
Submucosal	Easy to administer for dentists Relatively fast	NO titration Tissue sloughing and trauma Potentially rapid onset Liability costs and licensure	Dentists very familiar with route Needle phobia Augment a "failing" oral sedation
Intravenous	Predictable and precise 100 % bioavailability Titration: rapid onset Emergency drug access Reversibility Overrides patient behavior Cheaper than hospital	Technically challenging Eliminates coping behaviors Rapid onset – get into trouble quickly Requires highest level of monitoring Significant training requirements Liability costs and licensure	Pediatric dentists are not trained well and consistently in this technique Pediatric-specific training lacking Works well for those who are properly trained

depends heavily on the behavior of the child. A crying child may be redirecting more N_2O into the ambient environment than inhaling into the lungs.

Technique

There are two techniques for the administration of N_2O for children. The first is known as titration and the second is referred to as rapid induction. In the titration technique, the nasal hood is described and shown to the patient and then placed over the nose of the patient. Initially, the flow of oxygen is started and administered to the patient for a few seconds before the introduction of low concentrations of N_2O. Usually the administration of N_2O starts at 20 % concentration for a few breaths and then is stepped up in 5–10 % concentration gradients. During each step, the patient takes a few breaths and the dentist monitors the patient. The patient is taken to a final level of N_2O concentration that is comfortable for the patient based on the frequent querying of the patient's status and optimal clinical signs. Typically, these signs are relaxed limbs, open and moist palms, a "distant" stare, and a facial expression suggesting a slight smile. The concentration of N_2O that elicits these responses ranges from 35 to 50 % in most children. At this point, the restorative procedures can begin.

The rapid induction technique of N_2O administration is usually reserved for children who are upset, nonresponsive to communicative interventions, and crying [1]. Often, but not always, some form of passive or active restraint of the patient is necessary before the administration of N_2O can be accomplished using this technique. Once the child is restrained, the nasal hood is held in the hands of the dentist so that the hood is positioned slightly above the face and covering the area between the nasal orifices and the mouth. The concentration of the N_2O is set at 70 %. The nasal hood is held in this place for 5–8 min, while the dentist and parent attempt to calm and distract the patient. A majority of the time a child will in fact calm down and become more responsive to communicative techniques. When the child has calmed down, the nasal hood is gently placed on the nose, and the concentration of N_2O is immediately decreased to 40–50 %. Before proceeding with the operative procedure, the dentist should establish good rapport with the patient and give the N_2O a chance to further decrease the child's emotional and behavioral responses. The rapid induction technique is often used for children who have received oral sedation. The use of N_2O at the beginning of an oral sedation cannot be over emphasized.

In a minority of these cases, the patient will not calm down within the 5–8 min period. In this case, the technique has failed and should be terminated. Other options of managing the patient should be discussed with the parent.

Combining oral sedation with N_2O has become a common technique in pediatric dentistry. Leelataweewud et al. [2] have shown that when N_2O was added to the triple combination oral sedation, behavior scores improved over that afforded by the triple combination alone and the depth of sedation increased. This is an important point to remember. Adding more sedative agents into the mix will result in a deepening of the sedation level achieved. Practitioners must be prepared for this.

Lack of Serious Adverse Effects

N_2O is considered to be inert and nontoxic when it is administered with adequate oxygen. The most commonly encountered side effect is nausea, which actually occurs rarely unless high concentrations of N_2O are used. Poor technique with high concentrations may also result in an excitement phase, in which the patient may temporarily become uncomfortable, uncooperative, and delirious.

Disadvantages

The use of N_2O in pediatric dentistry also has several disadvantages.

Weak Agent

Attempts to increase the concentration of N_2O to control moderately to severely anxious patients may be fraught with failure; however, trying to overwhelm the uncooperative, crying child with "hood over mouth," is a worthy effort albeit only for a period not to exceed 10 min. So in order to "settle" the disruptive youngster, raising the N_2O concentration to 70 % for a 5–10 min period is not contraindicated. Once the child does begin to settle, then the N_2O concentration should be adjusted to 50 % concentration or less.

Lack of Patient Acceptance

There are some patients (adults and children) who do not find the effects of N_2O pleasant. Often the patient complains of being out of control and smothered or is claustrophobic. These patients may become overtly noncompliant, remove the nasal mask, or otherwise aggressively act out.

Inconvenience

In some areas, such as the maxillary anterior teeth, the use of N_2O nasal mask may hinder working in the area. This may be a problem especially in small children.

Potential Chronic Toxicity

Some evidence suggests dental office personnel who were exposed to trace levels of N_2O suggest a possible association with increased incidence of spontaneous abortions, congenital malformations, certain cancers, liver disease, kidney disease, and neurological disease [3, 4]. These

associations underscore the necessity of scavenging (removing) waste gases adequately from the dental operatory. It should be noted that it can be difficult to scavenge N_2O adequately in the uncooperative child because gases that are exhaled through the mouth cannot be scavenged effectively.

Potentiation

Although N_2O is a weak and very safe agent when used with oxygen, deep sedation or general anesthesia may occur if N_2O is added to the effects of other sedative drugs. The combination of N_2O with any other sedative must be undertaken carefully by an individual who has the proper training and experience with deeper levels of sedation.

Equipment

N_2O equipment is expensive. The delivery system must be checked for proper function when installed and before all applications.

N_2O analgesia is relatively safe and effective for the treatment of children in the dental office. It is useful for decreasing mild levels of anxiety and is indicated for patients who have the capacity to be compliant and follow instructions during N_2O administration. Children who have nasal obstructions or are uncooperative when directed to breathe through the nose are poor candidates for N_2O administration. The analgesic properties of N_2O help raise the pain threshold and may be used to lessen the discomfort during a local anesthetic injection. But N_2O will not eliminate the need for local anesthetic pain control in most children except for very minor dental procedures (e.g., small class I or V preparations).

N_2O changes the patient's perception of the environment and the passage of time, thus aiding in managing children with short attention spans. This mild dissociation may be perceived by some children as unpleasant, in which case the level of N_2O should be decreased or discontinued.

A liter flow rate should be established first with 100 % oxygen. An adult usually requires 5–7 l/min, whereas a 3-to 4-year-old will typically require 3–5 l/min. While adjusting the controls, the dentist should use the "tell-show-do" technique with terminology appropriate for the age level of the child (e.g., "smell the happy air"). The nosepiece should be introduced with instructions to breathe nasally. Very young children may have difficulty understanding this directive.

After stabilization of the nosepiece and delivery of 100 % oxygen for 1–3 min, the N_2O level should be increased to 30–35 % and administered for 3–5 min for the induction period. While administering the N_2O, the dentist should talk gently to the child to promote relaxation, reinforce cooperative behavior, and establish rapport. N_2O concentration may be increased momentarily to levels that exceed 50 % during local anesthetic injections but should be returned to 50 % concentration or less especially when other sedative agents are being used.

Oral Route

A route of administration used commonly for sedation in pediatric dentistry is oral premedication. In fact the oral route may be considered the most common means of drug administration in children by professionals and parents. This route of administration and various drug regimens is discussed in more detail in Chaps. 4 and 6.

Advantages

Convenience

Usually oral drug administration is easy and convenient, especially if the medication tastes good and can be delivered in low volume. The drug may be given at home or in the office *depending on the classification of drug used and the unlikely event that unconsciousness will occur*. Giving it in the office has the advantages of supervision (to be certain that the proper dose is given at the appropriate time) and medicolegal safety. Usually it is best to administer oral premedications in a separate quiet, dimly lit room with a soft chair or rocking chair, where induction of sedation can be facilitated by the parent in a more conducive environment.

Economy

To administer oral premedications, no special office equipment needs to be purchased or maintained. However, special equipment is needed to monitor patients under sedation as specified in the *Guidelines of AAPD/APP*.

Lack of Toxicity

If therapeutic doses are calculated for each individual patient and single drugs are used in single doses, the oral route of sedation is relatively safe. However, if drug combinations are used or if two routes are combined (e.g., oral premedication followed by intravenous or inhalational medications), the chances of adverse side effects increase.

Disadvantages

Variability of Effect

The biggest disadvantage of oral premedication is the fact that a standard dose must be used for all patients on a weight or body surface area (BSA) basis. Individuals of the same weight (or BSA), however, may respond quite differently to the same dose of drug, depending on many variables. Absorption of the drug from the gastrointestinal tract can be altered by several factors, such as the presence of food, autonomic tone, fear, emotional make-up, fatigue, medications, gastric emptying time, and first-pass metabolism. The patient may not cooperate in ingesting the medication or may vomit, making impossible the estimation of the dose consumed If an inadequate dose has been given, a paradoxical response may be seen, which may be due to a direct effect or loss of emotional inhibitions. The patient may become agitated and more uncooperative rather than sedated and cooperative. These factors make the oral route of administration least dependable as far as certainty of effect is concerned. A second dose of oral medication to offset a presumably inadequate dose should never be given. Titration is not possible or safe with oral medication. If absorption of the initial dose has been delayed for any reason and a second dose is subsequently given on the assumption that the first dose was ineffective, both doses will eventually be absorbed, possibly resulting in a high serum level of the central nervous system (CNS)-depressant drug. This situation may lead to possible serious consequences such as respiratory arrest, cardiovascular collapse, and death.

Onset Time

Oral drug administration has the longest time of onset of any route of drug used for sedation. The lag time varies from 5 to 90 min depending on the drug.

Oral premedication is very useful in pediatric dentistry, but its limitations must be clearly understood. An adequate dose must be given, and enough time elapsed for absorption to take place before the desired effect can be expected.

It should be noted that for all parenteral routes (i.e., IM, SM, IN, and IV), the dose of the drug administered is lower on a milligram per kilogram basis than that of the oral route. Thus, the clinician must be cautious and use only therapeutic and recommended doses for these routes.

Intramuscular Route

The IM route of drug administration involves injection of the sedative agent into a skeletal muscle mass. It also involves certain advantages and disadvantages when used in pediatric dentistry (Table 9.1). Its use in pediatric health care has been primarily a precursor route for sedative administration prior to intravenous catheter placement or induction of general anesthesia.

There are very few studies of this route of sedative drug administration in pediatric dentistry which demonstrate its efficacy and success. And those which have been completed have involved very small numbers of patients.

Advantages

Absorption

Absorption from an injection deep into a large muscle is much faster and more dependable than absorption from the oral route.

Technical Advantages

Technically, the IM of administration might be considered the easiest of all routes. It requires no special equipment except a syringe and needle. Patient cooperation is required for the oral route of administration, sometimes making it very difficult to give a full dose of a bitter-tasting medication to an uncooperative child. When IM medications are administered, little or no patient cooperation is required, and the full calculated dose is given with a high degree of certainty. Even when a child requires restraint, IM injections are easier to accomplish technically than placement of an IV cannula.

The muscle of a child that can be used for IM technique of sedative medications is usually limited to the lateral aspect of the vastus lateralis of the thigh. The upper, outer portion of the thigh is gently squeezed between the thumb and fingers of the nondominant hand to slightly raise the muscular tissue and tense the skin. A syringe containing the sedative mix and a 23 gauge needle affixed to the syringe is used. The needle is inserted into the tissue gently but with a slight jabbing motion to the depth of approximately 3/4ths the length of the needle to ensure the muscle has been penetrated. The solution is rapidly expressed and the needle is removed. Slight pressure over the area with a 2×2 gauze is necessary for hemostasis. Usually the effects of the sedative mix become clinically obvious within 10–15 min.

Disadvantages

Onset

Absorption of the injected drug can be decreased or delayed by several factors. A patient who is cold or very anxious may experience peripheral vasoconstriction in the area of the injection, significantly decreasing the rate of absorption. Perhaps the biggest variable in onset is related to *where* the drug is actually deposited. If the drug is deposited deep into a large muscle mass, the high degree of vascularity will allow quite rapid uptake. If, however, some or the entire drug is deposited between muscle layers, onto the surface of the muscle, or not in the muscle at all (all distinct possibilities in small, struggling children), absorption may be quite unpredictable.

Effect

As with the oral route, a standardized dose is used that is based on the patient's weight or BSA. Drug effect cannot be titrated safely by administering additional doses for much the same reason as that described for the oral route, that is, the possibility of cumulative overdose. A standard dose may have little or no effect in some children, whereas it may sedate others heavily.

Trauma

Injection sites that are devoid of large nerves and vessels are used for IM injections, such as the mid-deltoid region, the vastus lateralis muscle of the thigh, and the gluteus medius muscle. Proper selection of the injection site and proper technique should minimize the possibility of tissue trauma.

Intravenous Access

The potential for more rapid onset of side effects and toxicity is higher with the IM route than with the IN or oral route. Compared with the IV route, a major disadvantage of the IM route is the lack of access (an IV catheter) in the event of a medical emergency.

Liability Costs

Malpractice insurance carriers charge a higher premium for dentists who administer parenteral sedatives in the dental office. In addition, many state dental practice acts have established requirements for permits for dentists who administer parenteral medications.

Submucosal Route

The SM route of administration is another route that has been more popular in previous decades than today. Like the intranasal route, the dose of an agent administered submucosally is less than that of the oral route. Also, the agent must be nonirritating to tissues. The traditional location for the submucosal route of administration is in the

buccal vestibule just between the 1st and 2nd primary molar of children. This injection is similar to that of local infiltration of local anesthetic to anesthetize the 1st primary molar. There is a fairly large venous complex in the pterygoid fossa of children, and thus, needle entry into the buccal mucosa pointed distal to the 2nd primary molar or maxillary tuberosity (i.e., similar to the posterior superior alveolar injection of local anesthetic) is highly likely to produce IV administration of a fairly large bolus of sedative and thus contraindicated. Care must be taken when the child is struggling not to insert the needle too far distal and increase the chance of rapid uptake. Agents such as meperidine when injected into this venous-laced area can result in respiratory depression, apnea, and hypotension. When properly administered, the onset of sedative agents occurs fairly rapidly (e.g., 10–15 min). Typically the SM injection is done with a tuberculin syringe and ultra-short needle. The disadvantage to this technique is that in many cases, the child is already fearful of needles and must now receive two injections in the mouth (i.e., sedative followed by the local anesthetic) although the local anesthetic injection if withheld until sedation effects are prominent. Hence, disruptive behavior can be an issue and is often resolved by gaining consent for the use of protective stabilization during this type of sedative administration. Another approach is to hide the tuberculin syringe which is smaller and less obvious than a local anesthetic syringe. But once the agent is being administered, it should be expected that the patient will begin struggling and crying because many sedative agents cause a burning sensation (e.g., meperidine). Meperidine can also cause localized release of histamine causing a red inflammatory wheal over the malar bone and area of injection. Significant pruritus is also notable requiring light rubbing of the area to counter the itching effect. If the child is in a papoose board or otherwise restrained, the itching can be a significant source of disruptive behavior.

Several studies have shown successful sedation can be achieved via the submucosal route. Pandey et al. [5] in a blinded randomized crossover trial of 23 children compared oral midazolam (0.5 mg/kg) alone to the same oral dosage of midazolam with addition of a submucosal injection of fentanyl (3 micrograms/kg). The combination of midazolam and fentanyl was statistically significantly superior to oral midazolam alone for completion of dental treatment although four children in the combination group did suffer transient desaturations which were readily corrected by changes in head position.

Myers et al. [6] have demonstrated that submucosal administration of midazolam can augment a failing sedation. In their study, in which children had received chloral hydrate (50 mg/kg) prior to dental treatment, submucosal injection of midazolam at 0.2 mg/kg deepened the sedation and improved behavior such that planned treatment could be completed. The advantage to this approach is that polypharmacy was avoided until a child demonstrated that the sedation with chloral hydrate alone was failing.

Advantages

Site

For dental procedures, some drugs may be injected SM within the oral cavity, usually into the buccal mucosa between the 1st and 2nd primary molar (similar to local anesthesia associated with posterior alveolar infiltration). This may be less objectionable to some patients and parents than other injection sites, and it may be more comfortable and convenient for the dentist to perform. Onset of clinical signs of sedation can be appreciated within 10 min or less after administration. *NOTE*: *The placement of the needle distal to the 2nd primary molar and directly posterio-superiorly is not advisable as a large venous complex usually is present in this location in children. Too rapid of an uptake of some medications following injection into this venous complex can cause rapid onset of respiratory depression and/or hypotension depending on the sedative agent used.*

Disadvantages

Technical Disadvantages

The rate of absorption is generally slower with the SM route than with the other parenteral

routes. Blood supply to the subcutaneous tissue often is sparse compared with muscle. Within the oral cavity, however, vascularity is abundant, and absorption is seldom a problem. SM injections can have an extremely rapid onset of action when the drug is injected in a highly vascularized area.

Tissue Slough

Because the drug is deposited close to the surface of the skin or mucosa, the possibility of tissue sloughing is present. For this reason, only nonirritating substances should be given SM, and large volumes of solution should not be injected.

Liability Costs

Administration of parenteral medications increases the costs of malpractice coverage and may be subject to state dental laws that require permits for the use of parenteral sedation.

Intranasal Route

The IN route, especially of midazolam, has gained in popularity over the last few years. Several publications have suggested that it is at least as effective as sedatives administered orally and often more reliable and superior to the effects seen with oral sedation [7, 8]. Initially tuberculin syringes without the needle attached were used to administer drops of midazolam. Sometimes this method resulted spillage around the nostrils. Transient pain from intranasal administration of agents is a common phenomenon. In recent years, a mucosal atomizer device (MAD – http://www.lmana.com/pwpcontrol.php?pwpID=6359) placed on the end of the tuberculin syringe to produce a fine, sprayed mist has become popular because it minimizes discomfort and distaste for the patient while facilitating intake.

With this device, pressure on the syringe plunger causes the liquid in the barrel of the syringe to be vaporized into tiny droplets that reach the nasal mucosa where the drug is absorbed. The use of the MAD also facilitates the physical administration of the agent as the device seals the nostril in young children leading to less spillage and likelihood of damage to the mucosal lining of the nostrils. The use of a syringe without a MAD can result in runoff from the nose to the eyes or a significant bolus that runs through the nasopharyngeal area and is swallowed. Each nostril can hold about 1 mL delivered by the MAD before runoff occurs as a liquid with its attendant taste issues. Antonio et al. [9] suggested pretreating each nares with 0.5 mL of 2 % lidocaine via the MAD to avoid the discomfort associated with IN drug administration. Should the practitioner choose to do this, the amount of local anesthesia administered must be included in the calculation of the maximum dosages of local anesthesia the child can safely receive.

IN administration of many sedative agents can be achieved. Certain agents such as chloral hydrate would be contraindicated because of its thicker consistency and extreme mucosal irritation. Generally speaking, the dose of agents administered intranasally is lower than that of the oral route. For instance, mild to moderate levels of sedation can be achieved with 0.5 mg/kg of midazolam when administered orally; however, the recommended dose for the IN route to obtain a similar effect is 0.2–0.3 mg/kg. Like most parenteral administrative routes, the onset of effects from intranasal administration of drugs is more rapid than the oral route. As an example, midazolam given intranasally can result in observation of effects within 5 min of administration, whereas 10–15 min passes before the same effects can be observed via the oral route. The IN compare to the oral route also can produce a higher incidence of adverse events due to the more rapid rise in blood concentrations and availability of the agent.

Advantages

The advantages of the IN route are significant. IN requires little cooperation on the part of the child and eliminates the likelihood of the child spitting out the drug solution. Absorption is rapid through the nasal mucosa involving almost 100 % uptake without first-pass metabolism in the liver. Therefore the onset is rapid (i.e., usually 5–10 min) and the dose must be lowered to prevent overdosing effects. Technically, the procedure is relatively simple. In addition, Heard et al.

[8] have shown that reversal agents can also be administered intranasally if required with an effect similar to that of IV administration.

Disadvantages

The cost of the syringes and atomizer is reasonably low. The eyes must be protected from inadvertent spillage or spray. Even on a fairly uncooperative child, care must be taken not to injure the nasal alae and septum occurring during the movement of the head during administration.

Efficacy

Several studies have been published recently comparing oral sedation to IN sedative administration or comparing IN administration of various sedative agents [7, 10–19]. The results have been somewhat mixed. Heard et al. [13] found that oral midazolam alone resulted in a superior sedation to IN administration of midazolam alone, IN midazolam plus oral transmucosal fentanyl citrate (the fentanyl patch) and IN administration of both midazolam and sufentanil. In fact, PO midazolam in this study had half as many failures as the combination of IN midazolam and sufentanil, a somewhat surprising result. Bahetwar et al. [11] showed that IN ketamine alone (6 mg/kg) or IN midazolam (0.2 mg/kg) plus IN ketamine (4 mg/kg) resulted in much more successful sedations than IN midazolam (0.3 mg/kg) alone.

Intravenous Route

The IV route is the optimal and ideal route for administration of sedation. In fact, the American Society of Anesthesiologists (ASA) discourages oral sedation protocols, especially for children, and states in the 2002 publication "*Practice guidelines for sedation and analgesia by non-anesthesiologists*" that "intravenous administration of sedative and analgesic medications increases the likelihood of satisfactory sedation for both moderate and deep sedation. They also agree that it decreases the likelihood of adverse outcomes."

Advantages

Titration

Among the enteral and parenteral routes, only the IV route allows titration to a desired effect. Because drugs are injected directly into the blood stream, absorption is not a factor. Within a few circulation times, the IV drugs will exert their maximal effect. Small, incremental doses should be given over a relatively short period of time until the desired level of sedation is achieved, thus avoiding under- or overdosing with a standardized single bolus dose, as is necessary with oral, IM, or SM injections. The primary advantage of IV sedation is the ability to achieve, firstly, a baseline level of sedation and then, secondly, maintain the patient in a "therapeutic window," wherein small doses of sedative and/or analgesic agents can be administered as needed to maintain the desired level of sedation. It is possible to predictably increase or decrease the depth of sedation during treatment depending on the patient's response and the procedure being performed. Furthermore, since treatment appointments may last considerable lengths of time, titrating short-acting agents when needed during the appointment will provide optimal benefit to both the patient and practitioner. For example, if a painful extraction is anticipated at some point during the appointment, administering an IV analgesic several minutes before the extraction will ensure the maximal effect of the drug and optimize patient comfort. There is a time savings benefit to this method once the IV line is established. This can be thought of as giving the correct drug at the correct time.

Additional advantages of IV sedation include significantly lower cost than treatment under general anesthesia in either a hospital or surgery center. Also, commonly used drugs during IV sedation are sedatives and analgesics (i.e., benzodiazepines and opioids) that can be rapidly reversed with an appropriate antagonist. In the

event of a medical emergency, administration of emergency drugs is almost always best accomplished through the IV route. Establishing IV access after an emergency has occurred can be very difficult and can consume precious time.

Test Dose

With the IV route, a very small initial test dose can be administered, and a short period of time is allowed to pass to observe for an allergic reaction or extreme patient sensitivity to the agent.

Disadvantages

Like any technique used in dentistry, there are disadvantages to IV sedation. Establishment of IV access (venipuncture) is technically a difficult skill. Like any skill requiring hand-eye coordination, mastering venipuncture requires significant training and practice. Inadvertent rapid administration of sedative and/or analgesic agents may lead to an exaggerated effect in a shorter period of time placing the patient into a deeper than intended level of sedation.

An additional disadvantage of IV sedation for pediatrics is the need to induce at least a moderate level of sedation and often deep sedation. This is especially true for younger children and children who are mentally challenged. While it is clear that many other sedation methods employed in pediatric dentistry can and often do induce deep sedation, the speed at which deep sedation can occur during IV sedation, unless exquisite care is taken to both monitor patients and titrate sedative agents, can be concerning and potentially catastrophic.

Potential Complications

Because potent drugs are injected directly into the blood stream, the IV route carries an increased potential for complications. Extravasations of drug into the tissues, hematoma formation, and inadvertent intra-arterial injections are possible complications of a misplaced IV catheter. Thrombophlebitis is a rare complication that may be attributable to the IV cannula or drugs. Treatment is usually palliative as the inflammation resolves with time. Warm, moist compresses may be applied for palliation.

If the medication is injected too rapidly, exaggerated effects may be produced. An immediate anaphylactic allergic reaction will become life-threatening more rapidly if it is due to an IV bolus of a drug than if it is due to an oral or intramuscular dose. These complications should be all avoidable by using a test dose and a proper, careful technique.

Although agitation, delirium, or combativeness is common upon emergence from general anesthesia, these complications can occasionally occur after sedation as well. Many children are upset with the feeling of numbness after local anesthesia administration. Some children react negatively to the restriction caused by placement of a papoose board especially if it is too tight. Significantly, a papoose which is too tight may restrict respiratory efforts resulting in hypoxia in a sedated child. A final reason for agitation during or after sedation is the urge to urinate. Although this may not be an issue with very young children, older children who do not wish to soil themselves will be become quite agitated in their attempts to prevent urination while sedated. For that reason, all patients who are to be sedated should be invited to visit the bathroom prior to initiating treatment.

Patient Monitoring

Because of the previously discussed increased potential of developing complications rapidly, the patient receiving IV sedation requires the highest level of monitoring.

Liability Costs

The liability costs are considerably higher than those for oral administration. With the additional monitoring and the armamentarium required, IV sedation is considered by many to be cost prohibitive for the routine practice of general dentistry.

Parenteral routes can usually result in faster onset of effects and potentially deeper levels of sedation. An understanding of the pharmacology including pharmacokinetics and pharmacodynamics by any route is paramount. Furthermore,

compliance with sedation guidelines for these deeper levels of sedation becomes a significant consideration.

Part of the consideration of deeper levels of sedation is practitioner competency and desire to start an IV line to maintain compliance with sedation guidelines associated with deep sedation. Also, deeper levels of sedation require, in addition to the potential need and use of an IV line, considerations of more stringent monitoring (e.g., the use of a capnograph), other equipment issues, and more detailed documentation of the procedure. If these considerations are uncomfortable for the practitioner, reliance on other practitioners, if available, can be discussed with the family. For instance, medical or dental anesthesiologists can provide in-office parenteral techniques (e.g., IV route) or even general anesthesia. To collaborate with these professionals, the practitioner must be knowledgeable and compliant with the state practice act regulating this type of pharmacological management and delivery of care (e.g., office inspection). Furthermore, the practitioner's training and experience with other professionals to include knowledge of the anesthetist's training and competency in delivering dental care under general anesthesia or deep sedation is necessary.

Similarly, deep sedation can be done in an outpatient surgical center or hospital. Under these circumstances, the practitioner will have to consider the issues of time away from the office, obtaining medical staff privileges and credentialing at the facility, familiarity with hospital and OR protocol, significant cost to the family, and risk for the patient.

Efficacy

Unlike pediatric medicine, there are few published studies evaluating intravenous sedation for the provision of dental treatment. The fact that training in intravenous sedation is essentially absent from advanced pediatric dental training programs likely accounts for this void. Those that have been published have used a dedicated and trained provider, either a dental anesthesiologist [20], certified registered nurse anesthetist [21], or a medical anesthesiologist [20, 22–24], to both administer medications and monitor the patient. Milnes et al. [25, 26] have published a case series of 153 children in which the dental provider worked with critical care registered nurses with sedation training, a team composition similar to that utilized in oral surgery practices, to both deliver sedation and dental treatment. Although success was high, there was still a small cohort of children who struggled during treatment indicating that perhaps a deeper level of sedation or general anesthesia was required to achieve patient cooperation.

General Anesthesia

The third major alternative is to provide oral health while the patient is under general anesthesia whether in the office of the practitioner, outpatient surgical center, or hospital. The following is a series of procedures essentially constituting a standard of care for general anesthesia.

Typically, general anesthesia cases in the operating room involve a "clean" technique. A "time-out" is done to confirm the right patient is identified, the nature of the procedure to be done, and other important patient information (e.g., patient weight and allergies). The patient is usually prepared and draped in such a manner that the body is covered by a sterile sheet, the eyes protected by tape or goggles, and the hair removed from the field using a towel to wrap the head in a turban. Monitors include pulse oximeter, capnograph, automated blood pressure cuff, EKG, and a temperature probe. Often a nasotracheal (and less often an orotracheal) tube is inserted to maintain and protect the airway and stabilized to prevent dislodgement. An IV line is started and stabilized.

Once anesthetized, fully prepared, the safe performance of the dental procedure can begin. Usually the first part of the procedure involves a thorough examination of the mouth to include soft tissues and teeth. Radiographs are exposed (if not taken previously in the office) and read before a final diagnosis and treatment plan are

developed. Once a plan is formulated, the dentistry can be completed. A moist throat pack, usually involving a moist 4×4 RayTech sponge or a shortened vaginal pack, is folded and draped around the hypopharynx and intubation tube to further protect the airway. Floss tied to the end of the pack and extending outside of the mouth is recommended as a reminder to remove the pack after the procedure. If left in place, significant airway blockage will occur during emergence from the GA. Restorative procedures require a rubber dam. Extractions and other surgical procedures require the need for hemostasis and adequate protection of the tissues (e.g., suturing and periodontal packs) prior to completion of the case and reemergence from general anesthesia.

When the procedures are completed and the oral cavity is fully suction and cleansed, the moist throat pack is removed. This is an important step that must be done for patient safety. All of the "counts" of sponges and dental-related items (e.g., wedges, rubber dam clamps) placed out on the surgical tray at the beginning of the procedure are visualized and verified (i.e., nothing is left in the mouth that shouldn't be there). A "final timeout" is done to indicate what procedures were completed and, importantly, where any surgical or extraction sites are located. The anesthesiology team will then begin emerging the patient from the general anesthesia.

A postoperative conference is usually conducted, while the child is emerging from general anesthesia. During this conference, it is necessary to provide postoperative instructions for the parents including follow-up information as well as any specialized information on oral hygiene, analgesics, diet, and oral care associated with the procedure.

Education and Alternative Routes of Sedative Administration

Many children and some adults need pharmacological management for invasive dental procedures. Among this group of patients are subsets that will not be able to endure dental procedures unless deeply sedated or generally anesthetized. General and pediatric dentists traditionally have not been trained in deep sedation techniques and management despite the fact that oral sedation regimens, especially those using polypharmacy, may inadvertently lead to deep sedation. Furthermore, there are more patients requiring deeper levels of pharmacological management than there are providers who can safely perform this depth of sedation in meeting the dental needs of these patients, especially under current reimbursement models. The argument that pediatric dentists, as a specialty, should be trained in deep sedation similar to that provided in oral and maxillofacial surgery programs carries considerable weight in light of changes noted in modern parenting and child behavior not to mention increased patient safety.

At the time of this writing, indirect evidence suggests training programs increasingly are experiencing a significant shortage of qualified faculty to teach any form of sedation let alone an advanced technique like IV sedation. As pointed out in Chap. 12, opportunities for training in moderate to deep sedation through continuing education are limited; and training in anxiety and pain management specifically using parenteral routes for dental students is almost nonexistent. Fortunately, some general practice residency programs have incorporated education and training in IV sedation as a core competency. However, these programs are almost exclusively targeting adult patients not children.

In medicine and nursing, physicians and nurses receive training and hands-on experience in parenteral drug administration. Many physician and nursing specialists (e.g., emergency room, intensivists, hospitalists, radiologists, gastroenterologists) sedate children yet have no formal or informal training in general anesthesia. They often provide deep sedation using drugs such as propofol and/or ketamine that are considered restricted drugs in dentistry, that is, restricted to those with training in general anesthesia. Medicine, for the most part, has handled this by requiring those providing deep sedation to acquire core sedation competencies (http://www.pedsedation.org/wp-content/uploads/2014/01/SPS_Core_Competencies.pdf). Perhaps, the time

has arrived wherein residency programs teach the necessary core competencies to all pediatric dental residents equivalent to that of oral surgeons, assuming an operator-anesthetist model will continue to prevail in dentistry.

Summary

Sedation of children for dental procedures using the oral route of administration is the most common pharmacological technique employed other than nitrous oxide inhalation. Unfortunately, its success rate for minimal to moderate sedation levels is limited and ranges from 65 to 90 %. Other routes of administration of sedative agents and deeper levels of sedation are alternatives to oral sedation. Limitations in the practitioner's training and experiences in the use of these alternatives are not uncommon. Hence, the services of other providers such as anesthesiologists in collaboration with the primary care dentist are needed for pharmacologically managing the dental needs of children who cannot be managed with oral sedation. Financial costs, monitoring needs, and medicolegal risk usually increase in these situations and must be appropriately considered.

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Deep Sedation and GA

10

Steven I. Ganzberg

Abstract

The use of deep sedation and general anesthesia (DS/GA) to permit the completion of high-quality dental care for young children and patients with intellectual, emotional, or physical challenges is recognized as indispensable for a subset of these patients. The combination of behavioral techniques, minimal and moderate sedation, and even prolonged restraint, which some practitioners still provide, is not uniformly successful in achieving dental surgical goals. DS/GA can be safely provided in the dental office, ambulatory surgery center, or hospital provided that well-trained anesthesia providers are utilized. Airway management can include intubated, laryngeal mask airway (LMA) or natural airway techniques in any of these venues. Either dentist or physician anesthesiologists can be used; however, only dentist anesthesiologists have specific training requirements in office-based anesthesia management. In some states where it is legal, certified registered nurse anesthetists can also provide anesthesia in the dental office. It is critical for the pediatric dentist to understand what the pediatric anesthesia training is between these various providers and to ensure that emergency protocols are well thought out and prepared for by the anesthesia provider. Fortunately, the safety record of office-based anesthesia by well-trained dentist and physician anesthesiologists is exemplary allowing cost-effective care for these children with special needs.

Introduction

Arguably, the greatest challenge in the treatment of the pediatric dental patient is managing the behavior of young children while providing intraoral injections and invasive procedures. It should be appreciated that dentists who treat children routinely provide invasive procedures that would

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rarely be provided by physicians without the aid of general anesthesia. For instance, ENT surgeons routinely take children who require frenectomy to the operating room for general anesthesia. Pediatric dentists are specifically trained in behavioral techniques and often are impressive in accomplishing treatment goals without pharmacologic adjuncts. When needed, sedation with nitrous oxide in oxygen with or without oral sedatives further improves the proportion of patients that can be managed without deep sedation or general anesthesia. Some children, however, require advanced pain and anxiety control measures to complete even routine dental care.

Indications for Deep Sedation/ General Anesthesia

Deep sedation and general anesthesia (DS/GA) are commonly required for completing high-quality pediatric dental care. Several indications for DS/GA of children requiring dental or oral surgical care are recognized (see Table 10.1). Pre-cooperative children (<4 years old) requiring other than minimal minor dental treatment as well as children <7 years old with extensive dental needs comprise a large group of these children. Even when moderate sedation has been utilized for these patients, it is not uniformly successful in achieving either behavioral or procedural goals. This is true of both oral and parenteral routes of administration. Further, when multiple appointments requiring moderate sedation for dental treatment are needed, it is not uncommon for children to decompensate at a second or third sedation appointment before all treatment has been completed. DS/GA then frequently becomes necessary. Older children with emotionally traumatic dental/oral surgical experiences in the past may have extreme anxiety regarding dental treatment and require DS/GA. This includes post-cleft lip/palate surgery patients who are very apprehensive about any oral procedures and many special needs patients.

Table 10.1 Partial list of children potentially in need of general anesthesia

Pre-cooperative children <4 years old
School-aged children with extensive dental needs whose behavior makes treatment completion unlikely
Children who decompensate following one or more minimal or moderate sedation appointments
Older children with extreme dental anxiety, usually due to past negative dental experiences
Patients with special needs (e.g., cleft lip/palate, intellectual disability, etc.)
Patients with inability to achieve adequate local anesthesia
Children with extensive dental needs in rural areas with few dental resources
Significant oral surgical procedures
Children whose parents want to avoid restraint to complete dental treatment
Children whose parents want to prevent negative early dental experiences

Some social/societal constraints lead to indication for DS/GA. Patients living in rural areas with limited access to care and with extensive dental needs may not have transportation options for several dental appointments. Alternatively, parents taking extensive days off work may be a significant economic hardship placing them in the difficult dilemma of choosing to provide food or other necessities for their family or taking time off for multiple dental visits in a faraway city. Certainly, some oral surgical procedures may require DS/GA for optimal surgical results. Many parents view early dental surgical experiences as very stressful for their children. In an effort to maintain a positive long-term dentist-child relationship, they opt for DS/GA for early age dental care relying on later long-term rapport building during examinations and dental cleanings. Lastly, inadequate local anesthesia for painful teeth requiring extraction or endodontic procedures presents yet another indication. This provides a partial list of common indications for DS/GA.

Definitions

The AAPD definitions of deep sedation and general anesthesia are listed in Boxes 10.1 and 10.2. These are very similar to the ADA definitions but have some added explanations which help amplify some critical points. Some details,

Box 10.1. AAPD definition of deep sedation [1]

"Deep sedation" ("deep sedation/analgesia"): a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully after repeated verbal or painful stimulation (e.g., purposefully pushing away the noxious stimuli)[a]. The ability to independently maintain ventilatory function may be impaired. Patients may require assistance in maintaining a patent airway, and spontaneous ventilation may be inadequate. Cardiovascular function is usually maintained. A state of deep sedation may be accompanied by partial or complete loss of protective airway reflexes

[a]Not simply reflex withdrawal (au)

Box 10.2. AAPD definition of general anesthesia [1]

"General anesthesia": a drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. The ability to independently maintain ventilatory function is often impaired. Patients often require assistance in maintaining a patent airway, and positive pressure ventilation may be required because of depressed spontaneous ventilation or drug-induced depression of neuromuscular function. Cardiovascular function may be impaired

however, still require clarification. Deep sedation is a state of consciousness that lies between moderate sedation and general anesthesia. In its most common form, as is typically provided in oral surgery offices where the technique was actually developed, baseline moderate sedation is provided with benzodiazepines and opioids followed by administration of small doses of short-acting intravenous general anesthetic drugs intended to produce short periods of unconsciousness. The patient is then allowed to slowly regain consciousness until they reenter a state of moderate sedation. At this point, if necessary, additional small doses of general anesthetic agents are administered to bring the patient back to a state of light general anesthesia, and this cycle repeats itself throughout the procedure. Because there are periods of light general anesthesia, risks such as pulmonary aspiration of blood, irrigation fluids, dental items, or emesis as well as laryngospasm can occur. These are the same risks that can occur when intended oral moderate sedation progresses to deep sedation. The patient becomes unconscious, airway support is usually needed, and the patient responds to deep painful stimulation with only partial or minimal arousal. According to ADA Guidelines, no treatment should be provided by moderate sedation providers until the patent returns to a state of moderate sedation to minimize the serious complications noted above.

When profound local anesthesia of a surgical site can be obtained, as for most dental surgical procedures, it is possible to maintain a state of deep sedation or what has perhaps been more accurately termed "ultralight general anesthesia" in which unconsciousness is maintained unless a deeply painful stimulus occurs. The inclusion of high-quality local anesthesia allows administration of smaller amounts of intravenous general anesthetic agents since minimal surgical stimulation and patient arousal occur. General anesthesia is a state where the patient is continually unconscious and unresponsive to surgical and other stimuli even without local anesthesia.

Techniques of Deep Sedation/ General Anesthesia

The airway is of primary concern in anesthesia practice, and techniques of general anesthesia are frequently classified as to the type of airway control that is provided. The three main types of airway management include endotracheal intubation, laryngeal mask airway (LMA), and "open airway." Open airway refers to techniques in which there is no airway adjunct which provides coverage or blockage of the glottis (laryngeal inlet to trachea and lungs). Nasopharyngeal

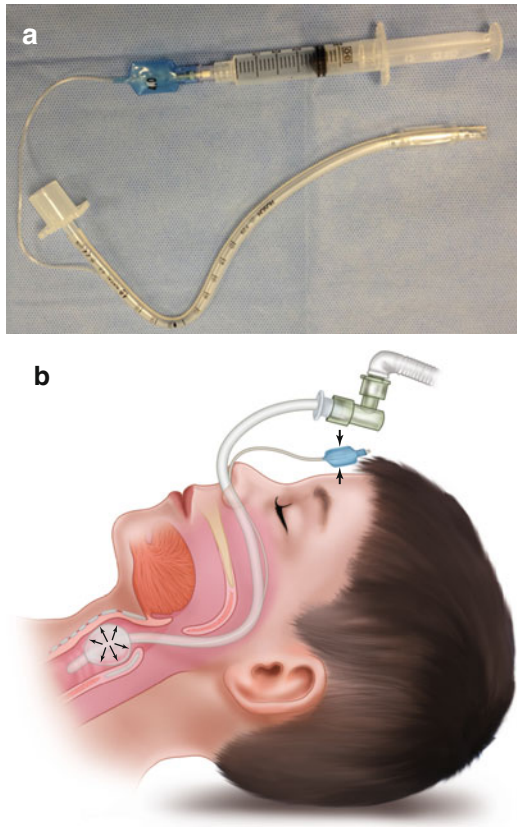

Fig. 10.1 (**a**) Cuffed nasotracheal tube. (**b**) Nasotracheal tube in place

airways are commonly placed in the open airway technique. General anesthesia can be provided with any of these forms of airway management. The patient may be spontaneously breathing or may require mechanical ventilation, which can only be provided if an endotracheal tube or LMA is used. There is a common misconception that if an endotracheal tube or LMA is used, this determines whether general anesthesia versus deep sedation is provided. The defining characteristic of whether deep sedation or general anesthesia is utilized is level of consciousness and not the type or lack of airway adjunct used.

General anesthesia or deep sedation may be administered in the hospital operating room or emergency department, in ambulatory surgery centers (ASCs), or in the office setting. Deep sedation provided by emergency room physicians in pediatric hospitals is generally limited to very specific indications and will not be discussed here. In the hospital operating room and ASCs, general anesthesia via nasotracheal intubation (see Fig. 10.1a, b) is routinely provided. The nasotracheal route allows the dentist to evaluate the occlusion. For most other surgical procedures, the orotracheal route is used but this does not allow for mouth closure.

To facilitate endotracheal intubation, inhalation induction is commonly provided. In this technique, the child breaths the potent inhalation agent sevoflurane until unconsciousness is attained, an intravenous line is started, nasotracheal intubation is performed, and the patient is maintained on inhalation agents. When treatment is completed, the patient is extubated when awake and transferred to the postanesthesia care unit (PACU). Various intravenous agents such as corticosteroids, antibiotics, neuromuscular blockers, propofol, antiemetics, and/or analgesics may be coadministered. In some hospitals and ASCs, an intravenous line is started while the child is awake with or without the aid of topical skin anesthetics, e.g., EMLA cream, and/or midazolam oral moderate sedation. Intravenous induction is then carried out to facilitate endotracheal intubation prior to potent inhalation maintenance of general anesthesia.

Although the LMA may be used for pediatric dental and oral surgery, it has not found favor in the United States as it has in Europe. When the LMA is used for oral procedures, the "flexible" type is used so the stem may be moved from side to side as needed to facilitate the dental procedure. Clearly, occlusion cannot be assessed as the tube blocks mouth closure (see Fig. 10.2).

In the office setting, either intubated or nonintubated general anesthesia can be utilized, most commonly via a total intravenous anesthesia (TIVA) technique. When an anesthesia machine capable of delivering sevoflurane is not available, as is typical is most dental offices, "induction" is most commonly provided with an intramuscular injection of ketamine and midazolam with or without an anticholinergic, i.e., such as glycopyrrolate or atropine. Common sites of injection include the deltoid and lateral vastus. A state of

dissociative anesthesia develops within 2–5 min and allows easy and amnestic separation of the child from the parent with acceptable maintenance of ventilation.

The patient is brought to the treatment room where supplemental oxygen is administered, standard anesthesia monitors are applied, an intravenous line started, and anesthesia is typically maintained with propofol with or without an opioid (commonly alfentanil or remifentanil) via a computer-controlled pump adjusted to an appropriate depth of general anesthesia depending on whether local anesthesia is applied.

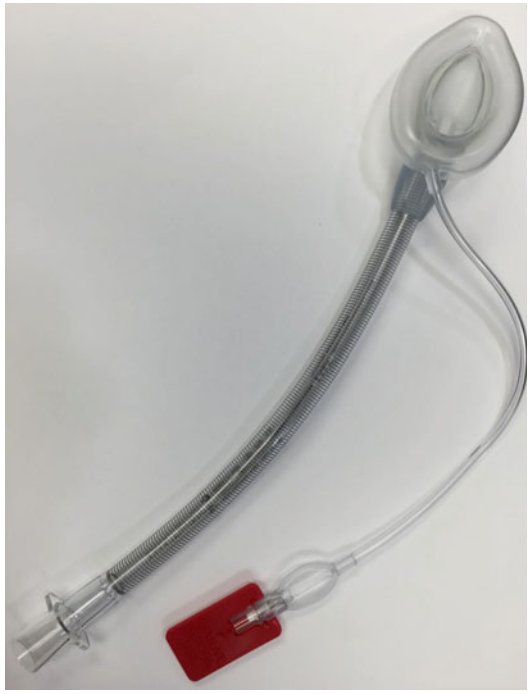

Fig. 10.2 Flexible LMA

Airway management is either via nasotracheal intubation or open airway. In the more common open airway technique, supplemental oxygen is supplied via nasal cannula in the nares. If an airway adjunct is used for this technique, it would be a nasopharyngeal airway placed with the tip in the oropharyngeal to upper-hypopharyngeal region (see Fig. 10.3a, b).

The nasal cannula can be cut and placed in the nasopharyngeal airway to deliver supplemental oxygen. Various intravenous agents may also be administered such as corticosteroids, antibiotics, antiemetics, and/or other opioid or non-opioid analgesics. This may be the most common form of dental office-based general anesthesia provided for pediatric dental patients. If local anesthesia is used for treatment, then a lighter plane of anesthesia, such as that approaching ultralight general anesthesia, may be adequate. Although deep sedation can be utilized for children undergoing dental procedures with the open airway technique and adequate local anesthesia, intermittent periods of movement common with this technique are generally not viewed favorably by

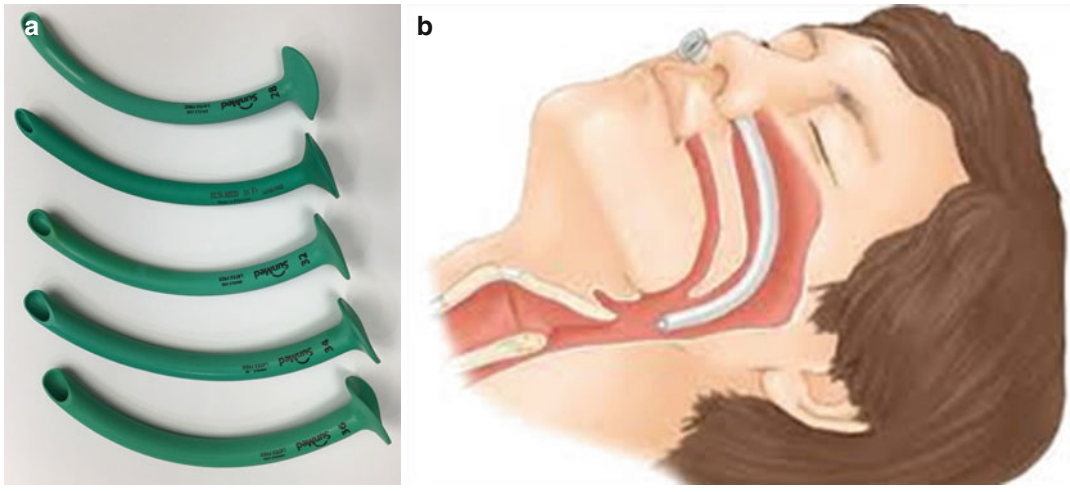

Fig. 10.3 (**a**) Nasopharyngeal airways. (**b**) Nasopharyngeal tube in place

either dentists or their anesthesia providers. What is termed "deep sedation" in the pediatric setting would better be termed "ultralight general anesthesia," even when local anesthesia is used in the oral cavity. Deep sedation may be effectively employed, however, for short oral surgical procedures such as tooth extraction.

Intubated office anesthesia can also be easily accomplished. If no anesthesia machine capable of delivering sevoflurane is available, intramuscular (IM) induction as above takes place, monitors are placed, and an intravenous (IV) line is started. Unconsciousness, profound analgesia, and apnea are obtained, most commonly with a combination of propofol and remifentanil; intubation is carried out and a Mapleson circuit (typically a Mapleson D or Jackson-Rees design) or a circle system with a transportable carbon dioxide absorber is used to deliver supplemental oxygen. Once resumption of ventilation takes place, maintenance of anesthesia is via TIVA as for the open airway technique. Extubation may be done "deep" (i.e., while unconscious) or awake.

In all of these techniques, supplemental oxygen is provided with either the dental nitrous oxide-oxygen delivery system or via E cylinders of oxygen. If nitrous oxide is used, attention must be directed to proper scavenging to limit environmental exposure. For anesthesiologists who utilize a portable anesthesia machine delivering sevoflurane, inhalation induction can take place. Anesthesia can be maintained with the TIVA intubated or non-intubated technique discussed above. Alternately, inhalational maintenance via an endotracheal tube may be employed as discussed in the hospital/ASC section above, provided that proper gas scavenging can be provided.

It should be noted that for some children 8 years or older, a full anesthesia facemask can be used to administer nitrous oxide 40–70 % in oxygen, with or without midazolam PO, in order to obtain IV access. This is frequently quite effective for painless and often amnestic placement of an intravenous line with subsequent intravenous induction of general anesthesia.

Monitoring

Monitoring for general anesthesia and deep sedation is more intensive than that required for moderate sedation. In addition to continuous blood pressure readings at least every 5 min and continuous pulse oximetry and pulse rate monitoring, continuous electrocardiography and ventilation monitoring is required. Ventilation may be monitored via either nasal cannula end-tidal CO_2 and/or precordial/pretracheal stethoscope for open airway cases. For intubated or LMA cases, end-tidal CO_2 monitoring is used and may be supplemented with precordial/pretracheal stethoscope.

Temperature monitoring is required when triggering agents for malignant hyperthermia are used (potent inhalation anesthetics and succinylcholine). Routine use of temperature monitoring is helpful for determining intraoperative hypothermia, which is common during prolonged procedures under general anesthesia. When neuromuscular blockers are used for paralysis, nerve stimulators (aka "twitch monitors") are used to determine degree of paralysis and return of normal neuromuscular function. Glucometers for regular blood glucose monitoring are mandatory for diabetic patients. More advanced invasive cardiovascular monitoring and other special monitors are used in specific clinical situations mainly in hospital operating rooms.

Anesthesia Providers

Various anesthesia providers deliver anesthesia in all the settings noted above. Dentist anesthesiologists provide the majority of dental office-based anesthetics for dentistry. Physician anesthesiologists, with or without the aid of certified registered nurse anesthetists (CRNAs) or anesthesiology assistants (AAs – physician assistants who complete 24–30 months of training post baccalaureate degree), provide the bulk of hospital-based general anesthetics. With the increasing development of "Dental Surgery Centers," i.e., accredited ASCs dedicated to dental and oral surgery, both dentist and physician anesthesiologists,

with or without CRNAs or AAs, are commonly found in these settings.

Nurse anesthetists often require direction by an anesthesiologist or supervision by a surgeon, usually a physician. All physician surgeons get training in presurgical medical evaluation of patients requiring general anesthesia, but most dentists do not. Therefore, most states require that dentists providing dental/oral surgical treatment to have a general anesthesia permit to supervise a nurse anesthetist providing deep sedation or general anesthesia in the dental office. This is not a universal requirement, and in some states nurse anesthetists are allowed to practice without supervision. However, should an adverse event occur, the liability of the dentist in this scenario is less clear than if a dentist or physician anesthesiologist was present.

Dentist anesthesiologists must complete 3 years of dedicated anesthesia residency after graduation from dental school. Accredited Dental Anesthesiology Residency programs, as per the Commission on Dental Accreditation, are the only anesthesia training programs that require outpatient dental anesthesia experience and specifically office-based experience. Additionally, these programs have arguably the most rigorous clinical pediatric patient requirements of any of the anesthesia providers (at least 125 children aged 7 or under) except for pediatric physician anesthesiologists. This is also true for patients with special needs (see Table 10.2; http://www.ada.org/~/media/CODA/Files/anes.ashx).

Physician anesthesiologists complete 3 years of dedicated anesthesia residency after graduation from medical school and 1 year of rotating internship. One hundred children must be anesthetized, and there is no specific requirement for office-based anesthesia nor for dental anesthesia (http://www.acgme.org/acgmeweb/Portals/0/PFAssets/ProgramRequirements/040_anesthesiology_07012014.pdf).

CRNAs complete 2 years of dedicated anesthesiology training following an undergraduate nursing degree and at least 2 years of critical care experience (examples include emergency room, intensive care unit, and coronary care unit). Only 35 children must be anesthetized for program completion, and there is no specific requirement for office-based anesthesia nor for dental anesthesia (http://home.coa.us.com/accreditation/Documents/Standards%20for%20Accreditation%20of%20Nurse%20Anesthesia%20Education%20Programs_January%202013.pdf).

For completeness, it should be noted that oral surgeons do obtain a general anesthesia permit from dental boards after completing approximately 6 months of deep sedation and/or general anesthesia experience and are competent at providing deep sedation, and in some cases general anesthesia, for patients undergoing usually brief oral surgery procedures. Office-based anesthesia training is provided. The only clinical requirement for pediatric anesthesia is for "children" 18 years and younger. Few oral surgeons gain competence in general anesthesia for young children for comprehensive

Table 10.2 Training requirements in overall months and for pediatrics for general anesthesia providers and oral surgeons

Anesthesia provider	Months in DS/GA training (minimum/usual)	Number of children required	Ages	Number of pts. with special needs required	Office-based experience required
Dentist anesthesiologist	24/31	125	≤7 years	75	Yes
Physician anesthesiologist	30/32	*100 total* 75 20 5	<12 years <3 years <3 months	No special requirement	No
CRNA	24/24	*35 total* 25 10	2–12 years <2 years	No special requirement	No
Oral surgeon	6/6	50	≤18 years	No special requirement	Yes

dental care or even for oral surgical care (http://www.ada.org/~/media/CODA/Files/oms.ashx).

Regardless of which anesthesia provider the pediatric dentist chooses to invite into their office, some basic information can help ensure the quality of the care. The following questions do not necessarily have a right or wrong answer but how your anesthesiologist answers these questions should allow you to assess whether he or she has thought through many of the important issues that make for a successful office-based anesthesia experience. Discuss with the anesthesia provider what types of patients are appropriate for the dental office based on age, medical condition, and duration of anesthesia. What monitors and equipment do you bring with you (should have at least capnograph, ECG, and temperature in addition to standard sedation monitors)? What do you need me to provide for you in the office? What type of airway management do you provide – open airway only? Intubation only? Depends on case? Other? Do you do inhalation induction or intramuscular induction? If inhalation agents are used, how do you manage possible malignant hyperthermia? Discuss what types of complications are commonly encountered and how are they managed. Are they ACLS and PALS certified? During an urgency or emergency, what support do you expect from my staff and me? Are there any situations in which the patient would need to be transferred to a hospital, and how is that handled? Again, it is the comfort level the anesthesiologist has answering the questions as much as the actual content of the answers that should allow you to make a reasonable evaluation.

Pharmacology

Discussion of medications in this section will be limited to those not discussed in previous pharmacology sections.

Intravenous Agents

Propofol

Propofol has supplanted the barbiturates as the primary intravenous general anesthetic agent. It has become the most popular sedative-hypnotic drug used for ambulatory surgery. Propofol, 2,6-diisopropylphenol (Fig. 10.4), is highly lipid soluble and available as a milky white 1 % suspension in soybean oil, glycerol, and egg phosphatide. Like benzodiazepines, propofol is thought to interact with the GABA receptor, causing increased chloride conductance and hyperpolarization of neurons. At higher doses propofol can produce amnesia and loss of consciousness. It is also an anticonvulsant, although spontaneous excitatory movements may be noted following administration [2].

Depending on the dose and technique, propofol is used for all levels of sedation and general anesthesia. In higher bolus doses it can induce general anesthesia. In the intermittent bolus technique frequently used for deep sedation in oral surgery, small increments of propofol (10–30 mg) are periodically administered, after attaining baseline moderate sedation with a benzodiazepine and opioid, in order to produce a state of deep sedation for local anesthetic administration and other stimulating portions of dentoalveolar surgery.

Propofol can also be used as a continuous intravenous infusion [3]. The dosages for moderate sedation range from 25 to 100 μg/kg/min, deep sedation from 75 to 150 μg/kg/min, and general anesthesia from 100 to 300 μg/kg/min depending on the method of airway control, age of the patient, concomitant medical conditions, and use of opioids and other adjuncts. The overlap of dose ranges, from moderate sedation to general anesthesia, highlights the lower margin of safety of this drug, especially if the intended level of sedation is moderate sedation. Use of additional benzodiazepines and opioids further blurs the dosing guidelines for various forms of

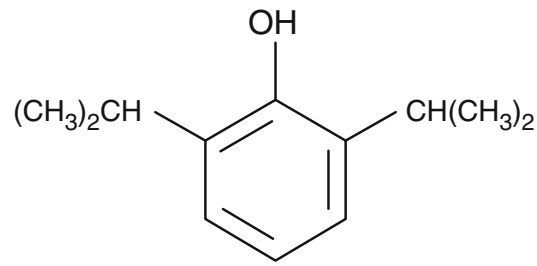

Fig. 10.4 Propofol molecule

sedation. The US FDA labeling prohibits use of propofol by those involved in the conduct of the surgical or diagnostic procedure.

Propofol is extensively metabolized by hepatic enzymes. In addition, extensive redistribution and other mechanisms of metabolism and elimination most likely occur, as the rate of propofol clearance from the plasma exceeds hepatic blood flow. This rapid plasma clearance may account for the decreased cumulative effect of this drug in the body, contributing to rapid awakening. The context-sensitive half-time (the time required for a 50 % decrease in plasma concentration following continuous intravenous infusion) for this drug is short, reaching a maximum of 40 min even after 2–6 h of continuous infusion. Context-sensitive half-times are even shorter with briefer infusions.

Propofol decreases systemic blood pressure by as much as 20–40 % from baseline through both central and peripheral mechanisms. Propofol also blocks sympathetic tone and allows parasympathetic vagal responses to predominate, thereby blunting the reflex tachycardia that would normally be associated with a drop in blood pressure. Hypotension may therefore be very significant following bolus administration or continuous infusion of propofol, particularly in elderly, medically compromised, and hypovolemic patients. This is generally not problematic in the healthy pediatric population.

Propofol also leads to dose-dependent respiratory depression and can produce apnea at higher doses. It is not associated with histamine release and has bronchodilatory properties.

Recovery from anesthesia with propofol has several unique characteristics. Compared to other induction agents, propofol is associated with a more rapid awakening and recovery, with less residual CNS effects, i.e., hangover. Even at subhypnotic doses, propofol is associated with decreased postoperative nausea and vomiting [2]. All these features make propofol an attractive choice for outpatient procedures where decreased time to discharge and minimal, if any, postoperative nausea are desirable.

Several considerations are necessary when using propofol. The solution can cause significant pain on injection, especially in smaller vessels. This may be attenuated with pre-administration of opioids or 1 % cardiac lidocaine.

Anaphylaxis is rare but has been reported in patients with a history of allergic reactions to other medications, especially neuromuscular blocking drugs. A history of egg allergy does not necessarily preclude the use of propofol, as the egg protein contained in the suspension is lecithin, whereas most egg allergies consist of a reaction to egg albumin. True soy allergy would, however, be a contraindication to propofol use. All propofol formulations are pH neutral and can support bacterial growth; therefore, a sterile technique and discarding of an opened vial or filled syringe after 12 h is recommended. The original proprietary agent, Diprivan, uses EDTA (ethylenediaminetetraacetic acid) as an antibacterial agent, whereas generic version contains metabisulfite or benzyl alcohol to retard bacteria growth.

Fentanyl

Fentanyl, a phenylpiperidine derivative, is the most commonly used opioid in anesthesia practice. It is a highly lipid-soluble mu-receptor agonist and has a rapid onset of action, and smaller bolus doses provide approximately 20 min of analgesic activity depending on dose. Large bolus doses can lead to apnea as well as chest wall rigidity. Continuous infusion of fentanyl leads to accumulation in various body sites leading to a prolonged context-sensitive half-time. Therefore, derivatives of fentanyl have been developed.

Remifentanil, Sufentanil, and Alfentanil

Remifentanil, sufentanil, and alfentanil are synthetic fentanyl derivatives used primarily for analgesia during general anesthesia. Remifentanil in particular is associated with a rapid onset and extremely short duration of action, resulting in a significantly shorter recovery time making it a very attractive agent for office-based anesthesia where rapid recovery is desired. Metabolized by nonspecific plasma esterases, its clearance is very rapid and independent of both hepatic and renal functions. It has a very short context-sensitive half-time of 4 min with virtually no cumulative effect, even following hours of continuous infusion

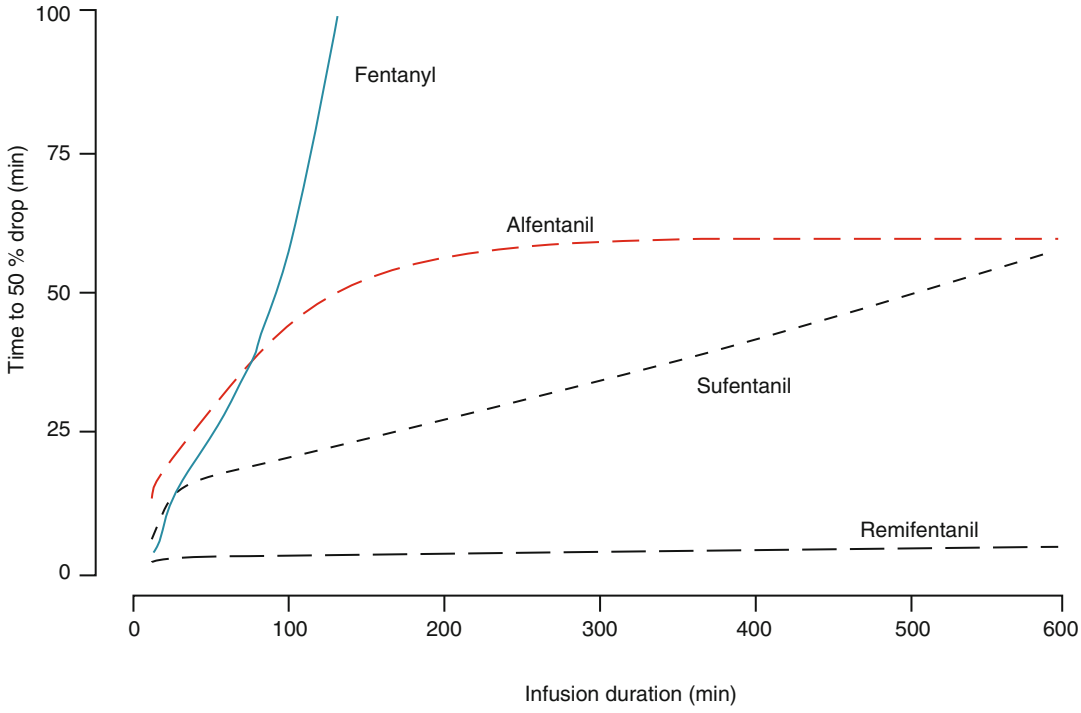

Fig. 10.5 Context-sensitive half-times for fentanyl and derivatives

(see Fig. 10.5). These features make remifentanil ideal for use in a titratable continuous infusion. Of note is the fact that because the actions of this medication are so short lived, postoperative pain will not be addressed by intraoperative remifentanil, and alternative pain control with another narcotic, a nonsteroidal anti-inflammatory drug (NSAID), or local anesthesia should be considered towards the end of the procedure.

Remifentanil is used in a total intravenous infusion anesthetic technique to maintain anesthesia during dental/oral surgery, often in combination with propofol. For analgesia during intubated general anesthesia with mechanical ventilation, it is used at a dose of 0.1–2 μg/kg/min. During spontaneously breathing general anesthesia, the dose ranges from 0.025 to 0.15 μg/kg/min.

Remifentanil, like fentanyl, can cause chest wall rigidity and caution should be used during bolus administration. It is also a highly potent respiratory depressant; even at lower doses, apnea may be pronounced. If spontaneous ventilation is desired, the remifentanil infusion is usually titrated to maintain an adequate respiratory rate.

Sufentanil and alfentanil are shorter-acting agents than fentanyl but not as rapid in offset as remifentanil. These agents are commonly used as a continuous infusion adjunct for general anesthesia, particularly when residual opioid effects are desirable postoperatively. None of these synthetic derivatives cause the release of histamine.

Inhalation Agents

Inhalation anesthetics include nitrous oxide (N_2O) as well as the potent volatile halogenated agents, isoflurane, sevoflurane, and desflurane. N_2O alone is commonly used in dental offices for anxiolysis and minimal sedation, but it is also used in combination with other medications to induce and maintain both sedation and general anesthesia. The pharmacology and dental use of nitrous oxide were discussed earlier in Chap. 4 and will not be discussed here.

Table 10.3 Blood: gas solubility coefficient and its effects

	Low	High
Dissolves	Poorly	Strongly
Onset	Fast	Slow
Offset	Fast	Slow

The halogenated agents are extremely potent and are used for induction and maintenance of general anesthesia. They are complete anesthetics providing unconsciousness, amnesia, analgesia, and muscle relaxation. The pharmacokinetics of inhalation anesthetic agents was discussed in Chap. 4. Each agent varies in its solubility in blood and other tissues such as the brain and fat, and these characteristics determine the ease with which the gas crosses into the different tissues. Of these, the blood-gas solubility coefficient (Table 10.4) is the most useful in describing the onset and offset of action of an anesthetic gas. The blood-gas solubility coefficient expresses the extent to which the anesthetic gas molecules from the alveolar spaces will dissolve into plasma before the plasma compartment becomes saturated. Conceptually, a lower coefficient means that the gas is less soluble in blood and will saturate the plasma compartment more quickly. Additional "overflow" molecules will then be free to move into other highly vascular tissues such as the brain, where the CNS anesthetic effect takes place. A lower blood-gas coefficient therefore translates into faster onset of action at the brain. Once the gas is discontinued and the alveolar and plasma concentrations decrease, the gas molecules move down their concentration gradient from the tissues back into the blood stream and then into the alveoli. Gases with lower blood-gas coefficients will likewise "off-load" from the blood stream into alveoli more quickly and can translate into a faster offset of action (see Table 10.3).

The potency of these agents is measured in minimum alveolar concentration (MAC), as for nitrous oxide. The MAC value of any given agent is the inhaled concentration, i.e., volume %, of that agent required to prevent movement in 50 % of patients to a surgical stimulus.

In general, a level of 1.3 MAC will prevent movement in 95 % of patients, whereas 1.5–1.7 MAC (MAC_{BAR}) will block an adrenergic response in 95 % of patients. Below 0.4 MAC (MAC_{AWAKE}), patient awareness is more likely. MAC values are additive. For example, if 0.5 MAC of N_2O (50 %) and 1.0 MAC of isoflurane (1.2 %) are given simultaneously, the total MAC of anesthetic agent administered to the patient is 1.5 MAC. It should be noted that MAC values are general guidelines, and individual anesthetic requirements can be influenced by a variety of factors such as age or medical status. Neonates have the lowest MAC requirement, whereas young children have the highest requirement, approximately 20 % higher than 40-year-olds. MAC requirements subsequently decrease in the elderly patient. MAC values are typically listed for adults (40-year-old) at 1 atm pressure and 20 °C, as in Table 10.4.

The exact mechanism of action of inhaled anesthetic agents at the CNS is still controversial. Earlier theories have suggested that anesthetic molecules insert into and disrupt the lipid bilayer of neuronal cell membranes, thus interfering with the cellular function. More current theories suggest that anesthetic molecules may instead directly interact with cellular proteins, possibly with membrane ion channels or even specific receptors.

Whereas N_2O has mild or minimal sympathomimetic effects, all of the halogenated agents produce generalized cardiovascular depressant effects. The potent volatile agents cause peripheral vasodilation thus lowering mean arterial blood pressure. At doses below 1 MAC the baroreceptor sympathetic reflex is activated, which leads to a compensatory increase in heart rate.

At usual doses N_2O does not appreciably affect respiration. However, the halogenated agents produce a characteristic "rapid and shallow" spontaneous breathing pattern. A decrease in tidal volume is accompanied by an increase in the frequency of breathing, but the faster respiratory rate does not fully compensate for the smaller tidal volumes. Therefore, minute ventilation is reduced and arterial CO_2 levels will be elevated in patients spontaneously breathing while under general

Table 10.4 Properties of inhalation agents (40 years old)

	Nitrous oxide	Isoflurane	Desflurane	Sevoflurane
MAC[a] in O_2	105	1.15	6.0	2.0
Partition coefficients at 37 °C				
Blood-gas	0.47	1.46	0.42	0.69
Brain-blood	1.1	1.6	1.3	1.7
Muscle-blood	1.2	2.9	2	3.1
Fat-blood	2.3	45	27	48

[a]*MAC* minimum alveolar concentration

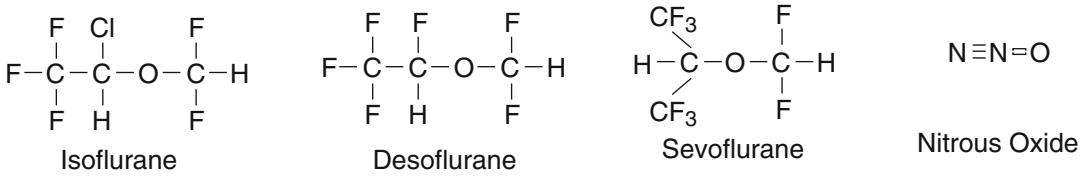

Fig. 10.6 Potent inhalation agents and nitrous oxide

anesthesia with these agents. The halogenated agents also produce bronchodilation and cause a dose-dependent decrease in airway resistance. There are minimal effects on hypoxic pulmonary vasoconstriction at 1–1.5 MAC.

Although hepatic blood flow decreases with these agents, hepatic damage, if any, resulting from hypoxia is usually subclinical and transient. Renal blood flow and urine output are reduced secondary to the decreased mean arterial pressure. The release of fluoride from the halogenated gases does not appear to cause clinically significant damage to renal tissues.

Potent Inhalation Agents

The halogenated inhalation agents commonly in use today in the United States include isoflurane, sevoflurane, and desflurane. As seen in Fig. 10.6, all are ether derivatives. Unlike the original anesthetic gas, diethyl ether, these agents are methyl-ethyl ethers, halogenated and nonflammable. The newer halogenated agents, sevoflurane and desflurane, are unique in that all of the side chain halogen ions are fluoride. The gases are stored and released by gas-specific vaporizers that control the concentration (volume %) allowed into the anesthesia circuits and into the patient. They must also be scavenged effectively so that room air levels do not affect health care personnel.

Sevoflurane

Sevoflurane is relatively nonpungent and a common choice for inhalation induction. It has an intermediate potency (MAC 2–2.4 %), and at higher doses, induction will be rapid. Recovery from sevoflurane is relatively rapid due to its lower blood-gas solubility coefficient (0.69). Sevoflurane has been associated with emergence agitation in up to 40 % of children, likely due to rapid awakening which can be disconcerting to parents who are involved in early recovery of their children following general anesthesia. For longer procedures, the recovery time may not be significantly improved due to reasonably high solubility in fat.

All of the side chain halogen ions in sevoflurane are fluoride, contributing to its low blood-gas solubility and recovery profile. Unlike earlier inhaled agents, the small amount of inorganic fluoride released during sevoflurane use has not been associated with renal damage. Sevoflurane and CO_2 absorbers produce a degradation product called compound A, an olefin, which is nephrotoxic in rats but has not been associated with significant permanent renal damage in humans. Regardless, sevoflurane may not be the agent of

choice for patients with renal disease. High fresh gas flows reduce the production of compound A.

Isoflurane

Isoflurane has an intermediate potency (MAC 1.2) and blood-gas partition coefficient (1.46). With the newer halogenated agents having improved pharmacokinetics, isoflurane is becoming a less common choice for maintenance of anesthesia, as recovery time is longer and there is less ability to quickly titrate the drug intraoperatively. Isoflurane is not a good choice for inhalation induction as it frequently leads to gagging and coughing when used. Isoflurane is, however, much more cost-effective for longer periods of anesthesia compared to two other popular agents, sevoflurane and desflurane; its cost per equivalent MAC administration is significantly lower than the other available agents.

Desflurane

Desflurane is extremely pungent and can be so irritating to nonanesthetized airways that it may precipitate coughing and laryngospasm. It is to be avoided for inhalation inductions. During initial administration of desflurane, tachycardia can also occur until deeper levels of anesthesia are realized. It is relatively contraindicated for children with a history of asthma.

Desflurane is delivered from specially heated vaporizers as its vapor pressure is close to atmospheric pressure. Like sevoflurane, it also possesses only fluoride substitutions which, like sevoflurane, confer a low blood-gas solubility. In fact, desflurane has the lowest blood-gas solubility coefficient (0.46) of any inhalation agent, lower than even nitrous oxide. This confers a quick onset and offset and easy titratability, and recovery can be very rapid following a short anesthetic with desflurane. Desflurane is the most expensive of the potent agents based on equivalent MAC administration.

It should be noted that if potent inhalation anesthetics or succinylcholine, a depolarizing neuromuscular blocker (paralyzing agent), are used, there is a specific risk of malignant hyperthermia (MH) that is not present with other agents. The risk is rare, estimated at 1:30,000 surgical procedures in children and 1:100,000 surgical procedures in adults. Nitrous oxide, nondepolarizing neuromuscular blockers, opioids, benzodiazepines, other intravenous anesthetic agents, and local anesthetics do not trigger MH. Exposure to triggering medications causes an abnormal ryanodine receptor in skeletal muscle cells to release excessive intracellular calcium, leading to uncontrolled muscle contractions. As a result, CO_2 production increases quickly and exhaled CO_2 rises sharply. Initial signs include tachycardia and tachypnea, along with muscle stiffness. Hypoxemia, metabolic acidosis, and hyperkalemia develop next and cardiac arrest is a possibility. Increasing body temperature is a relatively late sign.

The halogenated agent must be discontinued at once and 100 % O_2 administered. Dantrolene, the specific antidote for this condition, must be given at an intravenous dose of 2.5–10 mg/kg as soon as possible. Cooling measures and other specialized supportive care should be instituted. Emergency help must be obtained immediately, and the patient will require medical management and monitoring for at least 24 h following the episode. Reemergence of the reaction is common, requiring readministration of dantrolene, and acute renal failure is the most common morbidity secondary to myoglobinemia. A mortality rate of less than 5 % is associated with an acute MH episode, even with immediate proper management.

Risks of Deep Sedation/General Anesthesia

Deep sedation and general anesthesia, although necessary for many children, are not risk free. Common risks associated with anesthesia can occur with any of the above techniques: nausea and/or vomiting, bruising at the IV site, emergence agitation, and lingering sedation later in the day. With non-intubated general anesthesia, risks such as pulmonary aspiration, laryngospasm, and bronchospasm are present. Difficulty in maintaining an airway is also possible, particularly in children with large tonsils, obesity, or with anatomic airway abnormalities. If a

nasopharyngeal tube is used to aid in airway maintenance, nasal bleeding may occur. With intubated general anesthesia, risk of laryngospasm and pulmonary aspiration are reduced to the periods of induction and immediately post-extubation. However, there may be damage to nasal or laryngeal structures due to passage of the endotracheal tube, and bronchospasm risk may be increased over non-intubated techniques. A persistent dry cough is possible but not common. Post-extubation croup may occur but is unlikely with proper precautions.

Recently, a case of an airway fire during non-intubated general anesthesia of young child undergoing routine restorative dentistry in an ambulatory surgery center has led to concern regarding oxygen use and possible sparking from dental drills. This must be an extremely rare occurrence as supplemental oxygen is commonly used with nitrous oxide and for all sedation and general anesthesia techniques in dentistry. More research needs to be conducted to see what factors might increase this risk and what level of supplemental oxygen should be administered to balance the risk of airway emergencies versus that of an airway fire. Until more information is obtained, it would seem prudent that when an "open airway" is used for pediatric dental general anesthesia, dental handpiece water spray, high volume evacuation, and moist throat packs should be utilized. Cuffed endotracheal tubes and well-fitted uncuffed endotracheal tubes with moistened throat packs placed to provide a good seal for the glottic opening would be expected to minimize this complication.

Anesthesia providers routinely manage various cardiovascular urgencies, such as hypotension, hypertension, tachycardia, and bradycardia as treatment of these conditions is integral to anesthesia practice. Likewise, conditions such as cardiac arrhythmias, allergy and anaphylaxis, and other rare conditions should be anticipated and prepared for by those well trained in office-based anesthesia, such as dentist anesthesiologists.

Recently, concern has been raised over possible neurotoxicity of most general anesthesia and sedative drugs. In 2003, Jevtovic-Todorovic et al. presented their sentinel findings that a combined anesthetic (midazolam, nitrous oxide, and isoflurane) administered to 7-day-old rats for 6 h kills neurons in the developing brain and causes long-term impairment of brain function [4]. This finding was later shown to be generalized to primates in other studies [5–7]. It is impossible to reliably test whether anesthesia or sedation causes neuronal death in children but brain function could be tested if a large enough and diverse enough group of children could be studied. As recently as March 2011, the US FDA did not recommend a change in clinical practice until more data is available to make an informed decision.

To date, the human data are confounding. Some studies show a possible link to behavioral impairment particularly if anesthesia is administered before 2 or 3 years of age [8–10]. Studies involving twins, one of whom was exposed to anesthetic agents, did not show any neurobehavioral differences [11]. Likewise, there is animal data to suggest that short (<2 h) isoflurane anesthesia does not produce neurodegeneration [12]. It does appear that at some age the negative effects of anesthetic agents, if there are any long-term effects, decrease and are not detectable by current methodologies.

The current animal data suggest that both GABAergic (e.g., potent inhalation anesthetics, benzodiazepines, propofol) and NMDA antagonist (e.g., nitrous oxide, ketamine) drugs, particularly when combined, may be most harmful [13, 14]. Opioids have also been shown to be neurotoxic in some studies. In essence, all currently available agents may at some point in time prove to produce negative cognitive/behavioral consequences in young children. Important questions remain as to what factors may play a role in anesthetic neurotoxicity, if it is clinically significant at all. At this time, we do not know what the critical age threshold in brain development is that might lead to an increased risk for neurotoxicity. Nor do we know what the critical concentration of drugs might be to cause neurotoxicity or if there are differential effects between the various agents. Lastly we do not know if there are means to mitigate these possible effects. Ongoing basic science and clinical research continues to answer these important questions.

At this time, what can be said is that anesthesia should not be administered to young children unless necessary. Should anesthesia or sedation be administered for dental surgery? What is the risk of abscess or cellulitis from dental infection? What is the effect on development of permanent teeth? Speech? Nutrition? Does the benefit of good dental health warrant use of sedation or general anesthesia if there are possible long-term behavioral changes? Should pediatric dentists even use nitrous oxide, an NMDA receptor antagonist, on 2-year-olds? 3-year-olds? Any preschool child? Would it be better to use a papoose board and restrain young children while providing dental care? Would this cause more or less negative behavioral consequences? At this time, the data do not support discontinuing the use of appropriate sedatives and general anesthetic agents. As more well-controlled studies are published, the medical and dental professions will both need to assess the best way to proceed as patient safety is always of paramount importance to both pediatric dentists and their anesthesia providers.

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General Anesthesia for Pediatric Patients

11

Joseph P. Cravero

Abstract

In spite of many excellent behavioral management options, there are a number of children who require general anesthesia (GA) in order to accomplish dental interventions. The factors that lead dentists to refer a child for GA are varied and include behavioral issues, coexisting illnesses, as well as the availability of anesthesia expertise and operating room access. The relative impact of these factors has led to a great disparity between geographic populations in terms of the frequency of use of GA for dentistry. For children who receive GA, specific coexisting diseases including airway abnormalities, congenital heart disease, and obstructive sleep apnea must be considered. These issues need to be specifically addressed, and their impact on risk must be accommodated. Dentists must also appreciate the impact of general anesthesia on the overall cost of dental care for a patient. This calculation can be very complicated and must take into account the effectiveness and efficiency of care with GA versus sedation. In many cases, GA may be very cost-effective. Finally, dentists should be familiar with the current use of general anesthetics and airway devices which attempt to minimize preoperative stress, emergence agitation, and recovery time while improving safety.

In spite of having a myriad of behavioral management techniques and various sedation strategies, there are dental cases where general anesthesia (GA) is required to provide safe and effective dental treatment. Primary reasons for GA include extreme uncooperative behavior, multiple tooth extractions, extensive dental caries in a very young child, and dental treatment for children of all ages who have special needs (particularly those with autism or other psychosocial disabilities). The American Academy of Pediatric Dentistry (AAPD) endorses GA for pediatric patients who are unable to cooperate; experience ineffective local anesthesia; are extremely fearful, anxious, or uncommunicative; require significant

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surgical procedures; can benefit from GA protecting them from psychological trauma and/or reducing medical risks; and require immediate, comprehensive oral care [1]. Inevitably, the actual influences on this decision are multiple and quite varied [2]. Many times the decision is influenced by local resources and the ease in which GA can be obtained. In addition, there is significant parental bias: many parents demand that their child be asleep for extensive dental care because of their fear of the pain and anxiety treatment will create. On the other hand, other parents may refuse GA for many reasons including the cost involved (primarily in the USA) [3]. The exact rate at which children require this care is not clearly known, but surveys have found that between 1 and 3 % of children have had such treatment by the time they are 5 years of age [4]. Moreover, GA appears to have become a more acceptable option to families of patients requiring dental intervention over time. In a 2005 study, Eaton et al. evaluated the acceptability of several different behavioral management techniques using video examples and found that the most accepted techniques (in order) were (1) tell-show-do, (2) nitrous oxide sedation, (3) GA, (4) active restrain, (5) oral premedication, (6) voice control, (7) passive restraint, and (8) hand over the mouth [5]. This study also found that there was a trend toward greater acceptance of GA in the parents that were surveyed in 2004 compared to those surveyed in 1984.

Repeated use of GA in a single child is not unusual. In one cohort, Schroth and Smith examined a database contained claims for 339 Canadian First Nation (Native) children who received repeat GA procedures for rehabilitative dental core [6]. Of these children, the majority (76 %) received 2 procedures, while the remainder underwent three or more surgeries. Retreatment of previously restored teeth was a common. The authors note that the majority of patients (74 %) in this group were treated by general dentists rather than pediatric dentists. The mean age of children at the time of the first GA procedure was not associated with whether children received 2 or more GA procedures for dental care. The authors conclude that there is an over-reliance on GA for dental care among this select population. While this data cannot be generalized to all populations, it is clear that repeated requirements for GA are not unusual, particularly in the most vulnerable populations.

Impact of Coexisting Illnesses

Children requiring GA often have coexisting medical diagnoses. These coexisting conditions can include either medical or psychological problems. Developmental delays and behavioral problems are particularly prevalent in older patients who are selected for GA treatment. In one study Roberts et al. evaluated the trends in coexisting illnesses (or circumstances) present for children requiring GA. These investigators contrasted the diagnoses that were present in a cohort treated during 1990–1999 and contrasted the data with that available for patients treated during 2000–2008 at their university medical center in North Carolina (see Table 11.1) [7]. The percentage of pre-cooperative age and highly anxious but otherwise healthy children treated under GA increased from 46.7 % in 1990–1999 to 52.1 % in 2000–2008. The number of patients treated steadily increased in spite of no changes in OR availability during this time period. For children with coexisting illnesses, the most common was asthma, followed by neurological disorders (9.2 %), developmental delays (8.5 %), genetic abnormalities (8.5 %), autism (4.7 %), cardiac anomalies (5.0 %), attention deficit/hyperactivity (2.7 %), coagulation disorders (2.3 %), and craniofacial abnormalities (3.6 %).

Children with chronic health conditions are more likely than those without such conditions to receive GA for dental treatment. In a survey of almost 63,000 Iowa Medicaid-enrolled children <15 years old Chi et al. compared the frequency with which children with and without chronic health conditions received GA for dentistry. Overall, less than 1 % of children received GA; however, for children under 6 years of age, the rate was twice as high for those with chronic conditions as demographically similar children without conditions. Age also appeared to be a factor. In this same

Table 11.1 Diagnoses for children undergoing general anesthesia for dentistry 1990–1999 versus 2000–2008

	1990–1999 $N=941$	2000–2008 $N=2357$
Diagnosis	Number (%)	Number (%)
Asthma/respiratory issues	86 (9.1 %)	207 (8.8 %)
Autism	44 (4.7 %)	123 (5.2 %)
Attention deficit/hyperactivity disorder (ADHD)	25 (2.7 %)	75 (3.2 %)
Cardiac anomalies	47 (5.0 %)	108 (4.6 %)
Coagulation disorders/anemia	22 (2.3 %)	33 (1.4 %)
Craniofacial anomalies	34 (3.6 %)	73 (3.1 %)
Developmental delays/mental retardation	77 (8.2 %)	163 (6.9 %)
Genetic syndromes/chromosomal disorders	80 (8.5 %)	177 (7.5 %)
Neurological disorders (e.g., cerebral palsy, seizure disorders)	87 (9.2 %)	170 (7.2 %)
Well child/acute situational anxiety	439 (46.7 %)	1228 (52.1 %)

Source: Roberts et al. [7]

study, children between 6 and 14 years were three times as likely to require GA if they had a chronic health condition when compared to similarly aged children without a chronic condition [8].

Many different subgroups of patients offer challenges for GA. There is no question that patients with congenital heart disease (particularly those with cyanosis, congestive heart failure, or pulmonary hypertension) [9, 10] or lower respiratory tract disease (such as cystic fibrosis or persistent asthma) represent high-risk subgroups for anesthesia and should only be cared for in setting that have backup capability to manage their possible complications. Additionally, patients with craniofacial abnormalities, who may have difficult to manage airways, should only be anesthetized in full service pediatric care facilities (e.g., Crouzon's or Pierre Robin sequence).

More recently the anesthesia literature has highlighted the risks associated with anesthesia for patients with obstructive sleep apnea (OSA) [11]. In particular, there are multiple reports concerning the sensitivity of these patients to opiate medications and a higher rate of perioperative mortality in this subgroup [12]. With this in mind, dentists should question patients about symptoms of severe sleep apnea and be aware of any specific testing that may have been done to categorize a given patient concerning this problem. Dental providers should also be aware that these patients deserve special consideration when scheduled for GA and may require prolonged observation or even overnight observation following GA for dental procedures.

Quality of Care

General anesthesia can change the nature of the dental care that is possible for children with medical or behavioral problems. Multiple studies have documented the high quality of dental treatment that is possible under GA. In one study, Drummond et al. documented the outcomes of dental treatments in 292 children under GA. Ninety-five percent of the treated children were followed up. Fifty-five percent had new caries recorded. For the treatments provided, amalgam had a mean success of 57.1 %, composite 73.4 %, compomer 85.2 %, stainless steel crowns 92.8 %, and pulpotomies 84.6 % [13]. In another study, Eidelman and colleagues evaluated 34 patients with dental restoration performed under GA and compared them to 31 had restorations completed with conscious sedation. The group who underwent treatment with GA had a better success rate for marginal adaptation (93 versus 78 %), better success for anatomic form (92 % versus 79 %), a better rate of preventing secondary caries (97 % versus 90 %) [13, 14]. While these studies lack controlled or randomized comparative data with those who did not receive GA, there is no question that the quality of dental care provided with GA is high.

Quality of Life Measures

In considering the cost-effectiveness of GA for dental care, the effect of this care on longer-term outcomes such as the impact on general quality of life should be considered. These issues have been addressed by Jankauskiene and colleagues [15]. The authors carried out a literature search to identify relevant studies examining children's oral health-related quality of life following dental treatment under GA. Their review included 11 journal articles that had relevant results of clinical trials. The studies outcomes were measured by various questionnaires measuring children's oral health-related quality of life and parental satisfaction. They concluded that rehabilitation under GA results in the immediate improvement of children's oral health and corresponding improvement in physical, emotional, and social quality of life. The result was a corresponding positive impact on the family. While the authors recognize the difficulties in measuring quality of life given the different measures that were included, they suggest the trend toward immediate improvement is clear and advocate for further studies in the future. Similarly White et al. [16] found that GA was widely accepted by parents primarily because they believed there was a positive social impact on their children. A majority of parents felt that their child smiled more often and performed better in school following major dental rehabilitation under GA.

Unfortunately, there remains little prospective, randomized, controlled data on the use of sedation versus GA for dental treatment in children in terms of either the immediate outcome of the dental treatment or the longer-term impact on quality of life. In fact, a recent Cochrane collaborative review concluded that there were no studies that met their inclusion criteria for controlled, randomized, high-quality studies and simply recommended that the issue be studied with randomized controlled trial (RCT) in the future [17].

Cost Considerations

The impact of cost and availability of GA for dental care cannot be ignored. Unfortunately, this is a complex issue that should take into account not only the immediate cost of the care, but the many associated costs (expenses) that can be impacted by one type of care versus another. As a general rule, the choice facing dental providers is not simply that of GA versus no intervention, but rather GA versus some form of sedation. Consideration of the cost of anesthesia versus sedation for dental interventions must take into account multiple issues related to the patient and the dental process that is being treated. Lee et al. examined this topic in detail and determined that using GA for dental interventions may be less expensive than sedation when all factors related to cost are considered [18]. These factors include (but are not limited to) transportation costs, time away from work for parents, and the fact that a child may need multiple conscious sedation appointments to complete a dental treatment that could be accomplished with one general anesthetic. "Cost" data are further complicated by the fact that they will vary from location to location depending on the nature of the health-care system. In spite of these limitations, Lee and colleagues provide a helpful roadmap for considering the many factors that go into calculating total cost of a dental intervention specifically contrasting sedation provision to GA.

Operating Room Issues

In many cases, the utilization of GA for dental interventions will require the care to take place in the operating room as opposed to the clinic setting. There are numerous problems inherent in utilizing operating rooms for dental procedures. These include long waiting lists for treatment and various scheduling issues and cancellations due to emergency operative needs. In 2002, the average waiting time for complex dental care in the OR with GA in the US pediatric dentistry programs was reported as an average of 28 days for children experiencing pain and 71 days for children without pain [19, 20]. A subsequent study in 2012 found an average wait list time of 90 days [20]. The long duration of these wait times is often cited as a factor in dental professionals *not* choosing GA for a given procedure.

Utilization of time in the OR is of great interest to hospital administrators. In particular, GA for dental procedures requires prolonged blocks of time, and the cases are not always easy to predict in terms of duration or level of intervention. Forsyth et al. carefully evaluated the operating room utilization time at the University of Washington for over 700 dentistry procedures performed in the OR. They found that dental procedures finished earlier than the scheduled time by an average of 14 min and overran the scheduled time in 27 % of cases. The average amount of dentist operator time was 76 min. In this same study, the average age of patients was 7.1 years and the American Society of Anesthesiologists (ASA) distribution included 77 % ASA I or II with the balance of patients considered ASA III. Contrary to expectations, the probability of overrunning the allotted time decreased significantly as the ASA status increased. The results of this study point out that (in this institution) dental cases were appropriately scheduled and did not pose an unpredictable burden on the management of the operating room case flow.

General Anesthesia Techniques for Dentistry

General anesthesia for dentistry follows the same general principles as that for other surgical procedures. There are a few caveats that should be kept in mind with respect to this particular clinical setting:

1. Premedication with acetaminophen is common. Because of the presence of moderate pain (particularly after multiple extractions), many anesthesiologists will choose to premedicate children undergoing GA for dental interventions with acetaminophen. Generally, this is given as an oral solution at a dose of approximately 15 mg/kg, but it can also be given rectally (for age appropriate patients) at a dose of 30 mg/kg. The advantage of premedication is in the time it allows for an effective blood level to be established prior to emerging from anesthesia.
2. Dental patients may also benefit from midazolam premedication to smooth the induction of anesthesia process. There are multiple studies documenting the improvement of behavior while undergoing induction of anesthesia after 0.5–0.75 mg/kg of oral midazolam [21, 22]. While the practice is not considered "standard," it is not uncommon and can be particularly helpful in patients who have significant oppositional behaviors. The use of midazolam for premedication has been associated with a decrease in adverse behavior changes in the postoperative time frame [23]. On the other hand, the use of midazolam has also been associated with delayed awakening after GA and should be used with some caution for very short procedures [24].

   Dexmedetomidine has also been used as an oral premedication for dental surgery. In one study, the use of oral dexmedetomidine was equally as effective as midazolam in decreasing anxiety preoperatively, and it was not associated with any cardiovascular adverse events [25].
3. In most institutions in North America, inhaled induction with sevoflurane is preferred. This drug gives a smooth, rapid induction and is associated with very few adverse cardiac effects [26]. Bradycardia on induction (which was common with halothane anesthesia) is relatively uncommon with sevoflurane [27]. Induction of anesthesia with intravenous agents is certainly acceptable, but often considered challenging in the active, agitated patients that are not uncommon in the dental GA population.
4. Adjunctive steroid administration with dexamethasone is common for dental GA. The addition of this drug has been shown to improve pain control and minimize postoperative nausea and vomiting (PONV) for pediatric patients undergoing oral or ears/nose/throat surgery [28–30].

   Airway management for dental GA is chosen based on the expected duration of the procedure and the nature of the intervention itself. For full mouth rehabilitation, a nasotracheal tube is generally preferred as it is "out of the way" during the dental procedure and offers maximal access to the oral cavity (see Fig. 11.1). Most are placed under direct

visualization after deepening the anesthetic with opiates, propofol, and (occasionally) muscle relaxants.

5. Laryngeal mask airways (LMA's) have also been used to facilitate dental GA [31]. This airway is easier to place and less invasive and does not require as "deep" a level of anesthesia as the nasotracheal tube (See Fig. 11.2). The LMA can also provide a temporary airway in patients who are difficult to intubate under direct visualization, and many also provide a conduit for oral intubation in that subgroup [32, 33]. The use of an LMA requires dentists to work around the tube in the mouth and need to be aware that changing the position of the head and neck can change the "seal" of the LMA. The lack of a good "seal" will allow volatile agent into the mouth and can also result in the leaking of oral contents into the esophagus/stomach or trachea.
6. The maintenance of anesthesia can be accomplished with inhaled agents or intravenous agents. Multiple studies have evaluated the use of IV versus inhaled anesthetics for children undergoing day surgery. In most of these investigations, inhaled anesthesia is maintained with sevoflurane, and IV anesthesia is based primarily on an infusion of propofol.

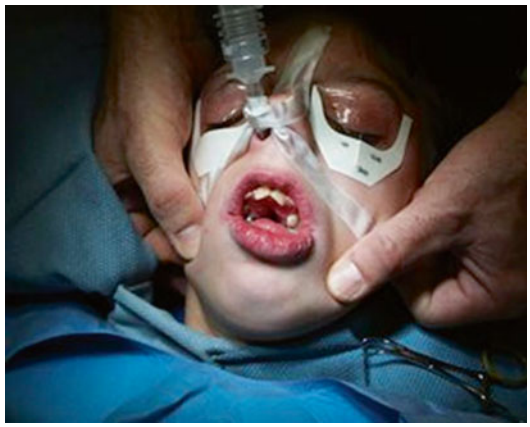

Fig. 11.1 Special needs of patient with nasotracheal tube in place offering maximal access to the oral cavity

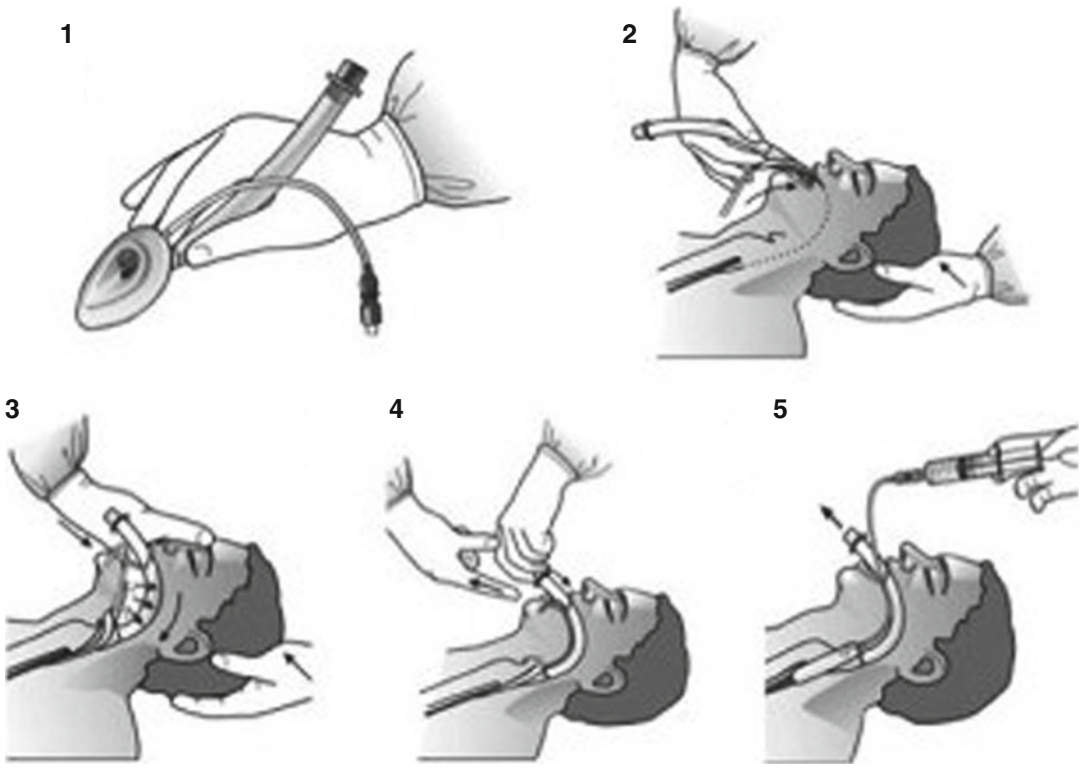

Fig. 11.2 Placement of the laryngeal mask airway

In these studies, propofol intravenous anesthesia has overwhelmingly been associated with less emergence agitation, less PONV, and lower pain scores than GA with inhaled anesthetic agents [34–36]. A single dose of propofol at the end of inhaled anesthesia has also been associated with a decrease in agitation behaviors in the postoperative time frame [37]. On the other hand, a recent report from Konig et al. evaluating the quality of emergence from anesthesia specifically in dental GA cases resulted in a slightly different outcome [38]. In this prospective, randomized, blinded trial of 179 patients, the incidence of emergence delirium was not different between the different types of anesthesia. The use of sevoflurane was associated with a significantly increased risk of PONV and the need for postoperative nursing interventions. Time to discharge readiness was slightly faster in the sevoflurane cohort and parental satisfaction was not different between the groups.

Data on Safety

Data on the safety of GA for dental procedures is sparse. Reports of adverse events are sporadic, and there is literally no possibility of estimating the total number of these cases that are performed each year given the wide variety of practice settings and individuals that are involved. One method for studying these cases is the review of closed legal claims related to adverse events occurring with sedation or anesthesia. In one such report, Chicka and colleagues reviewed closed claims relating to sedation or GA for dental procedures in the USA that were available between 1993 and 2007 [39]. They discovered 17 total claims of which 13 were related to sedation, 3 to local anesthesia (alone), and 1 to GA. Death or permanent brain injury was present in 53 % of cases. The average age was relatively young at 3.6 years. The litigation often involved a drug overdose, which most commonly involved a local anesthetic (41 % of claims). The majority of cases took place in a dental office (71 %).

Table 11.2 Patient and care characteristics for pediatric dental deaths

Characteristics	*N*	Percent
Age category		
0–23 months[a]	2	4.6
2–5 years[b]	21	47.7
6–12 years[c]	8	18.2
13–21 years	13	29.6
Procedure		
Routine/prevention	1	2.3
Filing/crown	14	31.8
Extraction (caries, wisdom tooth)	18	40.9
Other (maxillofacial surgery, root canal)	3	6.8
Not reported	8	18.2
Anesthetic depth		
Local anesthesia	4	9.1
Moderate sedation (oral/intravenous)	20	45.5
General anesthesia	10	22.7
Not reported	10	22.7
Anesthesia provider		
General/pediatric dentist	25	56.8
Oral surgeon	8	18.2
Anesthesiologist	7	15.9
Not reported	4	9.1
Facility		
Office	31	70.5
Surgery center/hospital	6	13.6
Not reported	7	15.9

With permission from John Wiley & Sons. Lee et al. [40]
The characteristics of media reports of pediatric dental deaths by patient age, dental procedure type, anesthetic depth, specialty of anesthesia provider, and facility
The total number of deaths and proportion within categories are reported
Notations for patients with preexisting medical conditions are as follows:
[a]1 patient with a postmortem diagnosis of congenital heart disease
[b]1 patient with preoperative diagnosis of pulmonary stenosis
[c]1 patient with preoperative diagnosis of Treacher Collins syndrome

Other attempt to evaluate the nature and cause of deaths due to anesthesia or sedation in dentistry was recently made using an extensive search of the lay press. In this study Lee et al. uncovered 44 cases through a Lexis-Nexis search [40]. The reported deaths were most often in 2–5-year olds (21/44) and in the office setting (21/44) with a general/pediatric dentist as the provider (25/44) (see Table 11.2).

While these reports are incomplete compilations with significant bias related to the methodologies used, some useful trends are identified. Very young patients and the office setting are clearly associated with the worst outcomes. Notably, however, almost none of these reports involve GA provided by an anesthesia-trained professional utilizing monitoring and quality measures that are up to the standards of the American Academy of Pediatric Dentistry, American Academy of Pediatrics, and American Society of Anesthesiology. Indeed, in the surgical literature, data on GA for children (in general) indicate that it is relatively safe when practiced by specifically trained providers in appropriate settings with rates of death or serious injury as low as 0.25/10,000 anesthetics.

Summary

General anesthesia for pediatric dentistry remains an important option for patients with specific psychological and physical health problems. Acceptance of GA as a methodology for completing treatment in difficult patients has risen over the last several decades, and the overall rate of use also appears to be on the rise. Progress in the delivery of anesthesia (in general) has resulted in improved outcomes and safety for pediatric patients. On the other hand, wait times for GA care can be prolonged and the availability of anesthesia resources is not consistent. Dental professionals must weigh their own skill/training in distraction or sedation and their practice setting against the cost and availability of GA to formulate the ideal management plan for their challenging patients.

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Practitioner Training in Procedural Sedation

12

Sujatha S. Sivaraman and Paul S. Casamassimo

Abstract

Practitioner training begins in dental school and can progress in advanced training and after graduation with continuing education courses. Training is based largely on sedation guidelines. Previous emphasis on drugs and pharmacology in training has diminished due to safety concerns. Training in accredited dental educational programs usually offers more rigor, control, and scientific base than courses found in the marketplace, and some specialty training programs specify requirements. States mandate training in a highly variable matrix of rules, equipment, emergency preparedness, and experiential thresholds for acquiring approval to provide sedation. Both accredited educational training offerings and those in the marketplace attempt to provide training to reach the standards set by the states for clinical practice. Auxiliary participants in procedural sedation also have access to training to fulfill personnel requirements in state practice acts and sedation guidelines. Training in procedural sedation continues to evolve as laws, technology, dental practice, and the clinical science of sedation change. State requirements for continuing education to maintain skills vary. Quality measurement, continuing competency requirements, and accountability for clinical outcomes will affect training in the future.

Introduction

Practitioner training begins in dental school and can progress in advanced training and after graduation with continuing education courses. Training today is based largely on sedation guidelines which share the common elements among those offering them of the process of sedation and management of sedation-related emergencies. Previous emphasis on drugs and

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pharmacology in training has diminished due to safety concerns. Training in the accredited dental educational system usually offers more rigor, control, and scientific base than courses found in the marketplace. States mandate training in a highly variable matrix, some with clear qualifications and patient numbers and others not. Both accredited educational training offerings and those in the marketplace attempt to provide training to reach the standards set by the states for clinical practice. Auxiliary participants in procedural sedation also have access to training to fulfill personnel requirements in state practice acts and sedation guidelines. Training in procedural sedation continues to evolve as laws, technology, dental practice, and the clinical science of sedation change. Quality measurement, continuing competency requirements, and accountability for clinical outcomes will affect training in the future.

Training of providers in procedural sedation ranks only second in importance to the implementation of clinical guidelines when it comes to safety. Across the country, variation exists in required training for dentists who wish to engage in sedation practice. These variations begin in training and extend to certification of providers in the licensure arena. Some of the variation follows function. That is, provider application of sedation may run a gamut of intensity, with some providing only analgesia, while others render patients into deep sedation using more advanced medications with a higher need for rescue. Consistent across procedural sedation for the combined operator-anesthetist provider is the need to have training in all elements of sedation from preoperative assessment through discharge, with both technical and basic science background. At the clinical level, training must include adequate practice (usually considered numbers of patients treated under supervision), rigorous continued assessment to attest to competency, and testing of responsiveness of providers to emergent situations. New to dental practice but growing in importance is continuing competency and ongoing quality measurement of outcomes and provider skills. These last two elements are common in hospital practice and credentialing but not well established in the dental sedation arena of dental practice.

This chapter will look at sedation training of student providers as well as options for postgraduate and continuing education available for the experienced and novice provider. Because of the constant evolution of sedation guidelines, state practice rules, technology, and pharmacology, among other factors, it would be difficult to offer anything other than a cross-section in time related to provider training. An example at the time of the writing of this chapter is the consideration of a requirement for capnography for procedural sedation in dentistry. The benefit of an additional measure of ventilation and physiologic response is incontrovertible, but the technical aspects of capnography, particularly for the active or resistive child, remain daunting. Similarly, drugs come into and go out of favor, as was the case with chloral hydrate, which is less and less a drug of choice for oral procedural sedation. Finally, in this chapter, providers will be defined broadly to include dentists, specialists, and auxiliary personnel who in many states can assist in sedation according to state law.

Figure 12.1 is an attempt to portray the forces at work in the training of providers of sedation services in the dental care system. Dental education provides a coarse basic biomedical science background as well as behavioral science, medical management of emergencies, and a basic understanding of the physiology and anatomy important in procedural sedation. Pain control is another subject area common to predoctoral dental education. Since sedation is not a procedure graduates routinely take with them in to practice, what is learned in dental school must be seen as a primer to the broad areas of importance in sedation. Information provided by advanced training and/or community-based continuing education enhances that basic knowledge. Finally, the entire training cosmos includes ever-changing pressures and factors such as accepted practice mores, improved sedation guidelines, credentialing and statutory change, and advances in technology and pharmacy, to name a few. The concept of a static educational base for sedation

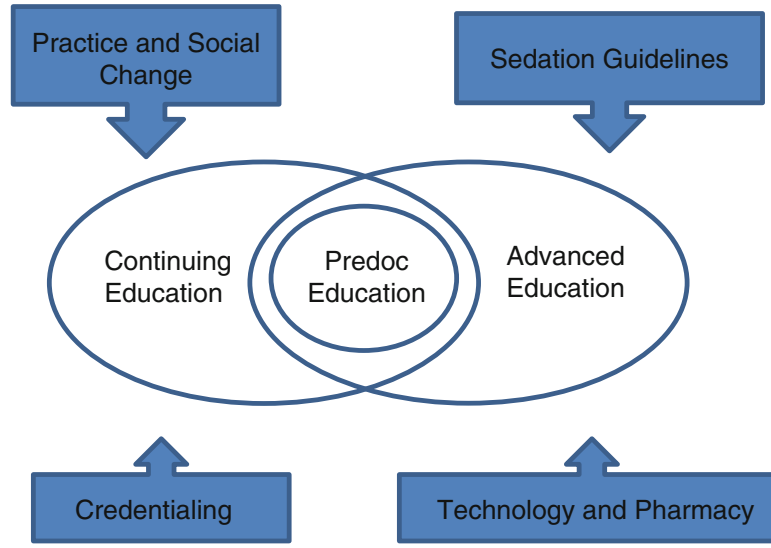

Fig. 12.1 The sedation training cosmos and factors affecting change

training is outdated as factors in the health environment change over time.

The reader should be aware that by the time of publication, some information may be outdated and new information not included. The authors have attempted to make this point-in-time presentation timely and accurate. At the same time, readers should be advised to consult with appropriate sources to determine state-of-the-art and contemporary local or regional educational and training requirements.

Rules and Regulations Governing Sedation

While academic interests and proclivities shape training in sedation to a large degree in the realm of science, state regulation governs sedation practice in dentistry. In about a dozen years, a threefold increase occurred in the number of state dental boards regulating oral sedation from 14 states (28 %) in 2001 requiring a permit to administer oral sedation to 41 states currently (82 %).

While sedation laws vary from state to state, the content is largely similar and based on contemporary sedation practice [1]. Variance across states can be attributed to a host of factors, not the least of which is political influence. In some states, permits are based on the route of administration, such as inhalational, enteral, and parenteral sedation. The permit requirements in other states are based on the level of consciousness and sedation defined in terms of minimal, moderate, and deep sedation. Most commonly, states require basic life support (BLS) training, in addition to licensure for administration of nitrous oxide/oxygen, for analgesia and minimal sedation, while continuing education and advanced training such as Pediatric Advanced Life Support (PALS) and Advanced Cardiac Life Support (ACLS) are required to obtain moderate and deep sedation permits. These requirements drive training in academic institutions to some degree.

At the time of this writing, some states do not require a separate permit for administration of nitrous oxide and oxygen and administration of antianxiety medications. Michigan and the District of Columbia do not require permits but require the provider to satisfy the board requirements to administer sedation and general anesthesia. Lapointe et al. stated that 41 states out of 50 require a permit to administer oral sedation [2]. Alaska, Connecticut, Indiana, Michigan, Nebraska, and South Dakota do not require a permit for administration of enteral or oral conscious sedation. On the other hand, Florida, Kentucky, Missouri, North Carolina, and Oklahoma

mandate a separate permit for pediatric conscious sedation. The only state, at the time of writing this chapter, that requires a permit for anxiolysis was West Virginia. The permits for general anesthesia, parenteral sedation, and oral conscious sedation most often need to be renewed annually, biennially, or triennially, while in Idaho, there is a 5-year renewal period. The training requirements for renewal are also variable with some states requiring none.

In addition to the provider training and certification, some states mandate the need to inspect the office where sedation is performed. Consultants appointed by the board will inspect the office for operatory and equipment requirements, emergency equipment, required drugs, and written emergency protocol. In addition to evaluation of the above, the consultants will evaluate the applicant's knowledge in the use of the required equipment and drugs in administering the sedation. Some states also have additional regulations with respect to medications used, maintenance of patient records, patient scheduling, discharge criteria, and use of other providers like physician anesthesiologists and nurse anesthetist. Clearly, while these checkpoints might be considered in the area of practitioner preparedness, they entail a training component.

Rules and regulations for every state, and thus provider education, are constantly evolving to improve the safety of patients treated with sedation and general anesthesia. The ADA, in addition to listing the sedation guidelines, also provides information with respect to requirements to obtain permits in different states. The other source for information on rules and regulations governing sedation and dental anesthesiology can be found in *Dental Anesthesiology: A Guide to the Rules and Regulations* [3]. As mentioned above, since regulations are constantly changing, readers are advised to contact their respective boards for more updated information with respect to sedation and general anesthesia in their state.

In summary, individual state dental boards use their state dental practice acts to protect patient's safety and welfare and thus influence provider training. State law supersedes those sedation guidelines approved and propagated by national organizations such as the American Dental Association (ADA), American Academy of Pediatric Dentistry (AAPD), and the American Association of Oral and Maxillofacial Surgeons (AAOMS). This necessitates the need for all states to act in a unified manner and develop similar guidelines to decrease adverse events and reduce confusion. To do so would help educational institutions and organizations to develop standardized continuing education courses and training without much variation. This in turn will increase patient safety and provider compliance with sedation regulations. Sedation permit requirements are available online for most states.

Predoctoral Dental Education Training

Currently, no requirement exists for training dentists in sedative techniques, according to the most recent iteration of the accreditation standards for predoctoral dental education. The most recent standards are general in nature and do mandate that a graduate who is deemed competent to practice (1) have biomedical and behavioral science training, (2) be able to handle certain medical emergencies, and (3) be able to manage pain and anxiety in patients [4]. In implementation of these three areas relevant to sedation, depth and variation exist across the spectrum of dental education, with no exposure to and competence in sedation a guarantee. Some dental education programs offer exposure to nitrous oxide/oxygen analgesia to selected students but without a specific competency requirement; these experiences are variable. A few dental education programs offer elective experiences in various forms of sedation but limit student experiences. Some of these aim to provide adequate numbers of cases to enable participants to approach or meet state requirements for sedation certification upon graduation. In summary, predoctoral dental education does not uniformly graduate practitioners with sedation competency but does provide some prerequisites necessary for certification and practice. A small but unknown number of dentists do

acquire basic skills in their predoctoral education program that would permit acquisition of permits in some states.

Postdoctoral Dental Education Training

Table 12.1 portrays the disposition of sedation training in standards for the dental specialties [5]. Characteristics of these training standards are a wide range of experiences, ranging from pain and anxiety control in rather nonspecific language to specific reference to documents and guidelines, numbers and types of patient experiences, and adjunctive qualifications such as ACLS or PALS. To some degree, the waning concept of the operator-anesthetist drives the intensity of training in sedation across specialties. Oral and maxillofacial surgery and pediatric dentistry are two specialties that utilize this dual role in day-to-day practice. It also appears that when a specialty organization has a policy on sedation or its own guidelines, it tends to have more specific and rigorous training standards. Diagnostic specialties such as oral and maxillofacial pathology and radiology do not have strict training mentioned in their advanced standards which is understandable by the nature of their scope of practice and lack of need for these skills. Specialties and accredited training programs that have numbers of cases also tend to have required training encompassing all of the areas that are common to sedation guidelines such as basic biomedical science, assessment of patients, pharmacology, and management of emergencies (some requiring advanced skills). The numbers maximally are intended to provide the perceived broad experience to insure safety in practice upon graduation and minimally to meet the typical number of cases required by states for certification in some form of sedation. Specialty programs are also moving toward a long-standing medical practice of case logs for sedation patients treated in training as licensing authorities move to more intense scrutiny of training in light of publicized morbidity and mortality from sedation.

In summary, a wide range of training exists among advanced programs in dentistry, which is perhaps reflective of the perceived need for those skills in day-to-day practice of the respective specialty. Readers are encouraged to review training standards on the website of the Commission on Dental Accreditation as these are subject to change and are reviewed and revised on a periodic basis by the respective specialty or accredited interest area in dentistry.

Table 12.1 Sedation treatment in postdoctoral specialty and other accreditation standards

Dental specialty or accredited area[a]	Guidelines on sedation	Sedation in training standards	Biomed and other requisites[b]	Patient numbers and/or types required[c]
Dental anesthesia	Yes	Yes	Yes	Yes
Advanced general dentistry	Yes[d]	Pain and anxiety management only	No	No
Oral and maxillofacial surgery	Yes	Yes	Yes	Yes
Oral and maxillofacial radiology	No	No	Yes	No
Pediatric dentistry	Yes	Yes	Yes	Yes
Periodontology	No	Yes	Yes	No
Endodontics	No	Pain and anxiety management only	Yes	No

[a]Specialties not listed do not have appropriate training in their standards
[b]Requires teaching of areas that would qualify for a part of sedation training
[c]Mandates numbers of cases and in some instances, patient types such as pediatric
[d]Academic of General Dentistry guidelines

Auxiliary Personnel

Statutes and guidelines addressing sedation often specify the role of dental hygienists and dental assistants in sedation procedures. The ability of dental hygienists to initiate, monitor, and adjust nitrous oxide/oxygen analgesia varies from state to state, with some allowing no participation and other states allowing any or all of the above functions, under various levels of dentist supervision. Sedation guidelines also specify roles for other non-dentists and lesser trained and skilled personnel. Ubiquitous in guidelines is the term "appropriately trained" when referring to additional personnel involved in a sedation procedure, and while vague in most cases, the presumption is familiarity with the procedure, training in aspects like monitoring and recording, and the ability to participate in emergency management of complications related to sedation. Certification in BLS is often separately mentioned in guidelines perhaps to leave no doubt as to its perceived benefit in case of emergency. Some guidelines also specify increasing numbers of appropriately trained adjunctive personnel for intended deeper levels of sedation. The vagueness of terminology and lack of clear specification of skills on the one hand leave discretion to the provider of sedation as to staffing of procedures but, on the other hand, place responsibility on that provider to adequately provide a safe and effective service. Boynes provides an excellent summary of the nature of auxiliary participation and statutory limitations related to sedation [3].

Content of Training

Over the last two decades or more, the content of training programs has changed and followed the advances in procedural sedation. An historical perspective is beyond this chapter, but some commentary on the evolution of sedation education is helpful. Early on, the focus was pharmacology-driven. Knowledge of drugs, their benefits, modes of action, and side effects were the basis for much education. In pediatric dentistry, the foundation of sedation training was on patient and drug selection to achieve an outcome which was usually immobilization of the patient to allow achievement of an acceptable clinical procedural goal. In other dental specialties, particularly when the desired outcome was a deeper level of sedation, content of education included more procedural elements of monitoring, maintenance, and recovery. With recognition of untoward outcomes of procedural sedation [6], a sea of change in education content occurred which can best be summarized as addressing two major areas: the process of sedation and management of sedation-related emergencies. The process of sedation transformed an educational system of silo areas into a unified sequence of interrelated procedures and steps that intended to raise the safety of procedural sedation. Review of and preparation for sedation-related emergencies and their management and the staging of ASA classifications into a sedation risk framework also were intended to reduce the likelihood of unexpected results.

Table 12.2 provides a composite of (1) common areas included in contemporary guidelines and (2) the topical areas in training for procedural sedation. While not all guidelines place the same emphasis on each area, most cover them based on a desired educational outcome and the address of major areas is almost universal. It is safe to say that the content depth is driven by the goals of sedation in respective realms of practice. For example, pediatric dentists whose range of procedural sedation is mild to moderate with little expectation of reaching deep sedation would receive training emphasizing that approach. Oral and maxillofacial surgeons whose scope of practice includes general anesthesia would have training that would be more extensive and deeper within each area, yet maintain the basic format of sedation guidelines.

How the appropriate number of cases is determined is still another factor that varies by dental specialty. To some degree, the expected levels of sedation to be utilized by that specialty dictate that number. The expectation is that with more cases in training, the more likely the provider is to experience human variation and possible

Table 12.2 Guideline areas and common related content in provider training

Guideline area	Common training content	Comments
Definitions	Levels of sedation	Now consistent across most guidelines
	Verb meanings (e.g., must, shall)	
	Personnel	
	Training levels	
Goals of sedation	Safety	Now consistent across most guidelines
	Pain control	
	Behavior control	
	Reversibility	
	Personnel and training	
	Recovery and rescue	
Physiology related to sedation	Airway	Varies with level of sedation training desired
	Respiratory drive	
	Cardiovascular	
	Other CNS effects	
Pre-sedation phase	Consent	Now consistent across guidelines
	Review of systems	
	Physical examination	
	ASA classification	
	Risk assessment	
	Dietary issues	
	Documentation	
Intraoperative phase	Monitoring	Varies with level of sedation training desired
	Positioning/immobilization	
	Clinical status	
	Documentation	
Recovery phase	Discharge criteria	
	Post-sedation care	
	Rescue preparedness	
	Documentation	
Drugs	Sedative medications	Wide variations and choices in relation to the depth and routes of administration
	Interactions	
	Combinations	
	Local anesthesia	
	Routes of administration	
Equipment/devices	Monitors	
	Rescue devices	
	Immobilization	
Emergencies	Potential complications	Continuing competency and quality assurance areas to grow and be incorporated into future guidelines
	Equipment and drugs	
	Personnel training	
	Drills and readiness	
	EMS	
Other	State and institutional requirements and credentialing	Eventual movement from the operator-anesthesiologist model to the partner model of anesthesiologist working with surgeon-operator
	Combined operator/sedation model	
	Dental anesthesiologists	

untoward complications of the process. Another unclear aspect of training is how it is provided temporally during advanced training. In other words, is exposure all at once in an intensive period within overall training or done sporadically, perhaps with observation or, assisting done prior to actual direction of a sedative procedure. Each specialty approaches this differently. Some limited evidence suggests that regular, interrupted experiences across extended training maintain skills and freshness in trainees.

Continuing Education

Sedation continuing education courses address specific needs of practitioners. Courses offered teach practitioners administration and monitoring of nitrous oxide inhalational anesthesia as a basic set of skills in the sedation continuum. More advanced procedural sedation courses address safe and effective use of oral sedatives as well as nitrous oxide in obtaining mild and moderate levels of sedation. Separate courses are available for parenteral techniques. Intravenous (IV) sedation courses usually include didactic training in addition to 20–30 clinical dental cases. These courses occasionally also include BLS and advanced training in airway management, and many courses are specifically tailored to meet state requirements for an oral sedation permit or its renewal.

Continuing education courses include web-based sedation didactic courses and a combination of didactic and clinical experiences. The clinical experience usually includes hands-on simulator training, while some IV sedation courses offer direct participation in administering IV sedation to dental patients. Clearly, the growth is in simulation as the headaches of patient scheduling, credentialing of learner-providers, and the ease of manipulating simulators for specific ends trump the on-site, single location hands-on patient model. Courses are taught by dentists, pediatric dentists, dental anesthesiologists, anesthesiologists, oral and maxillofacial surgeons, or a combination of the above, depending upon the intended content and audience. Because of the dominance of the operator-anesthetist model, multiple education providers may be desirable as expertise in different phases is important. Similarly, point-in-time courses that require presence of learners must provide optimal intensity in a short period of time. Online courses can pace learning and extend length to accommodate learner schedules. Courses identified in this chapter are offered to general dentists, specialists, dental hygienists, and some to the dental team which includes the dentist administering the sedation and the dental auxiliaries who plays a vital role in monitoring and assisting the sedation procedures, as well as playing key roles in emergency management.

The continuing education marketplace has quality protections on process including managing conflict of interest and tempering proprietary influence but less so on content which is often driven by continuing education provider. Various dental organizations, regulatory agencies, and organizations are aided in their efforts to service dental practitioners with quality continuing education through application and review processes known as the ADA Continuing Education Recognition Program (ADA CERP) [7] provider and the Academy of General Dentistry Program Approval for Continuing Education (PACE). As mentioned above, this is a service to assist dental professionals in identifying quality providers of continuing dental education. In addition, institutions of higher education in most professions have policies demanding attention to strict transparency in continuing education courses with *a priori* identification of relationships of speakers and provision of this information to participants. Some require course teachers to provide the scientific basis of courses through reading lists.

Dentists wishing to practice sedation have access to different continuing education courses for different levels of sedation. The goals of these courses are primarily to teach safe and effective techniques as well as management of medical emergencies in a dental office setting. Courses are designed for providers who are interested in initiating sedation practice in their offices and also those who are interested in renewing their

permits to practice sedation. Various courses are available and approved by the ADA and American Academy of General Dentistry. The specialty organizations offer their own sedation courses specifically tailored to the needs of their members. The AAPD [8] and Association of Diplomates of the American Board of Pediatric Dentistry offer sedation courses for pediatric dentists to train them in providing different levels of sedation in children. Similarly, American Academy of Periodontology and the AAOMS offer sedation and anesthesia courses. These courses provide their members an opportunity to obtain continuing education and updated knowledge in sedation.

The American Dental Society of Anesthesiologists [9] provides courses for dental practitioners interested in safe and effective administration of general anesthesia, sedation, and the control of dental anxiety and pain. The courses offered at this writing are general anesthesia/deep sedation and minimal/moderate sedation review. Courses are also offered using human simulation and preparing auxiliaries with "appropriate skills" in an assistants' sedation/anesthesia course. In addition to the different specialty organizations, dental schools also offer various courses in nitrous oxide and oxygen analgesia and conscious sedation. At this writing, schools that offer such courses include the University of Pittsburgh-School of Dental Medicine, University of North Carolina-School of Dentistry, University of Detroit Mercy-School of Dentistry, University of Florida-College of Dentistry, and University of Minnesota-School of Dentistry to name a few, and information is accessible to the public on the Internet. Dental hygiene schools across the country also offer nitrous oxide/oxygen analgesia courses that bring dental hygienists to the level of participation as allowed by law in those jurisdictions. Table 12.3 offers a smattering of course offerings searched at the time of writing, but may not include all courses, courses advertised only to a fixed audience, or courses already concluded in the period prior to the search.

Proprietary interests may also offer courses related to products or devices. Organizations promoting a particular procedure such as the use of triazolam (Halcyon) in general dental practice may offer training in that procedure. The continuing education marketplace in sedation is driven by demand for courses, promotion of techniques and products, and other factors. The oversight of this training resource is highly variable. The continuing education marketplace is less regulated than educational programs and *caveat emptor* prevails to some degree outside the formal dental education system.

In summary, a wide range of continuing education courses are available to educate and train dental practitioners in their desired level of administration of sedation.

Table 12.3 Examples of continuing education in sedation in the United States

Certified	Cost*	Course title	Location	Purpose	Audience	CE credits
Yes	$1695–650	Adult Oral Sedation Permit Course	Texas	Requirements to obtain an adult sedation permit	Dental assistant, dental hygienist, dentist, general practitioner, specialist	25
Yes	$500	Nitrous Oxide and Oxygen Conscious Sedation Workshop	Missouri	N2O/02 certification	Dentist/dental hygienist	14
Yes	$995–1195	Contemporary Sedation of Children for the Dental Practice: Enteral & Parenteral Techniques	California	Child personality and drug selection	Dentist, general practitioner, specialist	19

(continued)

Table 12.3 (continued)

Certified	Cost*	Course title	Location	Purpose	Audience	CE credits
Yes	$1550	Management of Pediatric Sedation Emergencies: A Simulation Course	California	Emergencies and complications	Dentist, specialist	
Yes	$550–275	Dental Sedation Permit Renewal Course	Utah	Sedation permit renewal	Dental assistant, dental hygienist, dentist, general practitioner, specialist	8
Yes	$12,500	IV Sedation Training for Dentists	Utah	Sedation permit qualification	Dental assistant, dental hygienist, dentist, general practitioner, specialist	100
Yes	$250	Monitoring Nitrous Oxide and Oxygen Conscious Sedation	Missouri	Auxiliary role	Dentist, dental hygienist	7
Yes	$150–400	Office-Based Dental Sedation in the Twenty-first Century: Pharmacological Approaches to Managing the Pediatric Dental Patient—day 1	Pennsylvania	Sedation procedures	Dentist, general practitioner, specialist	6
Yes	Not listed	A Review of Oral Sedation of Children for Dental Procedures: Its Current Status with Dr. Stephen Wilson	North Carolina	Overview of guidelines and procedures	Dental assistant, dental hygienist, dentist, general practitioner, specialist	6
Yes	Not listed	Nitrous Oxide/ Oxygen Sedation for the Dental Hygienist and Registered Dental Assistant	Michigan	Auxiliary role	Dental assistant, dental hygienist	9
Yes	$699–499	Nitrous Oxide Psychosedation: Certification	Florida	Review for certification for auxiliaries	Dental assistant, dental hygienist, dentist	20
Yes	Not listed	Nitrous Oxide/ Oxygen Inhalation Sedation: A Training Program	Minnesota	Certification	Dental assistant, dental hygienist, general practitioner, specialist	12
Yes	$99	Pediatric Sedation Emergencies: Can They Be Avoided?	National	Emergency overview	Not listed	1
Yes	$1500	Sedating the Pediatric Dental Patient: A Seminar And Clinical Simulation	Texas	Guidelines and procedures (part hands on)	Pediatric dentists—diplomates only	14 + 4

* U.S. dollars

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Emergency Management

13

Steven I. Ganzberg

Abstract

The pediatric dentist commonly provides minimal and moderate sedation in the office-based setting. The proper management of sedation emergencies is critical to ensure the safety of the children for whom we care. The vast majority of sedation-related emergencies occur when intended moderate sedation progresses to deep sedation or general anesthesia. Due the variability in both pharmacodynamic and pharmacokinetic sedative drug effects, even the "standard dose" may turn out to be an overdose in a susceptible patient. Airway complications are the most likely sedation-related complications in healthy children. Airway obstruction from the tongue, a foreign body, laryngospasm, and bronchospasm are the most probable diagnoses. The ability to provide positive pressure oxygen, with or without an oropharyngeal airway, is the most critical skill needed to rescue children from sedation-related emergencies aside from recognition that a problem has actually occurred. An algorithm for managing these airway emergencies is provided.

The pediatric dentist provides invasive procedures to very young children on a regular basis that are either too painful or extensive to be accomplished with local anesthesia alone even with the addition of minimal sedation. To this group of children, we must also add those who are uncooperative or have special needs that simply cannot be managed without some form of advanced pain and anxiety control. Many of these procedures could be accomplished in the operating room with general anesthesia if insurance companies acknowledged that these "dental" procedures are in some cases more invasive, or at least similar in invasiveness, to many "medical" procedures and thus extended their benefits accordingly. In addition to this challenge in our healthcare system is the widespread lack of training to competency of the technique of intravenously administered sedation in most

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pediatric dental residencies. Therefore, orally administered sedatives to minimal or moderate levels of sedation, with or without the addition of nitrous oxide/oxygen, has become the common form of sedation in the pediatric dental practice.

The majority of pediatric patients administered oral sedation in dental offices are American Society of Anesthesiologists (ASA) Physical Status I. For this group of children, the most common adverse event is related to airway complications. Young children are particularly prone to rapid desaturation secondary to airway compromise due to anatomic and physiologic factors including:

- Decreased number of alveoli until age 8 [1]
- Immature pulmonary vasculature surrounding the alveoli [2]
- Oxygen consumption 1.5–2 times that of the adult [3]
- Decreased functional residual capacity [4]

When reviewing retrospective data on pediatric sedative emergencies [5–7], it is clear that airway complications leading to hypoxemia with subsequent cardiac complications were the most frequently encountered emergencies regardless of provider type or venue. Although valid conclusions are difficult, if not impossible, to draw from retrospective studies, poor resuscitation and delay in activating emergency medical services (EMS) for support seem to be two factors in poor outcomes, particularly in the dental setting.

The preoperative identification of the pediatric patient at risk for airway complications should be a priority for every dentist contemplating sedation for his/her patient. Although the Mallampati scoring system is widely used as an airway assessment tool, the score is designed to predict difficult intubation, not mask ventilation. And it is the ability to mask ventilate a patient who is apneic, hypoventilating, or faced with soft tissue or other airway obstruction that will dictate successful resuscitation. Other prognosticators that might be of greater value in predicating the potential of difficult airway management include a detailed history of the following: presence of snoring at night, diagnosed obstructive sleep apnea, history of nocturnal enuresis, and possibly behavioral disorders that might, in part, be related to disordered nocturnal breathing. A focused physical examination observing the size of the tongue in relation to the mandibular vault, tonsil size, weight, mobility of the neck and TMJ adds important information. In children with a history of bronchospastic disease or recent URI, auscultation of the chest is important to detect the presence of preoperative wheezing or crackles.

A Guided Risk Assessment (GRA) to preoperatively identify patients at risk for sedation-related complications was created by Hoffman et al., in 2002 [8]. It important to note that five of the 12 (designated by **) factors studied were related to airway issues:

1. Snoring, stridor, or sleep apnea**
2. Craniofacial malformation**
3. History of airway difficulty**
4. Vomiting, bowel obstruction
5. Gastroesophageal reflux
6. Pneumonia or oxygen requirement**
7. Reactive airway disease**
8. Hypovolemia, cardiac disease
9. Sepsis
10. Altered mental state
11. History of sedation failure
12. Inadequate NPO time

The use of this GRA was found to improve outcomes in pediatric sedation. Other factors that appeared to contribute to complications included sedation utilizing multiple drugs as well as the use of chloral hydrate, whether part of a multidrug technique or not.

While the pediatric dentist should attempt to identify patients at an increased risk and prepare for specific sedation-related emergencies, he or she may also need to manage non-sedative-related medical emergencies that may be encountered in the dental office. Common medical emergencies that are most likely to occur in the pediatric dental office, such as an asthma attack, allergy/anaphylaxis, or seizures, will not be covered in this chapter as they are not directly sedation-related emergencies. Certainly, these emergencies can

occur as part of a sedation treatment and, when appropriate, will be discussed below.

Since airway obstruction or hypoventilation are clearly the primary initiating events in most dental office-based sedation emergencies, this chapter will focus on the recognition and management of various airway-related sedation emergencies. The American Academy of Pediatric Dentistry (AAPD) [9], as well as the American Dental Association [10], definition of moderate sedation includes the following statement: "No interventions are required to maintain a patent airway." This includes the most basic of interventions – the head tilt/jaw thrust maneuver used to open the airway in the patient experiencing the most common cause of sedation-related airway obstruction: the tongue moving posteriorly and fully or partially blocking the upper airway. Despite this type of airway obstruction in the adult patient, a response to a verbal command, such as "Mr. Smith, take a deep breath," might be sufficient to reinitiate breathing. The verbal command could be combined by "light tactile stimulation," such as gently shaking the shoulder. According to standard definitions, this patient would still meet the criteria of moderate sedation if these maneuvers reinitiated voluntary breathing and the patient was easily arousable [5, 6]. If, however, the head tilt and/or jaw thrust were required to eliminate airway obstruction, a state of deep sedation would be diagnosed. When the only response to a painful stimulus is reflex withdrawal or a repeated painful stimulus is necessary to arouse a sedated child, he/she is in deep sedation or general anesthesia; this must be recognized immediately, monitored and managed accordingly, and rescued back to a moderate level of sedation.

It must be appreciated that if a dentist is only educationally qualified and permitted to administer moderate sedation, any deviation into deep sedation and general anesthesia is fraught with the possibility of misadventure. The focus of the pediatric dentist is always to maintain the child in moderate sedation, and going further down the sedation/anesthesia continuum is likely the cause of mortality and morbidity in pediatric sedation. Moderate sedation-trained pediatric dentists cannot guarantee that all patients will be able to complete their treatment plans. There will be some unsuccessful sedations, but this should be viewed positively since the dangers of deep sedation could result in more serious consequences than incomplete dental treatment.

What are the dangers of an unqualified practitioner allowing their patient to enter a state of deep sedation? As a child becomes more deeply sedated, these respiratory issues may arise:

1. Progressive loss of airway due to increased loss of airway muscle tone. Almost all common pediatric sedation drugs depress ventilation and diminish muscle tone. Although a moderately sedated patient is the goal, a reduction in airway muscle tone can lead to collapse of upper airway structures leading to airway obstruction. With oral sedative drugs, the peak effect is not predictable or consistent, and drugs administered orally cannot be titrated to effect as they can be via the intravenous route. Hence, initial signs of airway obstruction may not be true indications of the impending airway collapse as peak drug effects may not have fully taken place. As greater airway muscle relaxation occurs, airway obstruction may no longer be overcome with simple head tilt and/or jaw thrust. Other more advanced airway rescue techniques, not normally practiced routinely by moderate sedation providers, may need to be emergently employed.
2. Laryngospasm. This is an acute airway emergency wherein a normal reflex – involuntary closure of the vocal cords to prevent aspiration – becomes hyperactive and life threatening in the deeply sedated patient. In the conscious patient, when a small amount of water or other material irritates the vocal cords, the body responds by coughing vigorously to clear the airway and forcing air into the lungs during brief inspirations. The vocal cords close partially to protect the delicate airway mucosa. This episode is colloquially referred to as "something went down the wrong pipe." In the deeply sedated patient with this type of stimulus, the vocal cords may close, or spasm, completely, leading to severe

hypoxemia and hypercarbia and is termed a "laryngospasm." Being trained to immediately diagnosis and respond to this emergency situation is one of the most important aspects in the training of dental deep sedation and general anesthesia providers. A laryngospasm may be overcome with the gentle application of positive pressure ventilation via a bag/valve/mask or in more resistant cases with a short-acting skeletal muscle relaxant, which should only be administered by those with advanced training.

3. Aspiration. Although not a common complication, regurgitation of gastric contents can occur in patients who lose their protective airway reflexes during deep sedation. Patients are at increased risk when emetogenic agents, such as opioids and chloral hydrate, are used. The aspiration of gastric contents is a major medical/sedative emergency and the combination of bronchospasm and physical obstruction of the airway can be life threatening.

All of the airway complications described above require advanced clinical and didactic training. Advanced Cardiac Life Support (ACLS) and Pediatric Advanced Life Support (PALS) are no substitutes for intensive hands-on emergency management taught to competency. When an airway emergency does occur, children desaturate quickly, and thus continual observation and monitoring of the child during sedation is mandatory to rapidly detect early signs of dropping oxygen saturation or poor ventilation before an airway event becomes critical.

In the following sections, emergency equipment and drugs will be reviewed as well as a suggested algorithm for initially managing these airway complications. The presence of equipment and drugs pales in significance to a well-functioning sedative dental team where all members have value and where communication skills are practiced and honed. Constant review and updating of emergency scenarios is a must to keep the team cohesive and prepared. The introduction of pediatric emergency simulation courses using high-fidelity human simulators combined with the tenets of Crisis Resource Management has resulted in educational programs for the entire pediatric dental team as offered by the AAPD, American Society of Dentist Anesthesiologists, American Dental Society of Anesthesiology, and possibly other groups.

Equipment and Drugs

The apparatus to deliver oxygen under positive pressure ventilation (PPV) is the single most important item of emergency equipment for overcoming apnea and soft tissue airway obstruction due to unintended deep levels of sedation. Besides an oxygen source, a bag/valve/mask with a reservoir combined with a full-face mask is required. There are many brands to choose from, but importantly, as with any emergency equipment in the pediatric dental office, pediatric- and adult-sized versions are required. The adult size is needed for larger adolescents and parents should a medical emergency occur. Emergency oxygen from a portable "E" cylinder when full (2000 psi on the pressure gauge) contains approximately 660 l of oxygen that can deliver approximately 60 min of oxygen at a flow rate of 10 l/min. Besides the portable "E" cylinder, oxygen can also be accessed via the nitrous oxide/oxygen unit with the appropriate adaptors. A portable E cylinder is still required should a medical emergency occur outside the operatory. A Robert Shaw demand valve that can deliver up to 50 psi oxygen is not advocated for PPV in children for moderate sedation trained dentists for its use can possibly result in barotrauma and pneumothorax.

Oropharyngeal airways (OPAs) in various sizes are important in overcoming soft tissue obstruction in an unconscious child. See Fig. 13.1a, b for proper positioning of the OPA. Placement of the OPA can be performed by depressing the tongue with a tongue blade and inserting the airway with the curve pointing caudal or by inserting it with the curve cephalad and turning it 180° when fully inserted. This skill should be practiced in dedicated simulation courses and/or basic life support, PALS, or ACLS courses. Nasopharyngeal airways may also be used, but the risk of nasal bleeding

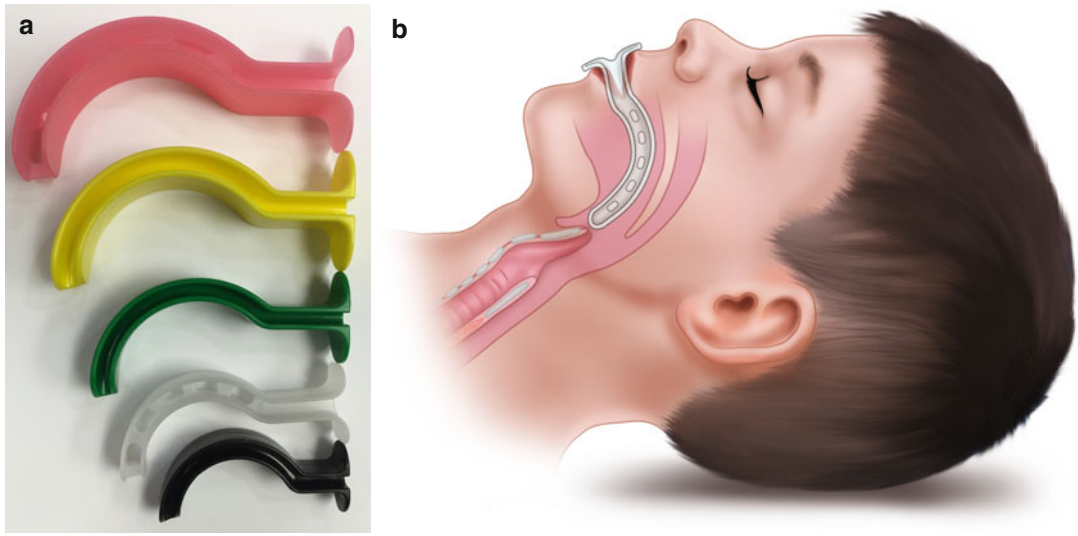

Fig. 13.1 (**a**, **b**) Oropharyngeal airways, sizing and in proper position

Fig. 13.2 Nasopharyngeal airways

during an airway emergency may limit their utility. See Fig. 13.2.

Various supraglottic airways can also be utilized in unconscious patients as advanced airway adjuncts and are indicated when BVM and the insertion of an oropharyngeal airway do not overcome soft tissue airway obstruction or the pressure needed to generate an adequate tidal volume is too high, such that gastric insufflation is likely. A supraglottic airway is generally easy to insert and provides a conduit for air directly to the glottic area. There are many to choose from and one commonly used type is the laryngeal mask of which various brands and designs are available. Of the laryngeal masks, the i-Gel brand does not require cuff inflation, has venting for gastric air, and does not fold at the tip. Therefore, the i-Gel may reduce tasks and ease placement such that PPV can be more rapidly provided in an emergency. Placement is generally uncomplicated, but repeated training in its use is required (Fig. 13.3). Another supraglottic airway, the King LTD, is one version of a supraglottic airway that enters the esophagus with inflatable cuffs that seal the esophagus and oropharynx. Fenestrations between the cuffs allow an attached BVM to provide ventilation to the glottis (Fig. 13.4). Although endotracheal intubation is the gold standard for securing the airway, endotracheal tube insertion is generally not in the skill set of the pediatric dentist (Fig. 13.5).

The AAPD recommends drugs and equipment that should be available in pediatric dental offices for both medical- and sedation-related emergencies. Significant latitude is allowed for individual practitioners, however. Tables 13.1, 13.2, and

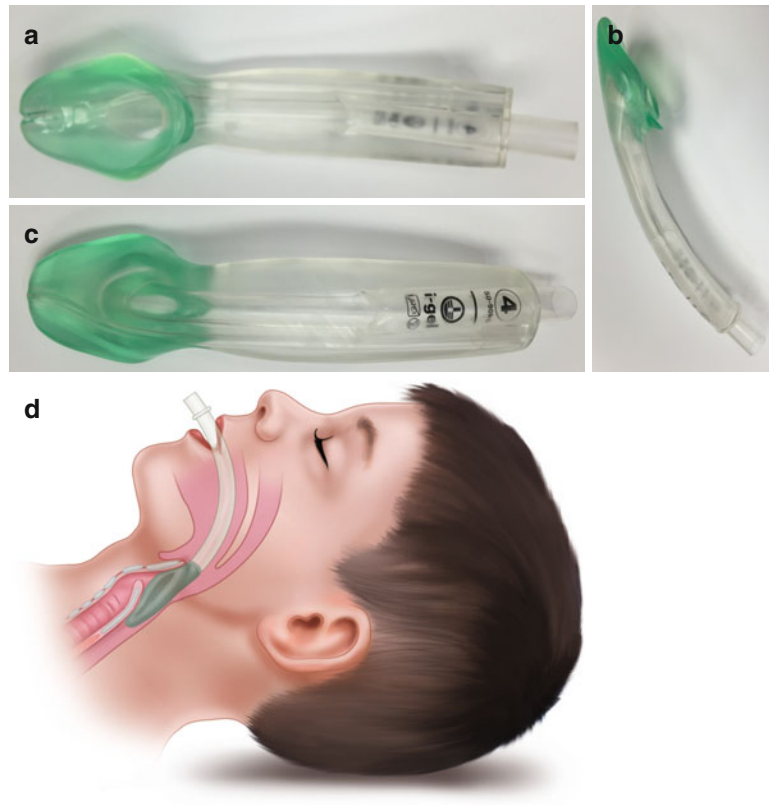

Fig. 13.3 (**a**–**d**) i-Gel laryngeal mask top, bottom and side views and laryngeal mask in position

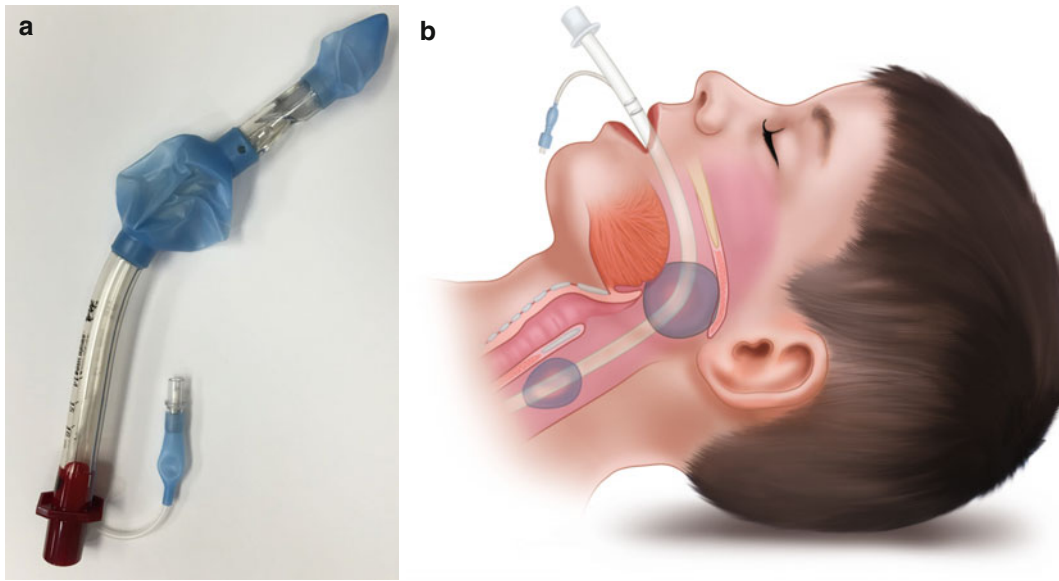

Fig. 13.4 (**a**) King LTD and (**b**) King LTD in position

13.3 list recommended AAPD medical emergency drugs as well as sedation emergency drugs and equipment listed in the 2007 Joint American Academy of Pediatrics (AAP)/AAPD Guideline for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic

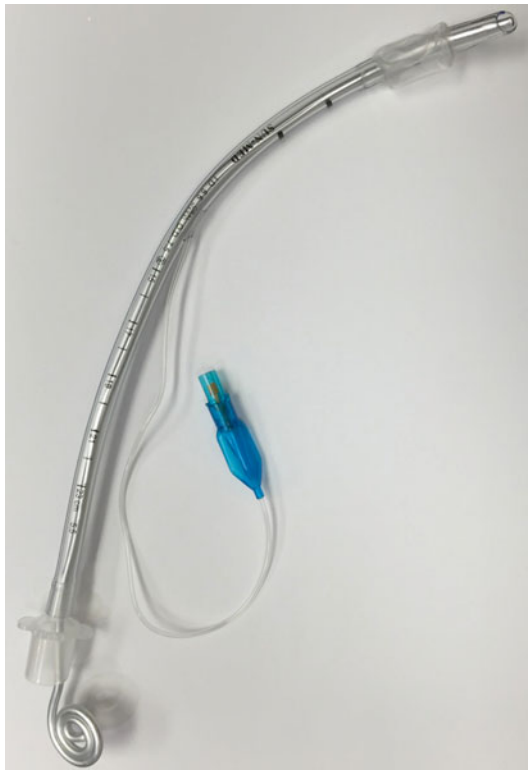

Fig. 13.5 Endotracheal tube with stylet

Table 13.1 AAPD recommended medical emergency drugs

Oxygen (with delivery device for PPV)
Diphenhydramine oral
Albuterol inhalation
Diazepam IV
Epinephrine 1:1000 IM
Flumazenil IV
Naloxone IV/IM
Ammonia inhalation
Syringes and needles prn

and Therapeutic Procedures [9] that can be modified based on provider training, skill, and practice. According to the Joint Guidelines, "The choice of emergency equipment may vary according to individual or procedural needs." Therefore, Tables 13.4, 13.5, and 13.6 list what the author considers a focused and practical medical and sedation emergency kit for the pediatric dentist providing office-based oral moderate sedation based on current training standards. All of these drugs and devices may not be discussed

Table 13.2 AAP/AAPD drugs that may be needed to rescue a sedated patient

All AAPD *medical* emergency drugs *and:*
Atropine IV/IM
Epinephrine 1:10,000 IV/IM
Lorazepam IV
Methylprednisolone IV
Fosphenytoin IV
Racemic epinephrine (inhalation)
Sodium bicarbonate IV
Dextrose (25 or 50 %) IV
Lidocaine (cardiac/local) IV
Succinylcholine IV/IM
Rocuronium (non-depolarizing paralytic) IV

in this chapter so the pediatric dentist is encouraged to review these tables carefully.

A number of basic and critical emergency drugs are required for the pediatric dental office setting in addition to oxygen as listed above. Epinephrine is a critical emergency drug for a number of emergencies, including bronchospasm, anaphylactic shock, and bradycardia secondary to severe hypoxia during sedation. The pediatric dose of epinephrine is 0.01 mg/kg to a maximum of 0.3 mg intramuscularly (IM). It can be delivered via an auto-injector (e.g., EpiPen), and they are available in adult (0.3 mg/dose) and pediatric doses (0.15 mg/dose). Although the FDA inserts suggest the EpiPen be used for patients over 30 kg and the EpiPen Jr. for patients under 30 kg for self-use, in the monitored environment of the dental office where a trained medical provider is present, the author's recommendation is to use the EpiPen for patients over 20 kg and the EpiPen Jr. for patients less than 20 kg. The author's rationale is based on the premise that epinephrine will only be used in the dental office if a truly life-threatening emergency is present on generally healthy patients. For the pediatric patient with cardiovascular disease, the lower dosing regimen can be used (but these children are unlikely to be sedated in a dental office). The alternative formulation for pediatric IM administration is 1:10,000 epinephrine in preloaded syringes. Each 1 ml of solution contains 0.1 mg of epinephrine. Hence, for every 10 mg of body weight, one ml of solution would be administered IM to a maximum individual dose of

Table 13.3 AAP/AAPD equipment that may be needed to rescue a sedated patient

Intravenous
Assorted IV catheters (24, 22, 20, 18, 16)
Tourniquets
Alcohol wipes
Adhesive tape
Assorted syringes (1, 3, 5, 10 ml)
IV tubing
Pediatric drip (60 drops/ml)
Pediatric burette
Adult drip (10 drops/ml)
Extension tubing
Three-way stopcock
IV fluids
Normal saline
Lactated Ringer's
D_5W/0.45 % saline
Pediatric IV boards
IV needles/butterflies
25, 22, 20, 18
Intraosseous bone marrow needle
Sterile gauze pads
Gloves (sterile and non-sterile)
Airway management equipment
Face masks
Infant, child, adult sizes
Bag/valve/mask set
Oropharyngeal airways
Infant, child, adult sizes
Nasopharyngeal airways
Small, medium, and large
Laryngeal mask airways
1, 1.5, 2, 2.5, 3, 4, 5
Laryngoscope handle
With extra batteries
Laryngoscope blades
With extra light bulbs
Straight (Miller) 1, 2, 3
Curved (Macintosh) 2, 3
Endotracheal tubes
Uncuffed
2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6
Cuffed
6, 7, 8
Stylettes and surgical lubricant
Suction catheters
Yankauer (tonsillar) suction
Nasogastric tubes
Nebulizer kit

Table 13.4 Author-recommended medical emergency drugs

Oxygen with PPV device
Epinephrine
Epinephrine auto-injector (e.g., EpiPen)
Adult 0.3 mg [2]
Pediatric 0.15 mg [2]
Or Epinephrine 1:10,000 IM [2]
Diphenhydramine
Oral 25 mg tabs and/or
Injectable 50 mg/ml IM
Albuterol inhaler, preferably with a chamber delivery device
Midazolam 5 mg/ml IM
Glucose oral
Appropriate needles and syringes for drug delivery

Table 13.5 Author-recommended drugs that may be needed to rescue a sedated patient

All recommended medical emergency drugs *and* *If you use opioids or benzodiazepines:*
Opioid reversal
Naloxone 0.4 mg/ml (one 10 ml vial)
Benzodiazepine reversal
Flumazenil 0.1 mg/ml (four 5 ml vials)
Note: the author does not recommend you have succinylcholine or other non-depolarizing skeletal muscle relaxants

Unless the dental board requires it

Table 13.6 Author-recommended equipment that may be needed to rescue a sedated patient

Airway
Assorted clear masks
Assorted oral airways and tongue blades
Bag/valve/mask for positive pressure
Ability to connect to 100 % oxygen source
Magill forceps
Supraglottic airway(s) (e.g., laryngeal mask such as i-Gel, King LT-Ds, assorted sizes)
Colorimetric CO_2 indicator to connect to BVM
Suction
Yankauer suction
Flexible suction tips
Adaptors
Lighting
Flashlight
Automated external defibrillator (AED) with pediatric capability

0.3 mg (e.g., 10 kg child gets 1 ml; 25 kg child gets 2.5 ml; 40 kg child gets 3 ml). Ampules or vials of epinephrine 1:1,000, or 1 mg/ml, may also be used but require more steps and calculations to obtain the desired dosage and may result in delay in administration.

For grand mal seizures that do not terminate in minutes, midazolam 5 mg/ml solution IM can be administered. The dose is 0.2 mg/kg to a maximum of 10 mg. This is preferable to diazepam which has erratic IM absorption. Intranasal (IN) midazolam can be considered if special mucosal atomizer devices are available. The IN dose is the same with a maximum of 1 ml or 5 mg per nostril. Onset is faster than IM but sedative level may also be increased. Parents or other caregivers may have other medications to manage seizures, such as rectal diazepam. Discussion regarding seizure management at home prior to dental treatment of the epileptic patient is advisable, especially if seizures persist despite optimal medical therapy.

The opioid reversal agent, naloxone 0.4 mg/ml (Narcan), is required if opioids are part of the sedation regimen. The pediatric dose in sedation emergencies involving apnea or hypoventilation is 0.1 mg/kg to a maximum of 2 mg IM. Higher doses will not result in harm, however, in the setting of pediatric dental sedation in non-opioid-dependent children. Hence, the recommendation for the pediatric dentist is to administer the full 2 mg (5 ml) to all patients who require opioid reversal. It should be appreciated that opioid effects may outlast naloxone reversal and re-sedation and/or respiratory depression may recur. Regardless, for the pediatric dentist, if opioid reversal is required, EMS should have been called and patient transport to the hospital would be appropriate. Since 5 ml of solution is required, it is appropriate to have one 10 ml vial of 0.4 mg/ml naloxone.

The benzodiazepine antagonist flumazenil 0.1 mg/ml (Romazicon) in 5 ml vials is required if benzodiazepines are part of the intended sedation regimen no matter the route of administration. Flumazenil is FDA approved for IV administration only. IM dosing regimens are not evidenced based. *Initial* IV dosing is 0.01 mg/kg to a maximum of 0.2 mg/dose. This is for initial dosing only and it is highly likely multiple IV doses will be required in the setting of benzodiazepine overdose. Clearly, higher doses will be required IM due to slower absorption than IV administration. Although without any scientific basis, the author would recommend a practical approach of initial dosing of 10 ml, or 1 mg, administered in two IM injections of 5 ml each. In benzodiazepine overdose, this will only aid resuscitation without harming the patient, particularly if EMS is delayed. Again, if reversal agents are needed, EMS should already have been contacted. Four 5 ml vials of flumazenil are recommended as the minimum that should be available.

When discussing IM administration, the standard medical emergency access sites for intramuscular drug delivery, the deltoid and vastus lateralis muscles, are appropriate for sedative emergency drugs. For smaller children, only a maximum of 3 ml should be used in the deltoid. Larger volumes should be administered in the lateral vastus. Whether the deltoid or the vastus is utilized, injection with a 22G, 1" needle can take place through thin clothing such as a shirt or jeans. Very thick clothing such as thick sweatshirts may pose an injection obstacle. Although the tongue can be used for IM administration, injection in this site frequently leads to bleeding which is undesirable in an emergency. Likewise, the sublingual region may bleed or the lingual artery may be encountered which can lead to rapid sublingual swelling. Although these sites can be used, their limitations should be appreciated. In addition, the volume of the required injection makes these sites impractical.

Intraosseous (IO) access, as taught in PALS (http://www.heart.org/HEARTORG/CPRAndECC/HealthcareProviders/Pediatrics/Pediatric-Advanced-Life-Support-PALS_UCM_303705_Article.jsp), has also been advocated for the pediatric dentist for emergency drug administration. If considered, this will require the pediatric dentist having (1) up-to-date clinical experience in obtaining IO access, (2) all the intravenous equipment and IV fluid available, and (3) a trained staff who can assist in the procedure

and understanding intraosseous dosing (same as for IV). If all of these criteria are met, then this may be an alternative to IM or emergent IV administration. This author's concern is that obtaining IO access takes the dentist away from his/her primary objective in a serious airway emergency: BVM ventilation with 100 % oxygen. If other dental/medical personnel are available for IO access and the above requirements are met, certainly, IO access can be considered for reversal agents. Epinephrine should always be administered IM unless the patient does not have a perfusing rhythm or the dentist has advanced general anesthesia training and PALS certification.

Every office should rehearse procuring outside emergency assistance. Only the dentist should activate this system by communication to an appropriate staff member who should make the call. Practicing exactly what information should be transmitted and what type of help to request, preferably paramedic-trained emergency medical technicians (EMT-Ps), is needed.

As critical as it is to have all the necessary equipment and drugs in the dental office, if they are not immediately available, valuable time will be lost managing a sedation-related emergency. *All of the appropriate emergency equipment and drugs should be immediately available in the operatory where sedation is taking place*. This one step can make the difference in appropriately and rapidly responding to an emergency. Utilizing a checklist prior to a procedure, thus assuring that all contingencies have been addressed, as well as working together as a team is important in obtaining a good outcome in a sedation-related emergency. Every team member should have an assigned role in the event of an emergency. Staff should be cross-trained in their roles in case of a missing team member. A specific team member should be assigned to assure that emergency equipment is ready (e.g., that there is sufficient pressure in the oxygen tank) and that emergency drugs are in place and expiration dates have been verified. Cognitive aids such as algorithms and drug doses should be immediately available for consultation. Every second counts when addressing the emergency needs of a sedated child, and time is not on our side during pediatric airway emergencies. The more rapidly and effectively we respond, the greater the likelihood that there will be a successful resuscitation.

Monitoring

This topic is thoroughly discussed in Chap. 7. Monitoring derives from the Latin root meaning "to warn," and that is exactly its role for the pediatric dentist: to anticipate and respond to sedative emergencies focusing on ventilation and oxygenation whether administering minimal/moderate or deep sedation. Monitoring of ventilation ranges from observing chest excursions and extends to the use of pretracheal/cordial stethoscope and capnography. Combining monitors is more than merely complementary but adds great value. Oxygenation is monitored by the pulse oximeter as well as observation of skin and mucous membrane color.

If the sedated child is crying or otherwise interacting during moderate sedation in which a pretracheal stethoscope is being used, the pediatric dentist need not have the earpiece stethoscope or speakers in place as clearly the patient is in a level of minimal or moderate sedation and the level of consciousness is obvious.

Causes of Oxygen Desaturation

Oxygen desaturation can occur during pediatric oral sedation and is most often attributed to respiratory depression or airway obstruction at various levels of the airway. Table 13.7 lists the differential diagnosis of common sedative airway emergencies.

The most common airway complication during pediatric sedation is seen when the upper airway is obstructed by the tongue due to the effects of sedating drugs causing skeletal muscle relaxation of the tongue and pharyngeal structures. Commonly, the head tilt and/or jaw thrust maneuver will correct

Table 13.7 Differential diagnosis of common airway emergencies in pediatric oral moderate sedation

Hypoventilation
Upper airway obstruction
Tongue
High foreign body
Vocal cord obstruction
Laryngospasm
Foreign body at vocal cords/cricoid cartilage
Lower airway
Bronchospasm
Foreign body below vocal cords

this obstruction, but even when correctly performed, this maneuver may not adequately displace the tongue off the posterior pharyngeal wall. The presence of a rubber dam, particularly if placed on the entire mandibular arch, may posteriorly displace the tongue and block the airway. The dam may need to be repositioned or removed and more carefully placed. Foreign body obstruction can occur from many objects of dental origin such as a gauze pack behind the tongue, cotton rolls, crowns, or extracted teeth. Remember that blind finger sweeps are not part of the American Heart Association algorithm for lost foreign objects in the hypopharynx, if this situation is encountered. Tying a piece of dental floss to the gauze throat screen with the end of the floss taped outside the mouth facilitates removal and prevents aspiration.

Obstruction can also occur lower in the upper airway at the level of the vocal cords. This condition is termed laryngospasm and was discussed previously. Persistent laryngospasm is a condition where the airway reflexes are hyperactive and stimulation results in sustained vocal cord closure with inability to ventilate. By definition, the patient is in a level of deep sedation. In minimal and moderate sedation as well as general anesthesia, laryngospasm does not occur.

Finally, there can be obstruction in the lower airway either by the acute constriction of the small muscles of the tracheobronchial tree (bronchospasm) or the presence of a foreign body (e.g., tooth, crown, gauze, particulate vomitus) blocking the airway. Silent aspiration of gastric contents can occur when a patient regurgitates and then aspirates gastric contents without signs of choking or coughing. This can occur whenever laryngeal reflexes are diminished due to central nervous depressants and commonly leads to bronchospasm.

Emergency Airway Algorithm

Although there are many possible etiologies of decreased oxygenation, in ASA I and well-controlled ASA II patients undergoing office-based pediatric oral sedation, conditions other than airway obstruction are very rare, and in any case, primary management would still follow the standard algorithm below.

Assuring adequate respiratory exchange and acting immediately to address ventilatory issues are the most important aspects in the care of sedated children. Immediate diagnosis of impending hypoxia and hypercarbia is first detected by close observation of the child by the team and is confirmed by appropriate respiratory monitors and auscultation. The immediate introduction of airway rescue maneuvers, discontinuation of nitrous oxide, use of basic and advanced airway rescue equipment, and possible pharmacologic reversal of sedative drugs must take place in the framework of a logical and practiced algorithm.

Supplemental oxygen should be utilized during all pediatric dental sedations, whether by nasal hood, with or without nitrous oxide, or via nasal cannula. This will ensure that the child will have an oxygen reserve to increase the time to hypoxia during an airway emergency.

Diagnosis of emergent airway issues is based on diminished breath sounds, lack or decrease in end tidal CO_2 ($ETCO_2$) measurements, decreasing hemoglobin saturation of oxygen by pulse oximetry (SpO_2) readings, and a progressive bradycardia. Bradycardia during a respiratory emergency is an ominous sign and it indicates an impending cardiac arrest. The two most likely causes of these warning signs are hypoventilation secondary to excessive sedative drug effect or upper airway

obstruction by the tongue and tissues in the hypopharynx. Both will result in diminished breath sounds, lack of $ETCO_2$, and decreasing SpO_2 levels. The initial response should be the application of the head tilt, and if needed, jaw thrust, maneuver. If breath sounds and/or $ETCO_2$ waveforms increase, the cause can be assumed to be airway obstruction secondary to the soft tissue obstruction. It must be appreciated that this situation could also indicate a level of deep sedation, for during moderate sedation, by definition the airway needs no interventions. If the child is unresponsive, decreasing nitrous oxide, considering reversal agents, and meticulously monitoring ventilation and oxygenation are required.

If, however, a simple head tilt and jaw thrust does not improve ventilation, the dentist should remove anything blocking visualization of chest excursions such as a dental bib or loose papoose board straps. As needed, upper garments can be pushed up to the neck to see abdominal/thoracic movements. Objects of dental origin should be removed from the mouth. This is a major respiratory emergency. If ventilatory effort is being made against an anatomical airway obstruction, a paradoxical breathing pattern will occur. As opposed to regular abdominal movement present in sedated patients who are ventilating normally, vigorous abdominal movement followed by higher accessory airway muscle activity will manifest itself as a "rocking horse" or paradoxical breathing pattern. This rocking horse breathing pattern is characterized by alternating rise and fall in the chest and stomach areas, respectively, with no airway movement. This breathing pattern diagnoses airway obstruction as opposed to hypoventilation or apnea in which regular abdominal breathing is shallow or absent.

If hypoventilation is suspected, all material is removed from the mouth if not already accomplished including the rubber dam, the airway is opened again via the head tilt, and as needed, the jaw thrust maneuver is performed. Stimulating the patient with a repeated trapezius muscle squeeze, sternal rub, or deep mandibular angle pressure (i.e., strong anteromedially directed deep digital pressure behind the ramus of the mandible in the "laryngospasm notch" located just anterior to the mastoid bone) will often increase ventilation. If ventilation does not improve, positive pressure oxygen will need to be instituted. At this point, there will likely be a decreased SpO_2. If initial attempts at PPV do not result in audible breath sounds or increasing $ETCO_2$, but most importantly adequate chest rise, an oropharyngeal airway should be inserted immediately and PPV reinstated. If lack or severely diminished ventilation was due to serious airway obstruction secondary to the tongue despite head tilt/jaw thrust, breathing should resume or the patient should be able to be ventilated or assisted via PPV. In the face of an unresponsive, obstructed patient necessitating the insertion of an oropharyngeal airway, it is evident that this child is either deeply sedated or in general anesthesia. If these actions result in good ventilation via PPV and a return to normal SpO2, the dentist should discontinue dental treatment and continue to support ventilation providing rescue breathing as taught in BLS. The patient is in respiratory arrest.

At this point, the dentist has three options:

(1) Continue to assist ventilation as needed until the child returns to a level of minimal to moderate sedation, and then resume treatment after assuring responsiveness and acceptable vital signs are present.
(2) Terminate the procedure and continue to assist ventilation as needed until the patient returns to a level of minimal sedation and discharge the patient only when appropriate criteria are met. Reschedule for general anesthesia or another oral sedation procedure with different drug dosing or a different drug regimen.
(3) Terminate the procedures and administer appropriate IM reversal agents if benzodiazepines and/or opioids have been administered, monitor the patient for a minimum of 2 hours, and discharge when criteria are met.

If despite opening the airway with head tilt/jaw thrust maneuvers, PPV with a BVM, insertion of

an oropharyngeal airway, and more attempts with PPV via BVM, ventilation is still impossible, then a life-threatening emergency is underway. EMS must be activated as soon as possible, but they will not arrive in time to rescue this patient without the dentist and staff continuing resuscitative efforts until EMS arrives. The obstruction may be below the tongue and possibly at the level of the vocal cords – laryngospasm is most likely the diagnosis assuming there is no obvious foreign body. It should be appreciated that if silent regurgitation of particulate gastric contents occurred, a foreign body may be present but not recognized. The hypopharynx should be suctioned with a Yankauer suction tip. The application of gentle and continuous PPV should continue in an attempt to break laryngospasm. If laryngospasm is suspected, the patient is by definition in a state of deep sedation. At late stages, hypoxia and unconsciousness will also break laryngospasm with resultant muscle relaxation occurring including that of the vocal cords. The SpO2 may, however, be very low at this point and the patient may be frankly cyanotic and becoming bradycardic. Continued overzealous PPV may lead to gastric insufflation with increased risk of regurgitation. It is at this point that the insertion of a supraglottic airway should be considered. The use of succinylcholine, a skeletal depolarizing muscle relaxant, is not recommended for those moderate sedation providers who are not trained to manage the paralyzed patient.

If continued attempts at PPV are still ineffective, hypoxemia will progress and the patient will begin to develop diminished heart rate and, eventually, frank bradycardia. Always remember that this is an airway emergency that has now degenerated into a cardiac one. Although IM epinephrine, 0.01 mg/kg up to 0.3 mg, should now be administered to treat hypoxemia-induced bradycardia and treat possible bronchospasm, it is the lack of oxygen and retention of carbon dioxide that is the root of the problem, and without relief, the patient will suffer severe neurologic morbidity and mortality. However, epinephrine will help preserve circulation, and treat bronchospasm if this is the cause of airway obstruction, for a short time while airway control maneuvers continue.

Efforts at PPV must continue until EMS arrives and assists or takes over rescue efforts. If at any point breath sounds resume, chest excursions are noted, and/or $ETCO_2$ increases, it should be appreciated that the SpO_2 will increase very gradually, particularly if it is very low. There is a significant lag time in the pulse oximeter registering resumption of adequate ventilation with 100 % oxygen. More importantly, all delivered oxygen is being distributed to vital organs and none is attaching to hemoglobin until tissue oxygenation is adequate. It may take several minutes for oxygen saturation to return to normal in this scenario.

A summary of this algorithm is presented in Fig. 13.6.

Prior to EMS arrival, the dentist should dispatch a predetermined staff member to talk to the parent/guardian and inform them that there is a complication which the team is managing. EMS has been called as a precaution. The dentist should always stay with the patient, manage the airway, and travel with EMS personnel, if possible, or follow them to the hospital. Once the patient has been admitted to the emergency department (ED) and the details of the case have been discussed with ED staff, the dentist should meet with the parents to discuss the events.

Once the dentist has returned to the dental office after the ED, the dentist should make detailed notes or write a narrative as to the events that occurred as soon as possible. The sedation record should be completed and all available information secured, such as the monitor printout. If the dentist feels it is appropriate, he/she should invite all staff members involved to do the same. The case should be discussed and the feelings and impressions of all staff members should be shared, if not immediately, soon thereafter. All policies and procedures should be reviewed, and if any changes in protocol seem appropriate, they should be instituted. Appropriate authorities and professional liability insurance providers must be notified.

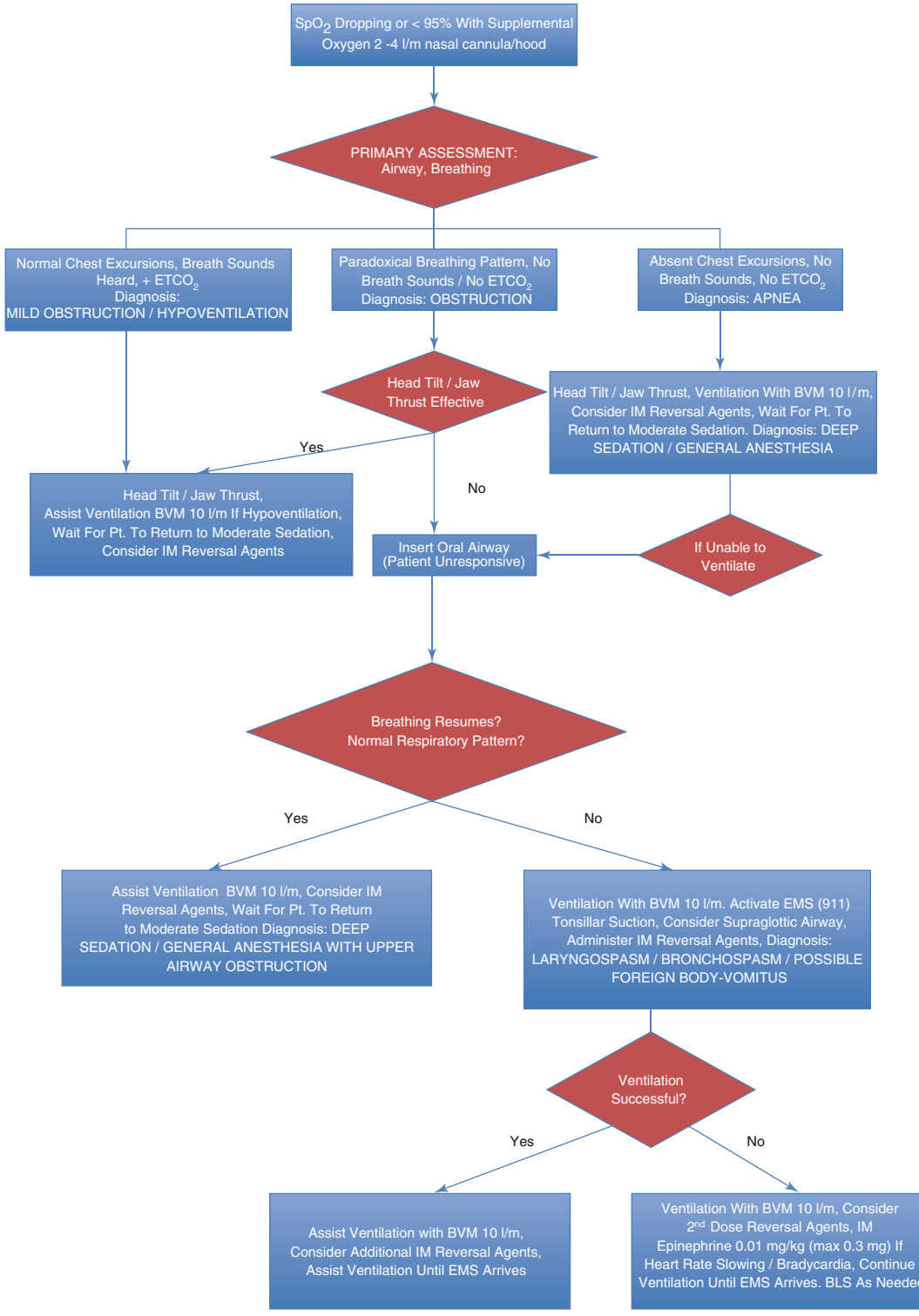

Fig. 13.6 Emergency airway algorithm for pediatric dental oral sedation providers (without IV capability) (*BVM* bag/valve/mask, *IM* intramuscular, *Epi* epinephrine) Note: BVM 10 l/m with 100 % O_2

Conclusion

Serious airway emergencies almost always occur when intended pediatric oral moderate sedation progresses to unintended deep sedation or general anesthesia. With standard dosing regimens, this is unlikely to occur. Of course, the pharmacokinetics and pharmacodynamics of sedative drugs are variable and there are always outlier patients for whom the "standard dose" is, in effect, an overdose that cannot be predicted. Having proscribed emergency drugs and equipment immediately available in the operatory where sedation is taking place can make the difference between a good outcome and an unacceptable one. Time is of the essence. Practicing emergency management on a regular basis with all staff, including new staff members, helps keep the entire team in a state of readiness. Alerting EMS in a timely manner when ventilation is not possible despite a properly placed oropharyngeal airway and attempts at PPV helps ensure that help is on the way. When proper guidelines, regulations, patient selection, and monitoring standards are followed, adverse events are very rare. However, they continue to occur, and all sedation providers must maintain constant vigilance and be prepared to manage acute emergency situations to ensure the health and well-being of these children who have entrusted us with their lives.

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Emergency Scenarios

14

Jeremiah L. Teague

Abstract

A medical emergency is an unanticipated complication that usually requires quick, focused, calm action to resolve a potentially life-threatening situation. The intent of this chapter is to present emergency scenarios focusing on simplified and logical process of managing the crisis in the dental office. We recommend that a written policy of emergency procedures be generated and discussed on a routine basis with the staff. Emergency protocols should be practiced a minimum of four times per year. The goal of managing an emergency should be to quickly stabilize the patient. To properly handle emergencies in the office setting, the dentist and key members of the team should review emergency protocols, identify in advance the resources and limitations of the practice, and take appropriate actions to correct or eliminate those limitations.

Emergencies

A medical emergency is an unanticipated complication that usually requires quick, focused, calm action to resolve a potentially life-threatening situation. The intent of this chapter is to present emergency scenarios focusing on simplified and logical process of managing the crisis in the dental office.

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We recommend that a written policy of emergency procedures be generated and discussed on a routine basis with the staff. Emergency protocols should be practiced a minimum of four times per year. The goal of managing an emergency should be to quickly stabilize the patient.

To properly handle emergencies in the office setting, the dentist and key members of the team should review emergency protocols, identify in advance the resources and limitations of the practice, and take appropriate actions to correct or eliminate those limitations. Critical management of emergencies most likely will require quick, focused action by the dental office team. If resolution of the complication cannot be rapidly and

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satisfactorily addressed, calling paramedics to the office is the next key step while continually assisting the patient using basic life support techniques. Transfer to an acute care facility where critical care staff is better suited to manage the acute and long-term aspects of the complication is usually indicated once paramedics are called to the office [1].

Although complications in the delivery of sedation for dental procedures are rare, emergency situations can occur that make it mandatory for certain types of equipment and medications to be readily available. An emergency cart should contain the necessary medications and equipment to resuscitate a non-breathing patient and address other conditions such as an allergic reaction, vomiting, hypoglycemia, and syncope [1].

It is highly likely that 99 % of medical emergencies that may occur in a pediatric office setting can be managed using three basic interventions. A thorough understanding of each will become significant in being prepared and confident when a medical emergency arises.

The first and most important intervention in almost every situation is the delivery of oxygen. The brain, without oxygen, suffers irreparable damage within 4–6 min. Death occurs within about 8 min. In each of the *emergency scenarios* that follow, oxygen *and its efficient delivery* will be paramount to rescuing a patient in virtually every emergency situation.

The second intervention is careful attention to patient positioning to facilitate airway patency. Favorable head positioning for dental procedures may not be best for ensuring airway patency. Many times, the simple jaw thrust-head tilt maneuver taught in every basic life support course to mechanically assist the lifting of the base of the tongue away from the posterior wall of the pharynx will open the airway to allow air exchange. Also, a shoulder roll to slightly lift the upper torso and facilitate airway opening in a sedated patient will often deter an impending desaturation crisis.

The third intervention is suction, which is almost always intended to also clear the airway of fluids and foreign material. Efficient suctioning to clear the oral cavity and especially the hypopharynx of debris, blood, saliva, and foreign particles is essential in an emergency involving an airway compromise – the most likely emergency to occur in a sedated child. Dental procedures themselves always encroach on the airway and tend to create secretions. Dental instrumentation and materials should be respected as potential foreign bodies. Meticulous attention to suctioning can aid in protection against aspiration of blood, irrigation fluid, or foreign bodies without interfering with completion of dental procedures.

In each situation involving oral sedation, emergency equipment to rescue a patient should always be nearby in the operatory and ready for immediate use. Seconds will count in a serious emergency.

The American Society of Anesthesiologists guidelines for office-based anesthesia [1] specifically address the challenges in dental offices. Procedure rooms in dental offices are usually small therefore compromising access to patients experiencing unexpected complications. Supplemental airway positioning devices that support the patient's upper torso, neck, and head can be helpful in passively assisting airway management. Dental offices may not have backup emergency power sources; therefore, lighting, communications, and monitoring equipment must have sufficient battery backup or battery-powered resources in the event of power failure. Provisions for backup suction must also be addressed.

Before administering any medications that may compromise respiration, verification of an adequately functioning means to deliver positive pressure ventilation must be made. A bag-valve mask, knowledge and skills in its use, as well as an unlimited source of oxygen are imperative.

An E cylinder of oxygen or a similar portable source of oxygen such as a Jumbo D cylinder should be readily available. The E cylinder or similar portable oxygen reservoir-type rescue device should be available and ready to use within 10–20 s after identifying the complication requiring oxygen.

The E cylinder contains roughly 625 l of O_2. A regulator that has a flow meter which controls gas flow through a "nipple" should be fitted to the

cylinder. The nipple can be used to supply oxygen to a bag-valve-mask reservoir. A nasal cannula may also be attached to the nipple to provide supplemental oxygen in less critical situations. The threaded attachments on the regulator can be used to connect a high-pressure gas hose to the regulator.

Suctioning can easily be accomplished in a dental setting using a saliva ejector and a high-volume evacuation system. The saliva ejector is beneficial because it is flexible and, most importantly, it is readily available. Unfortunately, its small lumen, fragile connection to the hose assembly, and lack of a venting system limits its usefulness in an emergency that requires large amounts of efficient evacuation. Additionally, the same flexibility that allows for curvature to match the shape of the mouth to the hypopharynx becomes a weakness as this flexibility makes the saliva ejector too weak for definitive suctioning.

The high-volume evacuation is normally equipped with a "straw" or similar hard plastic extension that is both straight and incapable of being curved to go past the base of the tongue and down the pharynx without scraping the posterior wall of the pharynx. It is virtually impossible to reach the area near the vocal cords where blood and saliva collect and block the airway.

A tonsillar or Yankauer suction tip with an associated hose can be attached to the high-speed evacuation (HVE) in less than 30 s. The tip has a lumen that is approximately three times the diameter of the saliva ejector tip and is a flexible hard clear plastic that is precurved to match the curvature from the mouth to the hypopharynx. Efficient high-volume evacuation of blood, saliva, and vomitus can be accomplished with this apparatus. If clogging occurs, the tip can be vented to dramatically reduce the negative pressure at the tip, and debris can be much more easily removed from the intake openings. The tip is smooth and rounded so to not damage the pharyngeal mucosa. It is specifically designed to evacuate this area.

In the *emergency scenarios* that follow, suctioning an otherwise patent airway should always be considered. If the mouth, pharynx, hypopharynx, and trachea are correctly aligned to facilitate air exchange but the "pipeline" is clogged with saliva, water, blood, and debris, ventilation will be compromised.

Additional devices such as the oropharyngeal and the nasopharyngeal airways are useful adjuncts for keeping the base of the tongue from collapsing against the posterior wall of the pharynx and bypassing large tonsils and redundant tissue. These adjuncts create and maintain airway patency. When employed, these devices allow less restricted, less labored spontaneous breathing or permit much more efficient exchange of air when using assisted ventilation using a bag-valve mask.

Compromised Airway

Introduction

A compromised airway is the most likely complication that will be encountered with oral sedation. The compromised airway may be due to soft tissue blockage such as the tongue falling back against enlarged tonsils, a foreign object (e.g., dropped stainless steel crown), an overdose of the sedative(s) causing loss of tone of the airway musculature, or a particularly sensitive patient who responds in an exaggerated manner to therapeutic doses of a sedative regimen. While a small decrease in the percent saturation will be tolerated in the short run by a patient, there is no way to determine how far the descent will be. Hence, trending of the oxygen desaturation is the key in determining when and how to adjust and open the airway.

Scenario 1

A 3-year-old 19-kg healthy Hispanic male is being treated for dental caries under oral sedation because of patient management problems. He was given 50 mg/kg of chloral hydrate approximately 40 min ago. The child appears asleep and quite limp. The mother was asked to carry the patient to the treatment room. He was laid supine on the dental chair. The patient was positioned on a pediatric dental chair and the oxisensor with an audi-

ble pulse-to-pulse tone was placed on the child's right great toe. The doctor administered 50 % N_20. The patient was anesthetized with the correct amount of local anesthesia for restorations in the lower left quadrant. A rubber dam was placed. Readings from the pulse oximeter immediately following the rubber dam application was 98 %. Ten minutes into the restorative procedure, the pulse oximeter demonstrated a steady and rapid decrease in saturation to 90 % then 85 %. The downward trend showed no signs of reversing. Paradoxical chest undulations were noted. The child seemed momentarily difficult to arouse.

Initial Assessment

The child appears to be attempting to breathe normally but no exchange of air can be heard through a precordial stethoscope. Since the restorations were in the mandible, the patient most likely has a non-patent airway due to the practitioner's depression of the mandible without its support with the nondominant hand.

Acceptable Actions

1. Discontinue treatment immediately.
2. Confirm the airway is patent by repositioning the patient's head with chin lift/mandibular thrust.
3. Immediately remove the rubber dam, and a thorough evaluation of the airway should be conducted to possibly remove foreign objects or throat packs.
4. Consider suctioning the mouth and hypopharynx with the saliva ejector.
5. Remove any patient coverings to allow direct visualization of patient's abdomen and chest.
6. Check for normal movement (normal movement should be accompanied by the sound of exchanging of air).
7. If paradoxical movement is present and no breath sounds are heard, begin the use of positive pressure oxygen with a bag-valve mask connected to 100 % oxygen source. Consider using an oral airway if ventilation is inadequate.
8. Call 911.
9. Perform a laryngospasm notch procedure (placement of fingers behind ramus of mandible just anterior to the mastoid process of the skull, pressing medially and anteriorly to open the mandible and simultaneously provide intense pressure).
10. Continue the combination of the positive pressure oxygenation and laryngospasm notch procedure while suctioning occasionally until breath sounds are heard as patient begins to arouse.

Unacceptable Actions

1. Continue the dental procedure hoping the child's oxygenation will improve.
2. Failure to provide immediate airway management.
3. Attempting to place an oral airway in an awake patient.
4. Assume the airway is clear without the need for suctioning.
5. Failure to ready bag-valve mask and oxygen supply and Yankauer suction device in the operatory should they be needed.

Progression and Summary

The obvious problem in this scenario was airway obstruction, most likely caused by the posterior positioning of the tongue against the soft tissue of the hypopharnyx and tonsils. With proper airway opening via a jaw thrust, the patient normally begins ventilating. One can anticipate that the strong stimulation caused by the jaw thrust at the laryngospasm notch aroused the child from a deeper to lighter level of sedation, and the ventilation caused the SpO_2 to rise. Typically, this strong stimulation also causes vocalization and movement of the head, shoulders, and arms in a reflexive manner. The initial assessment of a non-patent airway from mandibular depression was correct.

Respiratory Depression

Introduction

While respiratory depression is a drug-induced partial loss of respiratory drive, it may also be accompanied, in dentistry, by blockage of the airway causing poor ventilation and decreased

oxygenation. An open airway, adequate ventilation, and oxygenation (using 100 % oxygen and positive pressure via a bag-valve mask) along with stimulation of the patient can correct the situation.

Case Scenario 2

A hysterical and agitated 2-year-old Caucasian child weighing 14 kg was given 25 mg of midazolam and 45 mg of meperidine as an oral premedication. Thirty minutes later, the drowsy and very limp child was carried to the dental chair for dental treatment. A pulse oximeter was placed on the patient's toe and the initial reading was 95 %. The doctor placed a nasal hood on the child's nose and mouth and turned the setting to 6 l/min of 50 % nitrous oxide. The oxygen saturation improved to 97 %. Respirations were noted at 12/min. The doctor began treatment. Several minutes into the planned procedures, the oxygen saturation began to decline. The child was noted to be unresponsive to intense earlobe pinches. The respiration rate decreased further reaching a level of 8 breaths per minute. The reading on the pulse oximeter rapidly plunged to into the lower 80s. There are no apparent spontaneous respiratory efforts as evidenced by the lack of any chest movements or sounds of breathing.

Initial Assessment

The inadequate spontaneous respiration is likely the cause of the problem because of the combined actions of midazolam and meperidine *both of which exceeded the therapeutic doses for this child's weight*. Opioids depress ventilation, particularly respiratory rate, and have a more insidious effect when given orally compared to a parenteral route. Resting $PaCO_2$ increases and the normal set point for responding to a CO_2 challenge is blunted. The patient may stop breathing. These effects are mediated through the respiratory centers in the brainstem. The *apneic threshold* – the highest $PaCO_2$ at which the patient remains apneic – is elevated, and the hypoxic drive is decreased [2].

Acceptable Actions and Rationale

1. Discontinue treatment giving full attention to the patient.
2. Remove the rubber dam, throat packs, and foreign material from the mouth.
3. Confirm the airway is patent.
4. Consider suctioning with the flexible saliva ejector.
5. Summon the bag-valve mask, emergency oxygen, and Yankauer suction.
6. Call 911.
7. Open the airway and immediately begin positive pressure ventilations using a BVM (Ambu bag) attached to the emergency oxygen cylinder. Open the oxygen cylinder and turn the flow meter to 10–15 l/min.
8. Visualize chest rise.
9. Visualize fogging of the clear mask as moist, exhaled air as it contacts the inside of the mask.
10. If there is no evidence of effective ventilation such as chest rise or mask fogging, readjust head position, check mask seal, and strengthen jaw thrust. Consider inserting an appropriate-sized oropharyngeal airway.
11. Reattempt positive pressure ventilations.
12. Once ventilation is improved, continue ventilating while waiting for the higher pitched tones of the pulse oximeter indicating increased oxygenation.
13. Begin to evaluate cause of respiratory arrest.
14. Consider reversing the sedative agents with the appropriate reversal agents (i.e., flumazenil and naloxone for midazolam and meperidine, respectively – starting with naloxone).

Unacceptable Actions

1. Failure to recognize ineffective respiratory attempts as indicated by the radical change of respiratory signs
2. Maintaining a patent airway but without assisted ventilations
3. Administering reversal agents without demonstrating the capability to efficiently ventilate the patient

Progression and Summary

The patient was successfully ventilated. The SpO_2 rose steadily over a 1-min time period to 100 %. By the time an assessment of what had caused the respiratory arrest was made, the patient began spontaneously breathing. The mask seal was loosened to provide the patient the opportunity to breathe freely with some entrained room air mixed with the oxygen. After approximately 5 min, the patient was able to maintain saturation above 95 % on room air. The apparent metabolism of the opioid and/or benzodiazepine has reduced their bioavailability and effects to a level that respiratory drive had returned. Because of the intraoperative apneic episode, the patient was observed postoperatively for more than 1 hour, and the paramedics confirmed that the patient was responding normally. When all discharge criteria were met [1] and when the parents expressed confidence in the decision to discharge the child, the patient was sent home in good condition.

Reactive Airway

Introduction

Asthma is a disease characterized by chronic airway inflammation and reversible expiratory airflow obstruction owing to narrowing of airways in response to various stimuli and bronchial hyperreactivity. Despite being a chronic disease, the degree of expiratory airflow obstruction can vary widely over time and change within minutes or over a period of days to weeks [3]. While there remains a certain ambiguity about the disease, these ambiguous situations reflect the deficiencies in the definition of the disease for which there is no pathognomonic feature or diagnostic test. Wheezing, the most common finding during an acute asthma attack, is the term used to describe the expiratory sound produced by turbulent airflow through narrowed airways [3].

Scenario 4

A 6-year-old African American female weighing 30 kg presented to the dental office with a normal health history with the exception of a history of moderate asthma that, when triggered, is well controlled with albuterol via a spacer. The trigger for her asthmatic attacks is extreme excitement or stress. She appears afraid. She has been given 22 mg of oral midazolam to help her remain calm. However, 15 min after she was given the midazolam, evidence of a paradoxical effect is noted. She is, in fact, becoming hyperexcitable and extremely irritable. She is even more nervous about the impending dental treatment, and as she enters the treatment area, she becomes overly excited and stressed. She begins to have wheezing on expiration and she starts to cough.

Initial Assessment

The health history confirms well-controlled, moderate asthma. But, because of the paradoxical effect of the premedication combined with the stress of the dental appointment, asthma has been triggered. Also note that the dose of midazolam has exceeded the maximum recommended amount which in her already emotional state may have initiated the paradoxical response.

Acceptable Actions and Rationale

1. Seat the patient in the dental chair and allow her to assume the most comfortable position.
2. Attach a pulse oximeter to the patient.
3. Provide supplemental oxygen via a nasal cannula or mask at 10 l/min and give reassurance to the child.
4. Ask the parent to remain in the treatment area with the child to calm and also reassure the young girl.
5. Have the child or parent administer the albuterol.
6. Continue monitoring child and consider transport to a medical facility if improvement is not noted.

7. If improvement is noted, consider reappointing the patient and offer alternative pharmacological management to prevent a similar response at the next visit.

Unacceptable Actions

1. Ignoring the signs of an asthmatic attack and pressuring child to continue dental care
2. Failure to administer supplemental oxygen
3. Failure to administer beta-agonist (albuterol)
4. Asking the parent(s) to leave the room
5. Attempting to proceed with treatment

Progression and Summary

This patient became calmer when she became aware that there would be no dental treatment. She was seated and supplemental oxygen via a nasal cannula was administered to improve oxygenation. When a pulse oximeter was placed on her right middle finger, it revealed her saturation to be 88 %. The difficulty exhaling as the expiratory effort compresses and further narrows the small airways that are already restricted is typical of asthma, and oxygen saturation is less than normal. Mom's voice and touch have a calming effect and the action of the two puffs of albuterol, administered by the mother using a spacer provided by the pediatric dentist, averted an exacerbation of the asthmatic symptoms. Within 10 min, the asthmatic episode had subsided and the child was calming and saturating at 99 % with supplemental oxygen. The oxygen was gently removed and the saturation slowly descended to 95 % and remained at this level. The mother and child were reassured and were discharged to go home. Due to the nature of the asthma "trigger," mom agreed to have an anesthesiologist assist with the next visit.

Allergic Reaction (Mild)

Introduction

The most common reaction to opioids is nausea. Only one case of IgE-mediated reaction to opioids has been reported in the literature and this was controversial [4]. However, most opioids are capable of inducing pseudo-allergic reactions by causing degranulation of mast cells. Opioid-induced pseudo-allergic reactions are rarely life threatening.

Scenario 5

A 5-year-, 6-month-old girl weighing 28 kg came to her dental appointment accompanied by her mother. After careful review of her medical history and reviewing the same with the mother, she was given 40-mg meperidine combined with 40-mg hydroxyzine as an oral premedication. After waiting with her daughter for 30 min in a secluded room for the medication to take effect, the mom noticed the girl becoming a little restless and large welts were developing on her neck and upper body. They alerted the doctor. Upon examination, approximately 10–20 dime-sized, raised welts were noted. The girl was also noted scratching some of the lesions. They became more pronounced with passing minutes. No swelling of the lips, tongue, or eyes was observed. The patient was having no difficulty breathing.

Initial Assessment

The patient was obviously having a reaction to something in the office or to a component in the premedication. She must be observed vigilantly, and emergency medications for allergies must be made ready to administer should the symptoms worsen and airway compromise become a problem.

Acceptable Actions and Rationale

1. Move the patient to a bright treatment room and monitor the patient.
2. Administer supplemental oxygen as needed.
3. Monitor patient oxygen saturation and blood pressure.
4. Prepare EpiPen™ for administration.
5. Administer 25 mg of diphenhydramine.

6. Vigilant observation.
7. Readiness to summon emergency help if symptoms progress.

Unacceptable Actions

1. Failure to monitor the patient after administering the sedative medications
2. Failure to monitor the patient including O_2 saturation and blood pressure once the lesions were noted
3. Initiating dental procedures without confirming the reaction would not become more severe
4. Failure to prepare for rapidly deteriorating patient conditions such as airway compromise

Progression and Summary

Contrary to safety guidelines, the patient was not monitored or observed by trained personnel as she was waiting with her mother after the premedication was administered. Fortunately, the mother had noticed the reaction and alerted the office. Mom and daughter were immediately moved to a private treatment area for monitoring. An additional discussion with the mother revealed no history of allergic reactions. Meperidine can sometimes cause a histamine release that is self-limiting. No treatment with antihistamines is necessary, but it is also not contraindicated. The decision was made to give 25 mg of diphenhydramine preemptively. The child calmed, the reaction subsided, and the welts were waning in minutes. Although the dental treatment could have been started and completed despite the "reaction," the mother made the decision to return another day with a different premedication given and perhaps a calmer child.

Sudden-Onset Anaphylaxis

Introduction

Anaphylaxis is an exaggerated response to an allergen that is mediated by a Type I hypersensitivity reaction [5]. Anaphylactic shock and related immediate (Type I) IgE-mediated reactions affect both the respiratory and cardiovascular systems. The syndrome of bronchospasm, mucous membrane congestion, angioedema, and severe hypotension usually responds rapidly to parenteral administration of epinephrine, 0.15–0.3 mg. Intramuscular injection is the preferred route of administration; therefore, the vastus lateralis is the site of choice for injection with an EpiPen™ (0.3 mg) of EpiPen Jr™ (0.15 mg). Prompt administration of epinephrine is the first-line therapy during acute anaphylaxis. Epinephrine is the only medication that has exhibited lifesaving properties, and delays in administration have been associated with increased morbidity, mortality, and incidence of biphasic reactions [6]. With current epinephrine auto-injectors (EIAs), the 0.15 dose (EpiPen Jr) is suggested for patients <25 mg, and the 0.30 mg is recommended for patients >25 mg [6].

Case 6

A 10-year-old 70-lb girl with spina bifida presents to the office for extensive treatment. She has been given midazolam 15 mg, meperidine 30 mg, and hydroxyzine 30 mg as an oral sedative. She is observed by office personnel and after 30 min she is assisted to the dental chair. Nitrous oxide and oxygen are administered via a nasal hood to titrate the patient to the desired level of sedation. Treatment begins uneventfully. The patient is accidentally touched by the latex gloves worn by an assistant. Within 5 min, her lips and eyes are noticeably swelling. She complains of sudden difficulty in breathing, begins wheezing, and her breathing becomes labored. The situation for the patient is deteriorating quickly. The oxygen saturation is beginning to trend downward. It is currently reading 92 %.

Initial Assessment

This patient is having an anaphylactic reaction. The vascular system is rapidly deteriorating, significant edema is notable, and pulmonary congestion is occurring. This is a life-threatening reaction that requires immediate and specific attention.

Acceptable Actions and Rationale

Discontinue treatment. Give full attention to the serious emergency situation. Alert the dental team to immediately call 911.

1. Airway is checked for patency and the swelling of the tongue, floor of the mouth, and throat carefully observed.
2. Administer oxygen via loose fitting mask at 15 l/min.
3. Ensure airway patency and suction airway of secretions.
4. Prepare an EpiPen™ to inject and give in the vastus lateralis.
5. Adjunctive airway devices are readied to assist in maintaining patency should unconsciousness occur.

Unacceptable Actions

1. Not calling 911
2. Giving diphenhydramine (Benadryl) assuming it will stem off the reaction
3. Allowing the patient breathe room air only

Progression and Summary

This patient continued to "swell" for several minutes. She entered into a depressed level of consciousness and was becoming unresponsive. This state allowed placement of an oral airway. Positive pressure oxygen was administered via a bag-valve mask with oxygen flowing at 15 l/min. Her breathing was labored, but the supplemental oxygen kept her saturation levels in the 80 % range. Blood pressure was taken every 30–45 s and had declined appreciably since the original pre-op vitals. The epinephrine which was administered 2 min earlier in the thigh has begun to take effect, the swelling began to subside, and blood pressure began to increase. Coughing, gagging, and general movement began and the airway was removed and blow by oxygen continued. Breathing became less labored, and her saturation rose to 95 %. EMS arrived and was briefed by the doctor about the incident. She was transported to the local hospital where she was admitted and observed in PICU for approximately 48 h. She was then discharged in good condition.

Local Anesthetic Toxicity

Introduction

Systemic toxicity to local anesthetics is dose dependent. The use of anesthetic cartridges in dentistry has unfortunately spawned carelessness in appreciating the actual amount of anesthetic administered [7]. As local anesthetics are absorbed from the injection site, their concentration in the bloodstream rises. The peripheral and central nervous system are depressed in a dose-dependent manner. Initially, an overdose may result in paresthesia, drowsiness, and muscle twitching. As the serum level rises, the patient may experience convulsions followed by coma and then cardiovascular collapse and respiratory arrest.

Scenario 7

A 3-year-old 13-kg boy comes to his dental appointment for extensive treatment. He is given 26 mg of meperidine and 25 mg of hydroxyzine. It is a busy day at the office; all treatment rooms are filled with the sound of laughing and crying children. The doctor and his team are in "high gear." Approximately 30 min after the medication was administered, the patient is brought into the treatment room and gently placed in a Papoose board. A pulse oximeter sensor is placed on the child's finger. Two carpules of 2 % lidocaine are administered in the maxillary arch and two carpules of 4 % Septocaine are infiltrated bilaterally in the mandibular arch. A team member remains with the child. The doctor attends briefly to other patients. The doctor then returns to treat the 3-year-old boy. As treatment is initiated, the boy squirms and is agitated, and the doctor decides to administer 3/4th carpule of lidocaine. The doctor leaves the room briefly to take an "urgent" phone call. When the doctor returns, the patient is very irritable and the assistant is struggling to keep the pulse oximeter on the child's finger. The doctor helps to readjust the child in the restraint and moves the pulse oximeter to the left great toe.

Treatment begins. The child seems restless. The saturation begins to trend downward. Ten minutes into the treatment, the child becomes rigid and his eyes roll back into his head. The pulse oximeter continues to trend downward to 80 % then 70 %. The child begins to have "convulsions" in the Papoose board.

Initial Assessment

The patient may be approaching or in respiratory arrest. The rigid body followed by convulsions, eyes rolling backward, and five empty local anesthetic carpules on the tray is a suggestion of local anesthetic overdose.

Acceptable Actions and Rationale

Discontinue treatment. Give full attention to this emergent situation by keeping patient safe from self-injury from seizures with immediate environment.

1. Give supplemental oxygen via loose mask or bag-valve mask if possible.
2. Call 911.
3. Administer midazolam (0.2 mg/kg/dose; repeat every 10–15 min; maximum dose: 6 mg) in the vastus lateralis.
4. Confirm airway patency and continue ventilation once seizure subsides.
5. Likely he will enter into deeper level of sedation requiring advanced airway management with oral or nasal airways and bag-valve mask.
6. Transport to hospital.

Unacceptable Actions

1. Not administering oxygen
2. Administering narcotic reversal agent
3. Waiting longer than 5 min to see if seizures will stop
4. Not being prepared or willing to call 911 for assistance

Progression and Summary

The O_2 saturation continued to descend reaching 40 % before the seizure subsided and normal inspiratory tidal volumes resumed. Then, the O_2 saturations began to slowly and steadily rise. The convulsions had begun to diminish within 2–3 min after midazolam was administered. Emergency medical services were summoned and arrived at the office within 10 min. The patient was sleeping quietly in dental chair and ventilation supported. The emergency team was briefed and the patient was transported to the local hospital. He was admitted and observed in PICU for 24 h. Blood drawn in the emergency department revealed excessive levels of local anesthetic. He was discharged in good condition.

Syncope

Introduction

Syncope is most likely an adverse event that will be encountered in a dental office over the practice lifetime of a dentist. Also the parent may be the most likely individual who has the syncope episode. Syncope is the temporary loss of consciousness and postural tone caused by diminished cerebral blood flow. Treatment is relatively simple as long as the person did not injure themselves as they collapsed to the ground.

Scenario 10

A 14-year-old boy weighing 56 kg has come to his general dentist for restorations. He has denied being afraid, but his trembling hands and nervous demeanor betray his cavalier words. The dentist has elected, with parental consent, to give the adolescent a sedative cocktail of 25-mg hydroxyzine to help him calm his nerves and cooperate with the dental team. During 30 min after he was given the premedication, he has been sitting quietly in a secluded area of the waiting room. The assistant comes to bring him to the treatment room. His mother arouses him. He refuses help in standing and gets up unassisted. Only moments after standing he becomes very pale and his eyes begin to roll back in his head. The assistant is barely able to prevent injury as he slumps to the floor. She shouts for assistance. Another assistant

and the doctor rush to the room to find the 14-year-old boy collapsed on the floor.

Initial Assessment

With the description by the assistant who witnessed the collapse, the onset of facial pallor on standing, and the eyes rolling back in the head, the immediate assumption is syncope. The patient's medical history was unremarkable and even suggestive of a very active, healthy adolescent.

Acceptable Actions and Rationale

1. Immediately check for airway patency, pulse, and respirations.
2. Call for the emergency oxygen tank and pulse oximeter.
3. Administer oxygen using a loose fitting mask or nasal cannula at 4–6 l/min.
4. Make the patient comfortable while remaining supine.
5. Elevate the legs and feet to slightly above the head.
6. Check vital signs and oxygen saturation.
7. Reassure the patient and the family.
8. Assist the patient to sit up slowly and move him to the operatory where more oxygen can be delivered via the nasal hood.
9. Continue with dental treatment after obtaining the patient's assent.

Unacceptable Actions

1. Immediately returning the patient to a sitting position.
2. Insisting that the patient get up immediately and go to the operatory.
3. Failing to administer oxygen.
4. Beginning CPR before checking for airway patency and pulse.

Progression and Summary

This bravado 14-year-old has denied being afraid of the dentist. The addition of an oral sedative calmed the patient, but his insistence on standing up immediately without assistance precipitated orthostatic hypotension and temporary decreased blood flow to the brain and caused loss of postural tone and loss of consciousness (syncope). The ensuing collapse to the floor into a horizontal position usually a self-correcting measure. The assistant in the room responsibly prevented injury by "assisting" the patient to the floor. Emergency equipment was summoned in case the initial assessment was incorrect. The patient could have suffered an unexpected cardiac arrest and collapsed. But confirmation of a pulse and spontaneous breathing is not consistent with cardiac arrest. His consciousness returned within seconds. The patient was made comfortable and his vital signs were checked. They were within normal limits. He was observed while lying on the floor for several minutes. After that, he was gradually allowed to sit on the floor and then stand with assistance. After resting in a chair for about 10 min, the decision was made to proceed to the treatment room and complete the necessary treatment.

Obese Patient

Introduction

Childhood and adolescent obesity has increased dramatically in the United States. Obesity increases the risk for major causes of death. Medical and dental literature documents a definite association between obesity and decreased lung functions. Increased fat tissue causes mass loading of the chest wall and abdomen, reducing chest wall compliance and increasing airway resistance. Obesity can have a detrimental effect on pulmonary physiology, sleep, and airway responsiveness. Obesity and obstructive sleep apnea have been linked for many reasons. Increased fat deposition in the soft palate, uvula, and the neck region surrounding the collapsible part of the pharynx was noted in obstructive sleep apnea patients. The relaxation of normal pharyngeal muscle tone associated with sedation only exacerbates this complication. It is well documented that sleep apnea syndrome patients are at a much greater risk for airway obstruction during recovery from surgery and while sedated. Special attention must be given to airway management in these patients.

Scenario 11

A 4-year-old boy weighing 30 kg comes to his pediatric dentist for a moderate amount of dental treatment. Fifteen milligrams of midazolam is given orally to sedate the patient. After 15 min, the medication has taken effect and the boy is assisted to the treatment area, and radiographs taken reveal the dental pathology is far worse than expected. The treatment time will be double as what was anticipated. The parents are informed and agreed to proceed. Nitrous oxide/oxygen is administered via a nasal hood to further titrate the sedation to the desired level and as an adjunct to O_2 saturation control. The patient is fully reclined. The pulse oximeter reads 98 % as treatment begins. While the pediatric dentist is working in the maxilla, O_2 saturations remain in the upper 90s. When the treatment progresses to the mandible, the downward pressure associated with tooth preparation and the sizing stainless steel crowns (SSCs) compromises airway patency. Saturations fall to the lower 90s but gradually rise again to the mid-90s with encouragement of increased inspiratory effort. The patient is alert and interactive. During the final seating of the mandibular SSCs, the O_2 saturations fall to the 80s and then to the 70s. The patient seems to be struggling to breathe, and paradoxical chest motions are noted but difficult to interpret as the large amount of fat on the chest and abdomen camouflage important anatomical details of the actual movement. The patient states he is not choked, but it is hard to breath. The team wants to complete the seating of the SSCs before the cement starts to dry, but the situation has become more critical. The O_2 saturations are now in the 60s and plummeting. No air exchange can be detected.

Initial Assessment

The obesity of this patient has made him a definite candidate for airway obstruction when he is sedated and his airway is compromised by redundant tissue, a rubber dam, and a mouth filled with the usual dental paraphernalia. Airway obstruction appears to be the problem and is exacerbated by the compromised ability to expand his lungs because the fat on his chest is greatly increasing the work of breathing.

Acceptable Actions and Rationale

1. Confirm airway patency after removing rubber dam and all foreign objects from the airway.
2. Chin lift-jaw thrust to encourage the tongue to move from the back wall of the pharynx.
3. Listen and feel for air exchange noting chest rise with inspiratory effort.
4. If no air exchange, strengthen chin lift-jaw thrust.
5. Elevate child from supine to 50° upright position.
6. Suction to remove saliva/blood and create pharyngeal negative pressure.
7. Bring emergency oxygen/adjuncts to the treatment area.
8. Consider positive pressure as ventilation deteriorates.
9. Once stabilized and reassured, return to dental procedure.

Unacceptable Actions

1. Continuing to seat SSCs to save time in the face of an impending problematic desaturation
2. Taking no further remedial action if airway is not patent
3. Administering reversal agents without first ventilating the patient

Progression and Summary

This obese patient became an emergency near the end of the treatment. His constricted airway due to large tonsils, redundant pharyngeal tissue that usually accompanies obesity, and the depressant effect of the oral sedative caused his airway to become non-patent. The situation was exacerbated by the downward pressure exerted on the mandible during the final seating of the lower SSCs. With no efficient air exchange, the oxygen saturation levels dropped precipitously. The pediatric dentist first tried vigorous chin lift-jaw thrust to remedy the problem. The nitrous oxide is turned off and 100 % oxygen is delivered via the nasal hood at 6 l/min. The O_2 saturations began to rise quickly. The patient position was adjusted to

50° and he continued ventilating well, as the assistant applied constant chin lift and the SSCs were cemented. The patient was kept under observation an additional 15 min because of his obesity and the remote possibility he may become inadvertently obstructed again. He was alert, oriented, and responded appropriately to commands.

Intraoperative Vomiting

Introduction

In office-based anesthesia or sedation, the lack of a parent's preoperative control of the NPO status of the patient is concerning. It is imperative that thorough preoperative instructions be given and clearly understood by the parents of the children. Even then, the status of the child must be reconfirmed on the day of the appointment. Consideration should be given to the parent who "doesn't want to disappoint the doctor" or who may not confess they did not watch the child every moment. Care should be taken to explain these important matters to parents and even get a signature from them confirming their child has had nothing to eat or drink in the specified time designated by the doctor. The sequelae of intraoperative vomiting and aspiration of gastric contents carries significant morbidity risks and may result in death.

Scenario 12

A 5-year-old 22-kg Caucasian boy is diagnosed with some necessary dental treatment. His pediatric dentist has informed both anxious parents of the need for oral sedation to manage the behavior of their son. They agree and sign consents. Both understand the need to give the child nothing by mouth after midnight in preparation for the 7:30 AM appointment. Upon arrival, the child is given 20-mg meperidine, 8-mg midazolam, and 20-mg hydroxyzine for premedication. Thirty minutes later, the young boy is sedated and is taken to the treatment room. Nitrous oxide and oxygen are added to titrate the sedation. An audible pulse oximeter is placed on his thumb. He is saturating at 100 %. Treatment is initiated with the patient in a supine position and a rubber dam in place after local anesthesia. The patient closes his eyes but responds early in the procedure to the dentist's voice asking if he is OK. The dentist did not use a precordial stethoscope. The child seems to be doing well, but midway through the treatment, the dental team noted a sudden expulsion of vomitus exiting from around the rubber dam. His O_2 saturations begin to fall precipitously. His abdomen demonstrates noticeably unusual undulations. Copious amounts of brown fluid pours from his nose. He then struggles to breathe. The dental team rolls the child over to his side and begins suctioning the airway, but the thick saliva ejector is rapidly clogged with debris. A new wider-bore saliva ejector is then used to suction out the mouth and nose. The patient's saturation is now at 70 %. Breath sounds cannot be detected. At this moment, a front desk person enters the room to inform the doctor she has overheard the mother of this boy tell the father that she was not sure about a 5-min period when the boy may have been unobserved while getting ready for the appointment. She expressed to her husband that their son was hungry and she has begun to think that he may have "sneaked" into the kitchen and had some milk and something else (she wasn't sure) while she wasn't looking. She has just remembered this and forgot to inform the pediatric dentist. The team is alarmed as the saturation continues to fall rapidly. It is now 55 %.

Initial Assessment

Given the report by the front desk person about possible food and milk intake shortly before the appointment, intraoperative regurgitation of the stomach contents has occurred and there is a strong likelihood of aspiration. The airway was temporarily non-patent.

Acceptable Actions and Rationale

Discontinue treatment. Give full attention to the emergent situation.

1. Quickly remove the rubber dam and all dental materials from the mouth.
2. Roll patient onto his side.

3. Chin lift-jaw thrust.
4. Suction the mouth and hypopharynx with the first available suction that can reach the hypopharynx. This is usually the saliva ejector with the tip now curved to reach down the throat.
5. Attach the Yankauer and thoroughly suction the upper airway.
6. Continue to check for breathing.
7. Prepare for emergency positive pressure ventilations using the bag-valve mask.
8. Call 911.
9. Continue positive pressure ventilation while monitoring vital signs.
10. Transport to hospital as soon as paramedics arrive.

Unacceptable Actions

1. Chin lifting only without recognizing the airway may be blocked
2. Preparing reversal agents to be administered
3. Using positive pressure before the airway was cleared of the obstruction
4. Not considering the possibility of calling 911

Progression and Summary

As this patient continued to desaturate, the pediatric dentist and the team recognized oxygen was not getting to the alveoli. Fortunately, the team had practiced assembling the Yankauer tubing and tip to the high-speed evacuation. It was ready in less than 30 s. The Yankauer quickly and efficiently evacuated the remaining vomit. The pulse oximeter was blank and the child appeared blue. The doctor checked for a pulse and found a strong heartbeat estimated at 140 beats per minute. The doctor had 911 called for additional help. Positive pressure ventilations were attempted using the bag-valve mask attached to oxygen at 15 l/min. Chest rise was seen as fresh oxygen seemed to be entering the lungs via the now patent airway. The mask fogged as moist expired air contacted the inside of the clear mask. Within a couple of minutes, the patient appeared to be "pinking up" and the pulse oximeter was rising into the 60s, then the mid 80s. Additional suctioning was attempted without productivity. The parents were informed of the episode just as EMS was arriving. With the child saturating in mid-80s not improving, the decision was made by paramedics to transport the young boy to the emergency department (ED) of a local children's hospital for observation. The ED observed the boy, took a chest x-ray and drew blood for labs. The patient was admitted and monitored. With appropriate medical consultations and management, the patient returned to normal over the next week.

Some Concluding Thoughts About Sedation Emergencies

The greatest keys to avoiding an emergency are careful patient selection and review of the patient history. The greatest keys to solving an emergency in progress are preparation, organization, and practice.

In the American population, the growing tendency toward obesity can project a patient pool with increasing percentages of young children that are overweight. The redundant tissues in the neck present a much greater opportunity for relaxed tissues to obstruct the airway. Head positioning and shoulder rolls are important to align airways and assist in combating airway collapse. A history of chronic airway disease such as asthma should alert the practitioner to enhanced possibilities of perioperative problems. Large tonsils should be noted. Any of the above should trigger increased awareness of potential airway compromise. Dosing of sedative agents to these patients should be conservative to definitely avoid inadvertent sedation of the patient to a deeper than the intended level and exacerbating potential complications in an already challenging patient.

When an emergency occurs, preparation for that unexpected event will save precious time. Review of emergency protocol should be scheduled four times per year. Key members of the staff, who are lead by the doctor, must have definite understandings of their roles and each must review what is expected of them and the timing of their actions.

Each office should exactly organize the armamentarium and medications necessary for different emergent scenarios. Time wasted hunting for necessary drugs or accessories to solve an emergency will cause needless stress and will ultimately increase the chances of a bad outcome.

Everyone involved should practice resolving specific emergencies in real time. In all of life, we must continually practice our skills. So, to each of you, prepare, organize, and practice!

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