CLINICAL REPORT Guidance for the Clinician in Rendering Pediatric Care

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

# Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016

Charles J. Coté, MD, FAAP, Stephen Wilson, DMD, MA, PhD, AMERICAN ACADEMY OF PEDIATRICS, AMERICAN ACADEMY OF PEDIATRIC DENTISTRY

The safe sedation of children for procedures requires a systematic approach that includes the following: no administration of sedating medication without the safety net of medical/dental supervision, careful presedation evaluation for underlying medical or surgical conditions that would place the child at increased risk from sedating medications, appropriate fasting for elective procedures and a balance between the depth of sedation and risk for those who are unable to fast because of the urgent nature of the procedure, a focused airway examination for large (kissing) tonsils or anatomic airway abnormalities that might increase the potential for airway obstruction, a clear understanding of the medication's pharmacokinetic and pharmacodynamic effects and drug interactions, appropriate training and skills in airway management to allow rescue of the patient, age- and size-appropriate equipment for airway management and venous access, appropriate medications and reversal agents, sufficient numbers of staff to both carry out the procedure and monitor the patient, appropriate physiologic monitoring during and after the procedure, a properly equipped and staffed recovery area, recovery to the presedation level of consciousness before discharge from medical/dental supervision, and appropriate discharge instructions. This report was developed through a collaborative effort of the American Academy of Pediatrics and the American Academy of Pediatric Dentistry to offer pediatric providers updated information and guidance in delivering safe sedation to children.

## abstract

*This document is copyrighted and is property of the American Academy of Pediatrics and its Board of Directors. All authors have filed conflict of interest statements with the American Academy of Pediatrics. Any conflicts have been resolved through a process approved by the Board of Directors. The American Academy of Pediatrics has neither solicited nor accepted any commercial involvement in the development of the content of this publication.*

*Clinical reports from the American Academy of Pediatrics benefit from expertise and resources of liaisons and internal (AAP) and external reviewers. However, clinical reports from the American Academy of Pediatrics may not reflect the views of the liaisons or the organizations or government agencies that they represent.*

*The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical/dental care. Variations, taking into account individual circumstances, may be appropriate.*

*All clinical reports from the American Academy of Pediatrics automatically expire 5 years after publication unless reaffirmed, revised, or retired at or before that time.*

**DOI:** 10.1542/peds.2016-1212

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2016 American Academy of Pediatric Dentistry and American Academy of Pediatrics. This report is being published concurrently in *Pediatric Dentistry* July 2016. The articles are identical. Either citation can be used when citing this report.

**To cite:** Coté CJ, Wilson S, AMERICAN ACADEMY OF PEDIATRICS, AMERICAN ACADEMY OF PEDIATRIC DENTISTRY. Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016. *Pediatrics.* 2016; 138(1):e20161212

Downloaded from by guest on June 28, 2016

## INTRODUCTION

The number of diagnostic and minor surgical procedures performed on pediatric patients outside of the traditional operating room setting has increased in the past several decades. As a consequence of this change and the increased awareness of the importance of providing analgesia and anxiolysis, the need for sedation for procedures in physicians' offices, dental offices, subspecialty procedure suites, imaging facilities, emergency departments, other inpatient hospital settings, and ambulatory surgery centers also has increased markedly.[1–52] In recognition of this need for both elective and emergency use of sedation in nontraditional settings, the American Academy of Pediatrics (AAP) and the American Academy of Pediatric Dentistry (AAPD) have published a series of guidelines for the monitoring and management of pediatric patients during and after sedation for a procedure.[53–58] The purpose of this updated report is to unify the guidelines for sedation used by medical and dental practitioners; to add clarifications regarding monitoring modalities, particularly regarding continuous expired carbon dioxide measurement; to provide updated information from the medical and dental literature; and to suggest methods for further improvement in safety and outcomes. This document uses the same language to define sedation categories and expected physiologic responses as The Joint Commission, the American Society of Anesthesiologists (ASA), and the AAPD.[56,57,59–61]

This revised statement reflects the current understanding of appropriate monitoring needs of pediatric patients both during and after sedation for a procedure.[3,4,11,18,20,21,23,24,33,39,41,44,47,51,62–73,] The monitoring and care outlined may be exceeded at any time on the basis of the judgment of the responsible practitioner. Although intended to encourage high-quality patient care, adherence to the recommendations in this document cannot guarantee a specific patient outcome. However, structured sedation protocols designed to incorporate these safety principles have been widely implemented and shown to reduce morbidity.[11,23,24,27,30–33,35,39,41,44,47,51,74–84] These practice recommendations are proffered with the awareness that, regardless of the intended level of sedation or route of drug administration, the sedation of a pediatric patient represents a continuum and may result in respiratory depression, laryngospasm, impaired airway patency, apnea, loss of the patient's protective airway reflexes, and cardiovascular instability.[38,43,45,47,48,59,62,63,85–112]

Procedural sedation of pediatric patients has serious associated risks.[2,5,38,43,45,47,48,62,63,71,83,85,88–105,107–138] These adverse responses during and after sedation for a diagnostic or therapeutic procedure may be minimized, but not completely eliminated, by a careful preprocedure review of the patient's underlying medical conditions and consideration of how the sedation process might affect or be affected by these conditions: for example, children with developmental disabilities have been shown to have a threefold increased incidence of desaturation compared with children without developmental disabilities.[74,78,103] Appropriate drug selection for the intended procedure, a clear understanding of the sedating medication's pharmacokinetics and pharmacodynamics and drug interactions, as well as the presence of an individual with the skills needed to rescue a patient from an adverse response are critical.[42,48,62,63,92,97,99,125–127,132,133,139–158] Appropriate physiologic monitoring and continuous observation by personnel not directly involved with the procedure allow for the accurate and rapid diagnosis of complications and initiation of appropriate rescue interventions.[44,63,64,67,68,74,90,96,110,159–174] The work of the Pediatric Sedation Research Consortium has improved the sedation knowledge base, demonstrating the marked safety of sedation by highly motivated and skilled practitioners from a variety of specialties practicing the above modalities and skills that focus on a culture of sedation safety.[45,83,95,128–138] However, these groundbreaking studies also show a low but persistent rate of potential sedation-induced life-threatening events, such as apnea, airway obstruction, laryngospasm, pulmonary aspiration, desaturation, and others, even when the sedation is provided under the direction of a motivated team of specialists.[129] These studies have helped define the skills needed to rescue children experiencing adverse sedation events.

The sedation of children is different from the sedation of adults. Sedation in children is often administered to relieve pain and anxiety as well as to modify behavior (eg, immobility) so as to allow the safe completion of a procedure. A child's ability to control his or her own behavior to cooperate for a procedure depends both on his or her chronologic age and cognitive/emotional development. Many brief procedures, such as suture of a minor laceration, may be accomplished with distraction and guided imagery techniques, along with the use of topical/local anesthetics and minimal sedation, if needed.[175–181] However, longer procedures that require immobility involving children younger than 6 years or those with developmental delay often require an increased depth of sedation to gain control of their behavior.[86,87,103] Children younger than 6 years (particularly those younger than 6 months) may be at greatest risk of an adverse event.[129] Children in this age group are particularly vulnerable

Downloaded from by guest on June 28, 2016

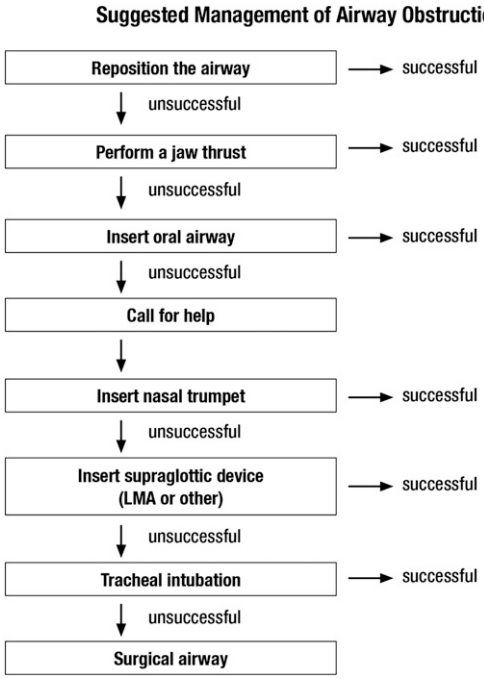


**FIGURE 1**
Suggested management of airway obstruction.

to the sedating medication's effects on respiratory drive, airway patency, and protective airway reflexes.[62,63] Other modalities, such as careful preparation, parental presence, hypnosis, distraction, topical local anesthetics, electronic devices with age-appropriate games or videos, guided imagery, and the techniques advised by child life specialists, may reduce the need for or the needed depth of pharmacologic sedation.[29,46,49,182–211]

Studies have shown that it is common for children to pass from the intended level of sedation to a deeper, unintended level of sedation,[85,88,212,213] making the concept of rescue essential to safe sedation. Practitioners of sedation must have the skills to rescue the patient from a deeper level than that intended for the procedure. For example, if the intended level of sedation is "minimal," practitioners must be able to rescue from "moderate sedation"; if the intended level of sedation is "moderate," practitioners must have the skills to rescue from "deep sedation"; if the intended level of sedation is "deep," practitioners must have the skills to rescue from a state of "general anesthesia." The ability to rescue means that practitioners must be able to recognize the various levels of sedation and have the skills and age- and size-appropriate equipment necessary to provide appropriate cardiopulmonary support if needed.

These guidelines are intended for all venues in which sedation for a procedure might be performed (hospital, surgical center, freestanding imaging facility, dental facility, or private office). Sedation and anesthesia in a nonhospital environment (eg, private physician's or dental office, freestanding imaging facility) historically have been associated with an increased incidence of "failure to rescue" from adverse events, because these settings may lack immediately available backup. Immediate activation of emergency medical services (EMS) may be required in such settings, but the practitioner is responsible for life-support measures while awaiting EMS arrival.[63,214] Rescue techniques require specific training and skills.[63,74,215,216] The maintenance of the skills needed to rescue a child with apnea, laryngospasm, and/or airway obstruction include the ability to open the airway, suction secretions, provide continuous positive airway pressure (CPAP), perform successful bag-valve-mask ventilation, insert an oral airway, a nasopharyngeal airway, or a laryngeal mask airway (LMA), and, rarely, perform tracheal intubation. These skills are likely best maintained with frequent simulation and team training for the management of rare events.[128,130,217–220] Competency with emergency airway management procedure algorithms is fundamental for safe sedation practice and successful patient rescue (see Figs 1, 2, and 3).[215,216,221–223]

Practitioners should have an in-depth knowledge of the agents they intend to use and their potential complications. A number of reviews and handbooks for sedating pediatric patients are available.[30,39,65,75,171,172,201,224–233] There are specific situations that are beyond the scope of this document. Specifically, guidelines for the delivery of general anesthesia and monitored anesthesia care (sedation or analgesia), outside or within the operating room by anesthesiologists or other practitioners functioning within a department of anesthesiology, are addressed by policies developed by the ASA and by individual departments of anesthesiology.[234] In addition, guidelines for the sedation of patients undergoing mechanical ventilation in a critical care environment or for providing analgesia for patients postoperatively, patients with chronic painful conditions, and patients in hospice care are beyond the scope of this document.

Downloaded from by guest on June 28, 2016

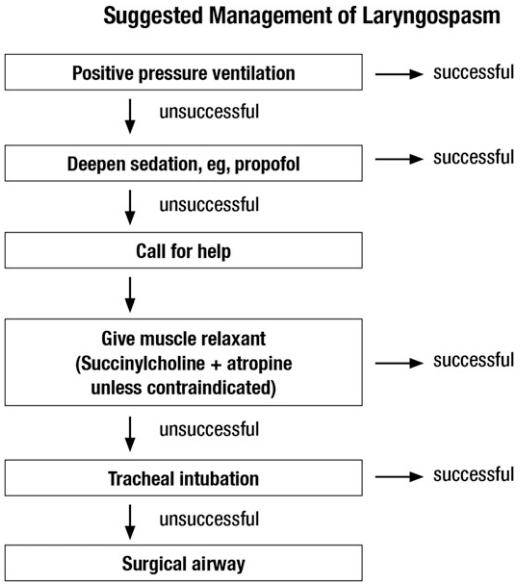


**FIGURE 2**
Suggested management of laryngospasm.

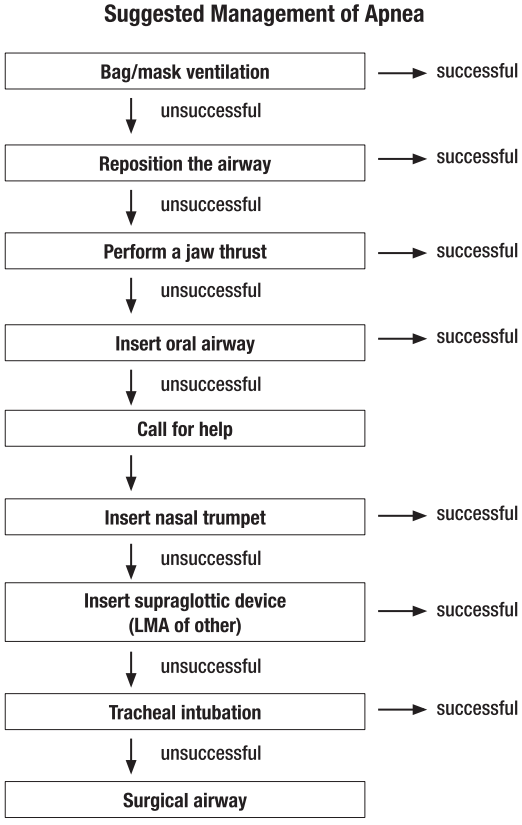


**FIGURE 3**
Suggested management of apnea.

## GOALS OF SEDATION

The goals of sedation in the pediatric patient for diagnostic and therapeutic procedures are as follows: (1) to guard the patient's safety and welfare; (2) to minimize physical discomfort and pain; (3) to control anxiety, minimize psychological trauma, and maximize the potential for amnesia; (4) to modify behavior and/or movement so as to allow the safe completion of the procedure; and (5) to return the patient to a state in which discharge from medical/dental supervision is safe, as determined by recognized criteria (Supplemental Appendix 1).

These goals can best be achieved by selecting the lowest dose of drug with the highest therapeutic index for the procedure. It is beyond the scope of this document to specify which drugs are appropriate for which procedures; however, the selection of the fewest number of drugs and matching drug selection to the type and goals of the procedure are essential for safe practice. For example, analgesic medications, such as opioids or ketamine, are indicated for painful procedures. For nonpainful procedures, such as computed tomography or magnetic resonance imaging (MRI), sedatives/hypnotics are preferred. When both sedation and analgesia are desirable (eg, fracture reduction), either single agents with analgesic/sedative properties or combination regimens are commonly used. Anxiolysis and amnesia are additional goals that should be considered in the selection of agents for particular patients. However, the potential for an adverse outcome may be increased when 2 or more sedating medications are administered.[62,127,136,173,235] Recently, there has been renewed interest in noninvasive routes of medication administration, including intranasal and inhaled routes (eg, nitrous oxide; see below).[236]

Knowledge of each drug's time of onset, peak response, and duration of action is important (eg, the peak electroencephalogram [EEG] effect of intravenous midazolam occurs at ~4.8 minutes, compared with that of diazepam at ~1.6 minutes[237–239]). Titration of drug to effect is an important concept;

Downloaded from by guest on June 28, 2016

one must know whether the previous dose has taken full effect before administering additional drugs.[237] Drugs that have a long duration of action (eg, intramuscular pentobarbital, phenothiazines) have fallen out of favor because of unpredictable responses and prolonged recovery. The use of these drugs requires a longer period of observation even after the child achieves currently used recovery and discharge criteria.[62,238–241] This concept is particularly important for infants and toddlers transported in car safety seats; re-sedation after discharge attributable to residual prolonged drug effects may lead to airway obstruction.[62,63,242] In particular, promethazine (Phenergan; Wyeth Pharmaceuticals, Philadelphia, PA) has a "black box warning" regarding fatal respiratory depression in children younger than 2 years.[243] Although the liquid formulation of chloral hydrate is no longer commercially available, some hospital pharmacies now are compounding their own formulations. Low-dose chloral hydrate (10–25 mg/kg), in combination with other sedating medications, is used commonly in pediatric dental practice.

## GENERAL GUIDELINES

### Candidates

Patients who are in ASA classes I and II are frequently considered appropriate candidates for minimal, moderate, or deep sedation (Supplemental Appendix 2). Children in ASA classes III and IV, children with special needs, and those with anatomic airway abnormalities or moderate to severe tonsillar hypertrophy present issues that require additional and individual consideration, particularly for moderate and deep sedation.[68,244–249] Practitioners are encouraged to consult with appropriate subspecialists and/or an anesthesiologist for patients at increased risk of experiencing adverse sedation events because of their underlying medical/surgical conditions.

### Responsible Person

The pediatric patient shall be accompanied to and from the treatment facility by a parent, legal guardian, or other responsible person. It is preferable to have 2 adults accompany children who are still in car safety seats if transportation to and from a treatment facility is provided by 1 of the adults.[250]

### Facilities

The practitioner who uses sedation must have immediately available facilities, personnel, and equipment to manage emergency and rescue situations. The most common serious complications of sedation involve compromise of the airway or depressed respirations resulting in airway obstruction, hypoventilation, laryngospasm, hypoxemia, and apnea. Hypotension and cardiopulmonary arrest may occur, usually from the inadequate recognition and treatment of respiratory compromise.[42,48,92,97,99,125,132,139–155,] Other rare complications also may include seizures, vomiting, and allergic reactions. Facilities providing pediatric sedation should monitor for, and be prepared to treat, such complications.

### Back-up Emergency Services

A protocol for immediate access to back-up emergency services shall be clearly outlined. For nonhospital facilities, a protocol for the immediate activation of the EMS system for life-threatening complications must be established and maintained.[44] It should be understood that the availability of EMS does not replace the practitioner's responsibility to provide initial rescue for life-threatening complications.

### On-site Monitoring, Rescue Drugs, and Equipment

An emergency cart or kit must be immediately accessible. This cart or kit must contain the necessary age- and size-appropriate equipment (oral and nasal airways, bag-valve-mask device, LMAs or other supraglottic devices, laryngoscope blades, tracheal tubes, face masks, blood pressure cuffs, intravenous catheters, etc) to resuscitate a nonbreathing and unconscious child. The contents of the kit must allow for the provision of continuous life support while the patient is being transported to a medical/dental facility or to another area within the facility. All equipment and drugs must be checked and maintained on a scheduled basis (see Supplemental Appendices 3 and 4 for suggested drugs and emergency life support equipment to consider before the need for rescue occurs). Monitoring devices, such as electrocardiography (ECG) machines, pulse oximeters with size-appropriate probes, end-tidal carbon dioxide monitors, and defibrillators with size-appropriate patches/paddles, must have a safety and function check on a regular basis as required by local or state regulation. The use of emergency checklists is recommended, and these should be immediately available at all sedation locations; they can be obtained from http://www.pedsanesthesia.org/.

### Documentation

Documentation prior to sedation shall include, but not be limited to, the following recommendations:

1. Informed consent: The patient record shall document that appropriate informed consent was obtained according to local, state, and institutional requirements.[251,252]
2. Instructions and information provided to the responsible

Downloaded from by guest on June 28, 2016

person: The practitioner shall provide verbal and/or written instructions to the responsible person. Information shall include objectives of the sedation and anticipated changes in behavior during and after sedation.[163,253–255] Special instructions shall be given to the adult responsible for infants and toddlers who will be transported home in a car safety seat regarding the need to carefully observe the child's head position to avoid airway obstruction. Transportation in a car safety seat poses a particular risk for infants who have received medications known to have a long half-life, such as chloral hydrate, intramuscular pentobarbital, or phenothiazine because deaths after procedural sedation have been reported.[62,63,238,242,256,257] Consideration for a longer period of observation shall be given if the responsible person's ability to observe the child is limited (eg, only 1 adult who also has to drive). Another indication for prolonged observation would be a child with an anatomic airway problem, an underlying medical condition such as significant obstructive sleep apnea (OSA), or a former preterm infant younger than 60 weeks' postconceptional age. A 24-hour telephone number for the practitioner or his or her associates shall be provided to all patients and their families. Instructions shall include limitations of activities and appropriate dietary precautions.

## Dietary Precautions

Agents used for sedation have the potential to impair protective airway reflexes, particularly during deep sedation. Although a rare occurrence, pulmonary aspiration may occur if the child regurgitates and cannot protect his or her airway.[95,127,258] Therefore, the practitioner should evaluate preceding food and fluid intake before administering sedation. It is likely that the risk of aspiration during procedural sedation differs from that during general anesthesia involving tracheal intubation or other airway manipulations.[259,260] However, the absolute risk of aspiration during elective procedural sedation is not yet known; the reported incidence varies from ~1 in 825 to ~1 in 30 037.[95,127,129,173,244,261] Therefore, standard practice for fasting before elective sedation generally follows the same guidelines as for elective general anesthesia; this requirement is particularly important for solids, because aspiration of clear gastric contents causes less pulmonary injury than aspiration of particulate gastric contents.[262,263]

For emergency procedures in children undergoing general anesthesia, the reported incidence of pulmonary aspiration of gastric contents from 1 institution is ~1 in 373 compared with ~1 in 4544 for elective anesthetics.[262] Because there are few published studies with adequate statistical power to provide guidance to the practitioner regarding the safety or risk of pulmonary aspiration of gastric contents during procedural sedation,[95,127,129,173,244,259–261,264–268,] it is unknown whether the risk of aspiration is reduced when airway manipulation is not performed/anticipated (eg, moderate sedation). However, if a deeply sedated child requires intervention for airway obstruction, apnea, or laryngospasm, there is concern that these rescue maneuvers could increase the risk of pulmonary aspiration of gastric contents. For children requiring urgent/emergent sedation who do not meet elective fasting guidelines, the risks of sedation and possible aspiration are as-yet unknown and must be balanced against the benefits of performing the procedure promptly. For example, a prudent practitioner would be unlikely to administer deep sedation to a child with a minor condition who just ate a large meal; conversely, it is not justifiable to withhold sedation/analgesia from the child in significant pain from a displaced fracture who had a small snack a few hours earlier. Several emergency department studies have reported a low to zero incidence of pulmonary aspiration despite variable fasting periods[260,264,268]; however, each of these reports has, for the most part, clearly balanced the urgency of the procedure with the need for and depth of sedation.[268,269] Although emergency medicine studies and practice guidelines generally support a less restrictive approach to fasting for brief urgent/emergent procedures, such as care of wounds, joint dislocation, chest tube placement, etc, in healthy children, further research in many thousands of patients would be desirable to better define the relationships between various fasting intervals and sedation complications.[262–270]

### *Before Elective Sedation*

Children undergoing sedation for elective procedures generally should follow the same fasting guidelines as those for general anesthesia (Table 1).[271] It is permissible for routine necessary medications (eg, antiseizure medications) to be taken with a sip of clear liquid or water on the day of the procedure.

### *For the Emergency Patient*

The practitioner must always balance the possible risks of sedating nonfasted patients with the benefits of and necessity for completing the procedure. In particular, patients with a history of recent oral intake or with other known risk factors, such as trauma, decreased level of consciousness, extreme obesity (BMI ≥95% for age and sex), pregnancy, or bowel motility dysfunction, require careful evaluation before the administration of sedatives. When proper fasting has not been ensured,

Downloaded from by guest on June 28, 2016

the increased risks of sedation must be carefully weighed against its benefits, and the lightest effective sedation should be used. In this circumstance, additional techniques for achieving analgesia and patient cooperation, such as distraction, guided imagery, video games, topical and local anesthetics, hematoma block or nerve blocks, and other techniques advised by child life specialists, are particularly helpful and should be considered.[29,49,182–201, 274,275]

The use of agents with less risk of depressing protective airway reflexes, such as ketamine, or moderate sedation, which would also maintain protective reflexes, may be preferred.[276] Some emergency patients requiring deep sedation (eg, a trauma patient who just ate a full meal or a child with a bowel obstruction) may need to be intubated to protect their airway before they can be sedated.

### Use of Immobilization Devices (Protective Stabilization)

Immobilization devices, such as papoose boards, must be applied in such a way as to avoid airway obstruction or chest restriction.[277–281] The child's head position and respiratory excursions should be checked frequently to ensure airway patency. If an immobilization device is used, a hand or foot should be kept exposed, and the child should never be left unattended. If sedating medications are administered in conjunction with an immobilization device, monitoring must be used at a level consistent with the level of sedation achieved.

### Documentation at the Time of Sedation

1. Health evaluation: Before sedation, a health evaluation shall be performed by an appropriately licensed practitioner and reviewed by the sedation team at the time of treatment for possible interval changes.[282] The purpose of this evaluation is not only to document baseline status but also to determine whether the patient has specific risk factors that may warrant additional consultation before sedation. This evaluation also facilitates the identification of patients who will require more advanced airway or cardiovascular management skills or alterations in the doses or types of medications used for procedural sedation.

**TABLE 1** Appropriate Intake of Food and Liquids Before Elective Sedation

| Ingested Material | Minimum Fasting Period, h |
|---|---|
| Clear liquids: water, fruit juices without pulp, carbonated beverages, clear tea, black coffee | 2 |
| Human milk | 4 |
| Infant formula | 6 |
| Nonhuman milk: because nonhuman milk is similar to solids in gastric emptying time, the amount ingested must be considered when determining an appropriate fasting period. | 6 |
| Light meal: a light meal typically consists of toast and clear liquids. Meals that include fried or fatty foods or meat may prolong gastric emptying time. Both the amount and type of foods ingested must be considered when determining an appropriate fasting period. | 6 |

Source: American Society of Anesthesiologists. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures. An updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. Available at: https://www.asahq.org/For-Members/Practice-Management/Practice-Parameters.aspx. For emergent sedation, the practitioner must balance the depth of sedation versus the risk of possible aspiration; see also Mace et al[272] and Green et al.[273]

An important concern for the practitioner is the widespread use of medications that may interfere with drug absorption or metabolism and therefore enhance or shorten the effect time of sedating medications. Herbal medicines (eg, St John's wort, ginkgo, ginger, ginseng, garlic) may alter drug pharmacokinetics through inhibition of the cytochrome P450 system, resulting in prolonged drug effect and altered (increased or decreased) blood drug concentrations (midazolam, cyclosporine, tacrolimus).[283–292] Kava may increase the effects of sedatives by potentiating γ-aminobutyric acid inhibitory neurotransmission and may increase acetaminophen-induced liver toxicity.[293–295] Valerian may itself produce sedation that apparently is mediated through the modulation of γ-aminobutyric acid neurotransmission and receptor function.[291,296–299] Drugs such as erythromycin, cimetidine, and others may also inhibit the cytochrome P450 system, resulting in prolonged sedation with midazolam as well as other medications competing for the same enzyme systems.[300–304] Medications used to treat HIV infection, some anticonvulsants, immunosuppressive drugs, and some psychotropic medications (often used to treat children with autism spectrum disorder) may also produce clinically important drug-drug interactions.[305–314] Therefore, a careful drug history is a vital part of the safe sedation of children. The practitioner should consult various sources (a pharmacist, textbooks, online services, or handheld databases) for specific information on drug interactions.[315–319] The US Food and Drug Administration issued a warning in February 2013 regarding the use of codeine for postoperative pain management in children undergoing tonsillectomy, particularly those with OSA. The safety issue is that some children have duplicated cytochromes that allow greater than expected conversion of the prodrug codeine to morphine, thus resulting in potential overdose; codeine should be avoided for postprocedure analgesia.[320–324]

The health evaluation should include the following:

- age and weight (in kg) and gestational age at birth (preterm infants may have associated

Downloaded from by guest on June 28, 2016

sequelae such as apnea of prematurity); and

- health history, including (1) food and medication allergies and previous allergic or adverse drug reactions; (2) medication/drug history, including dosage, time, route, and site of administration for prescription, over-the-counter, herbal, or illicit drugs; (3) relevant diseases, physical abnormalities (including genetic syndromes), neurologic impairments that might increase the potential for airway obstruction, obesity, a history of snoring or OSA,[325–328] or cervical spine instability in Down syndrome, Marfan syndrome, skeletal dysplasia, and other conditions; (4) pregnancy status (as many as 1% of menarchal females presenting for general anesthesia at children's hospitals are pregnant)[329–331] because of concerns for the potential adverse effects of most sedating and anesthetic drugs on the fetus[329,332–338]; (5) history of prematurity (may be associated with subglottic stenosis or propensity to apnea after sedation); (6) history of any seizure disorder; (7) summary of previous relevant hospitalizations; (8) history of sedation or general anesthesia and any complications or unexpected responses; and (9) relevant family history, particularly related to anesthesia (eg, muscular dystrophy, malignant hyperthermia, pseudocholinesterase deficiency).

The review of systems should focus on abnormalities of cardiac, pulmonary, renal, or hepatic function that might alter the child's expected responses to sedating/analgesic medications. A specific query regarding signs and symptoms of sleep-disordered breathing and OSA may be helpful. Children with severe OSA who have experienced repeated episodes of desaturation will likely have altered mu receptors and be analgesic at opioid levels one-third to one-half those of a child without OSA[325–328,339,340]; lower titrated doses of opioids should be used in this population. Such a detailed history will help to determine which patients may benefit from a higher level of care by an appropriately skilled health care provider, such as an anesthesiologist. The health evaluation should also include:

- vital signs, including heart rate, blood pressure, respiratory rate, room air oxygen saturation, and temperature (for some children who are very upset or noncooperative, this may not be possible and a note should be written to document this circumstance);
- physical examination, including a focused evaluation of the airway (tonsillar hypertrophy, abnormal anatomy [eg, mandibular hypoplasia], high Mallampati score [ie, ability to visualize only the hard palate or tip of the uvula]) to determine whether there is an increased risk of airway obstruction[74,341–344];
- physical status evaluation (ASA classification [see Appendix 2]); and
- name, address, and telephone number of the child's home or parent's, or caregiver's cell phone; additional information such as the patient's personal care provider or medical home is also encouraged.

For hospitalized patients, the current hospital record may suffice for adequate documentation of presedation health; however, a note shall be written documenting that the chart was reviewed, positive findings were noted, and a management plan was formulated. If the clinical or emergency condition of the patient precludes acquiring complete information before sedation, this health evaluation should be obtained as soon as feasible.

2. Prescriptions. When prescriptions are used for sedation, a copy of the prescription or a note describing the content of the prescription should be in the patient's chart along with a description of the instructions that were given to the responsible person. **Prescription medications intended to accomplish procedural sedation must not be administered without the safety net of direct supervision by trained medical/dental personnel.** The administration of sedating medications at home poses an unacceptable risk, particularly for infants and preschool-aged children traveling in car safety seats because deaths as a result of this practice have been reported.[63,257]

### Documentation During Treatment

The patient's chart shall contain a time-based record that includes the name, route, site, time, dosage/kilogram, and patient effect of administered drugs. Before sedation, a "time out" should be performed to confirm the patient's name, procedure to be performed, and laterality and site of the procedure.[59] During administration, the inspired concentrations of oxygen and inhalation sedation agents and the duration of their administration shall be documented. Before drug administration, special attention must be paid to the calculation of dosage (ie, mg/kg); for obese patients, most drug doses should likely be adjusted lower to ideal body weight rather than actual weight.[345] When a programmable pump is used for the infusion of sedating medications, the dose/kilogram per minute or hour and the child's weight in kilograms should be double-checked and confirmed by a separate individual. The patient's chart shall contain documentation at the time of treatment that the patient's level of consciousness and responsiveness, heart rate, blood pressure, respiratory rate, expired carbon dioxide values, and oxygen saturation

Downloaded from by guest on June 28, 2016

were monitored. Standard vital signs should be further documented at appropriate intervals during recovery until the patient attains predetermined discharge criteria (Appendix 1). A variety of sedation scoring systems are available that may aid this process.[212,238,346–348] Adverse events and their treatment shall be documented.

### Documentation After Treatment

A dedicated and properly equipped recovery area is recommended (see Appendices 3 and 4). The time and condition of the child at discharge from the treatment area or facility shall be documented, which should include documentation that the child's level of consciousness and oxygen saturation in room air have returned to a state that is safe for discharge by recognized criteria (see Appendix 1). Patients receiving supplemental oxygen before the procedure should have a similar oxygen need after the procedure. Because some sedation medications are known to have a long half-life and may delay a patient's complete return to baseline or pose the risk of re-sedation[62,104,256,349,350] and because some patients will have complex multiorgan medical conditions, a longer period of observation in a less intense observation area (eg, a step-down observation area) before discharge from medical/dental supervision may be indicated.[239] Several scales to evaluate recovery have been devised and validated.[212,346–348,351,352] A simple evaluation tool may be the ability of the infant or child to remain awake for at least 20 minutes when placed in a quiet environment.[238]

## CONTINUOUS QUALITY IMPROVEMENT

The essence of medical error reduction is a careful examination of index events and root-cause analysis of how the event could be avoided in the future.[353–359] Therefore, each facility should maintain records that track all adverse events and significant interventions, such as desaturation; apnea; laryngospasm; need for airway interventions, including the need for placement of supraglottic devices such as an oral airway, nasal trumpet, or LMA; positive-pressure ventilation; prolonged sedation; unanticipated use of reversal agents; unplanned or prolonged hospital admission; sedation failures; inability to complete the procedure; and unsatisfactory sedation, analgesia, or anxiolysis.[360] Such events can then be examined for the assessment of risk reduction and improvement in patient/family satisfaction.

## PREPARATION FOR SEDATION PROCEDURES

Part of the safety net of sedation is using a systematic approach so as to not overlook having an important drug, piece of equipment, or monitor immediately available at the time of a developing emergency. To avoid this problem, it is helpful to use an acronym that allows the same setup and checklist for every procedure. A commonly used acronym useful in planning and preparation for a procedure is **SOAPME**, which represents the following:

**S** = Size-appropriate suction catheters and a functioning suction apparatus (eg, Yankauer-type suction)

**O** = an adequate Oxygen supply and functioning flow meters or other devices to allow its delivery

**A** = size-appropriate Airway equipment (eg, bag-valve-mask or equivalent device [functioning]), nasopharyngeal and oropharyngeal airways, LMA, laryngoscope blades (checked and functioning), endotracheal tubes, stylets, face mask

**P** = Pharmacy: all the basic drugs needed to support life during an emergency, including antagonists as indicated

**M** = Monitors: functioning pulse oximeter with size-appropriate oximeter probes,[361,362] end-tidal carbon dioxide monitor, and other monitors as appropriate for the procedure (eg, noninvasive blood pressure, ECG, stethoscope)

**E** = special Equipment or drugs for a particular case (eg, defibrillator)

## SPECIFIC GUIDELINES FOR INTENDED LEVEL OF SEDATION

### Minimal Sedation

Minimal sedation (old terminology, "anxiolysis") is a drug-induced state during which patients respond normally to verbal commands. Although cognitive function and coordination may be impaired, ventilatory and cardiovascular functions are unaffected. Children who have received minimal sedation generally will not require more than observation and intermittent assessment of their level of sedation. Some children will become moderately sedated despite the intended level of minimal sedation; should this occur, then the guidelines for moderate sedation apply.[85,363]

### Moderate Sedation

Moderate sedation (old terminology, "conscious sedation" or "sedation/analgesia") is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands or after light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained. The caveat that loss of consciousness should be unlikely is a particularly important aspect of the definition of moderate sedation; drugs and techniques used should carry a margin of safety wide enough to render unintended loss of consciousness unlikely. Because the patient who

Downloaded from by guest on June 28, 2016

receives moderate sedation may progress into a state of deep sedation and obtundation, the practitioner should be prepared to increase the level of vigilance corresponding to what is necessary for deep sedation.[85]

### *Personnel*

The Practitioner. The practitioner responsible for the treatment of the patient and/or the administration of drugs for sedation must be competent to use such techniques, to provide the level of monitoring described in these guidelines, and to manage complications of these techniques (ie, to be able to rescue the patient). Because the level of intended sedation may be exceeded, the practitioner must be sufficiently skilled to rescue a child with apnea, laryngospasm, and/or airway obstruction, including the ability to open the airway, suction secretions, provide CPAP, and perform successful bag-valve-mask ventilation should the child progress to a level of deep sedation. Training in, and maintenance of, advanced pediatric airway skills is required (eg, pediatric advanced life support [PALS]); regular skills reinforcement with simulation is strongly encouraged.[79,80,128,130,217–220, 364]

Support Personnel. The use of moderate sedation shall include the provision of a person, in addition to the practitioner, whose responsibility is to monitor appropriate physiologic parameters and to assist in any supportive or resuscitation measures, if required. This individual may also be responsible for assisting with interruptible patient-related tasks of short duration, such as holding an instrument or troubleshooting equipment.[60] This individual should be trained in and capable of providing advanced airway skills (eg, PALS). The support person shall have specific assignments in the event of an emergency and current knowledge of the emergency cart inventory. The practitioner and all ancillary personnel should participate in periodic reviews, simulation of rare emergencies, and practice drills of the facility's emergency protocol to ensure proper function of the equipment and coordination of staff roles in such emergencies.[133,365–367] It is recommended that at least 1 practitioner be skilled in obtaining vascular access in children.

### *Monitoring and Documentation*

Baseline. Before the administration of sedative medications, a baseline determination of vital signs shall be documented. For some children who are very upset or uncooperative, this may not be possible, and a note should be written to document this circumstance.

During the Procedure The physician/dentist or his or her designee shall document the name, route, site, time of administration, and dosage of all drugs administered. If sedation is being directed by a physician who is not personally administering the medications, then recommended practice is for the qualified health care provider administering the medication to confirm the dose verbally before administration. There shall be continuous monitoring of oxygen saturation and heart rate; when bidirectional verbal communication between the provider and patient is appropriate and possible (ie, patient is developmentally able and purposefully communicates), monitoring of ventilation by (1) capnography (preferred) or (2) amplified, audible pretracheal stethoscope (eg, Bluetooth technology)[368–371] or precordial stethoscope is strongly recommended. If bidirectional verbal communication is not appropriate or not possible, monitoring of ventilation by capnography (preferred), amplified, audible pretracheal stethoscope, or precordial stethoscope is required. Heart rate, respiratory rate, blood pressure, oxygen saturation, and expired carbon dioxide values should be recorded, at minimum, every 10 minutes in a time-based record. Note that the exact value of expired carbon dioxide is less important than simple assessment of continuous respiratory gas exchange. In some situations in which there is excessive patient agitation or lack of cooperation or during certain procedures such as bronchoscopy, dentistry, or repair of facial lacerations capnography may not be feasible, and this situation should be documented. For uncooperative children, it is often helpful to defer the initiation of capnography until the child becomes sedated. Similarly, the stimulation of blood pressure cuff inflation may cause arousal or agitation; in such cases, blood pressure monitoring may be counterproductive and may be documented at less frequent intervals (eg, 10–15 minutes, assuming the patient remains stable, well oxygenated, and well perfused). Immobilization devices (protective stabilization) should be checked to prevent airway obstruction or chest restriction. If a restraint device is used, a hand or foot should be kept exposed. The child's head position should be continuously assessed to ensure airway patency.

After the Procedure. The child who has received moderate sedation must be observed in a suitably equipped recovery area, which must have a functioning suction apparatus as well as the capacity to deliver >90% oxygen and positive-pressure ventilation (bag-valve mask) with an adequate oxygen capacity as well as age- and size-appropriate rescue equipment and devices. The patient's vital signs should be recorded at specific intervals (eg, every 10–15 minutes). If the patient is not fully alert, oxygen saturation and heart rate monitoring shall be used continuously until appropriate discharge criteria are met (see Appendix 1). Because sedation medications with a long half-life

Downloaded from by guest on June 28, 2016

may delay the patient's complete return to baseline or pose the risk of re-sedation, some patients might benefit from a longer period of less intense observation (eg, a step-down observation area where multiple patients can be observed simultaneously) before discharge from medical/dental supervision (see section entitled "Documentation Before Sedation" above).[62,256,349,350] A simple evaluation tool may be the ability of the infant or child to remain awake for at least 20 minutes when placed in a quiet environment.[238] Patients who have received reversal agents, such as flumazenil or naloxone, will require a longer period of observation, because the duration of the drugs administered may exceed the duration of the antagonist, resulting in re-sedation.

## Deep Sedation/General Anesthesia

"Deep sedation" ("deep sedation/analgesia") is a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully after repeated verbal or painful stimulation (eg, purposefully pushing away the noxious stimuli). Reflex withdrawal from a painful stimulus is not considered a purposeful response and is more consistent with a state of general anesthesia. 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. Patients may pass from a state of deep sedation to the state of general anesthesia. In some situations, such as during MRI, one is not usually able to assess responses to stimulation, because this would defeat the purpose of sedation, and one should assume that such patients are deeply sedated.

"General anesthesia" is 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.

### *Personnel*

During deep sedation, there must be 1 person whose only responsibility is to constantly observe the patient's vital signs, airway patency, and adequacy of ventilation and to either administer drugs or direct their administration. This individual must, at a minimum, be trained in PALS and capable of assisting with any emergency event. At least 1 individual must be present who is trained in and capable of providing advanced pediatric life support and who is skilled to rescue a child with apnea, laryngospasm, and/or airway obstruction. Required skills include the ability to open the airway, suction secretions, provide CPAP, insert supraglottic devices (oral airway, nasal trumpet, LMA), and perform successful bag-valve-mask ventilation, tracheal intubation, and cardiopulmonary resuscitation.

### *Equipment*

In addition to the equipment needed for moderate sedation, an ECG monitor and a defibrillator for use in pediatric patients should be readily available.

### *Vascular Access*

Patients receiving deep sedation should have an intravenous line placed at the start of the procedure or have a person skilled in establishing vascular access in pediatric patients immediately available.

### *Monitoring*

A competent individual shall observe the patient continuously. Monitoring shall include all parameters described for moderate sedation. Vital signs, including heart rate, respiratory rate, blood pressure, oxygen saturation, and expired carbon dioxide, must be documented at least every 5 minutes in a time-based record. Capnography should be used for almost all deeply sedated children because of the increased risk of airway/ventilation compromise. Capnography may not be feasible if the patient is agitated or uncooperative during the initial phases of sedation or during certain procedures, such as bronchoscopy or repair of facial lacerations, and this circumstance should be documented. For uncooperative children, the capnography monitor may be placed once the child becomes sedated. Note that if supplemental oxygen is administered, the capnograph may underestimate the true expired carbon dioxide value; of more importance than the numeric reading of exhaled carbon dioxide is the assurance of continuous respiratory gas exchange (ie, continuous waveform). Capnography is particularly useful for patients who are difficult to observe (eg, during MRI or in a darkened room).[64,67,72,90,96,110,159–162,164–166,167–170,372–375]

The physician/dentist or his or her designee shall document the name, route, site, time of administration, and dosage of all drugs administered. If sedation is being directed by a physician who is not personally administering the medications, then recommended practice is for the nurse administering the medication to confirm the dose verbally before administration. The inspired

Downloaded from by guest on June 28, 2016

concentrations of inhalation sedation agents and oxygen and the duration of administration shall be documented.

### *Postsedation Care*

The facility and procedures followed for postsedation care shall conform to those described under "moderate sedation." The initial recording of vital signs should be documented at least every 5 minutes. Once the child begins to awaken, the recording intervals may be increased to 10 to 15 minutes. Table 2 summarizes the equipment, personnel, and monitoring requirements for moderate and deep sedation.

**TABLE 2** Comparison of Moderate and Deep Sedation Equipment and Personnel Requirements

| | Moderate Sedation | Deep Sedation |
|---|---|---|
| Personnel | An observer who will monitor the patient but who may also assist with interruptible tasks; should be trained in PALS | An independent observer whose only responsibility is to continuously monitor the patient; trained in PALS |
| Responsible practitioner | Skilled to rescue a child with apnea, laryngospasm, and/or airway obstruction including the ability to open the airway, suction secretions, provide CPAP, and perform successful bag-valve-mask ventilation; recommended that at least 1 practitioner should be skilled in obtaining vascular access in children; trained in PALS | Skilled to rescue a child with apnea, laryngospasm, and/or airway obstruction, including the ability to open the airway, suction secretions, provide CPAP, perform successful bag-valve-mask ventilation, tracheal intubation, and cardiopulmonary resuscitation; training in PALS is required; at least 1 practitioner skilled in obtaining vascular access in children immediately available |
| Monitoring | Pulse oximetry<br>ECG recommended<br>Heart rate<br>Blood pressure<br>Respiration<br>Capnography recommended | Pulse oximetry<br>ECG required<br>Heart rate<br>Blood pressure<br>Respiration<br>Capnography required |
| Other equipment | Suction equipment, adequate oxygen source/supply | Suction equipment, adequate oxygen source/supply, defibrillator required |
| Documentation | Name, route, site, time of administration, and dosage of all drugs administered<br>Continuous oxygen saturation, heart rate, and ventilation (capnography recommended); parameters recorded every 10 minutes | Name, route, site, time of administration, and dosage of all drugs administered; continuous oxygen saturation, heart rate, and ventilation (capnography required); parameters recorded at least every 5 minutes |
| Emergency checklists | Recommended | Recommended |
| Rescue cart properly stocked with rescue drugs and age- and size-appropriate equipment (see Appendices 3 and 4) | Required | Required |
| Dedicated recovery area with rescue cart properly stocked with rescue drugs and age- and size-appropriate equipment (see Appendices 3 and 4) and dedicated recovery personnel; adequate oxygen supply | Recommended; initial recording of vital signs may be needed at least every 10 minutes until the child begins to awaken, then recording intervals may be increased | Recommended; initial recording of vital signs may be needed for at least 5-minute intervals until the child begins to awaken, then recording intervals may be increased to 10–15 minutes |
| Discharge criteria | See Appendix 1 | See Appendix 1 |

## Special Considerations

### *Neonates and Former Preterm Infants*

Neonates and former preterm infants require specific management, because immaturity of hepatic and renal function may alter the ability to metabolize and excrete sedating medications,[376] resulting in prolonged sedation and the need for extended postsedation monitoring. Former preterm infants have an increased risk of postanesthesia apnea,[377] but it is unclear whether a similar risk is associated with sedation, because this possibility has not been systematically investigated.[378]

Other concerns regarding the effects of anesthetic drugs and sedating medications on the developing brain are beyond the scope of this document. At this point, the research in this area is preliminary and inconclusive at best, but it would seem prudent to avoid unnecessary exposure to sedation if the procedure is unlikely to change medical/dental management (eg, a sedated MRI purely for screening purposes in preterm infants).[379–382]

### *Local Anesthetic Agents*

All local anesthetic agents are cardiac depressants and may cause central nervous system excitation or depression. Particular weight-based attention should be paid to cumulative dosage in all children.[118,120,125,383–386] To ensure that the patient will not receive an excessive dose, the maximum allowable safe dosage (eg, mg/kg) should be calculated before administration. There may be enhanced sedative effects when the highest recommended doses of local anesthetic drugs are used in combination with other sedatives or opioids (see Tables 3 and 4 for limits and conversion tables of commonly used local anesthetics).[118,125,387–400] In general, when administering local

Downloaded from by guest on June 28, 2016

**TABLE 3** Commonly Used Local Anesthetic Agents for Nerve Block or Infiltration: Doses, Duration, and Calculations

| Local Anesthetic | Maximum Dose With Epinephrine,[a] mg/kg | | Maximum Dose Without Epinephrine, mg/kg | | Duration of Action,[b] min |
|---|---|---|---|---|---|
| | Medical | Dental | Medical | Dental | |
| Esters | | | | | |
| Procaine | 10.0 | 6 | 7 | 6 | 60–90 |
| Chloroprocaine | 20.0 | 12 | 15 | 12 | 30–60 |
| Tetracaine | 1.5 | 1 | 1 | 1 | 180–600 |
| Amides | | | | | |
| Lidocaine | 7.0 | 4.4 | 4 | 4.4 | 90–200 |
| Mepivacaine | 7.0 | 4.4 | 5 | 4.4 | 120–240 |
| Bupivacaine | 3.0 | 1.3 | 2.5 | 1.3 | 180–600 |
| Levobupivacaine[c] | 3.0 | 2 | 2 | 2 | 180–600 |
| Ropivacaine | 3.0 | 2 | 2 | 2 | 180–600 |
| Articaine[d] | — | 7 | — | 7 | 60–230 |

Maximum recommended doses and durations of action are shown. Note that lower doses should be used in very vascular areas.

[a] These are maximum doses of local anesthetics combined with epinephrine; lower doses are recommended when used without epinephrine. Doses of amides should be decreased by 30% in infants younger than 6 mo. When lidocaine is being administered intravascularly (eg, during intravenous regional anesthesia), the dose should be decreased to 3 to 5 mg/kg; long-acting local anesthetic agents should not be used for intravenous regional anesthesia.

[b] Duration of action is dependent on concentration, total dose, and site of administration; use of epinephrine; and the patient's age.

[c] Levobupivacaine is not available in the United States.

[d] Use in pediatric patients under 4 years of age is not recommended.

**TABLE 4** Local Anesthetic Conversion Chart

| Concentration, % | mg/mL |
|---|---|
| 4.0 | 40 |
| 3.0 | 30 |
| 2.5 | 25 |
| 2.0 | 20 |
| 1.0 | 10 |
| 0.5 | 5 |
| 0.25 | 2.5 |
| 0.125 | 1.25 |

**TABLE 5** Treatment of Local Anesthetic Toxicity

1. Get help. Ventilate with 100% oxygen. Alert nearest facility with cardiopulmonary bypass capability.
2. Resuscitation: airway/ventilatory support, chest compressions, etc. Avoid vasopressin, calcium channel blockers, β-blockers, or additional local anesthetic. Reduce epinephrine dosages. Prolonged effort may be required.
3. Seizure management: benzodiazepines preferred (eg, intravenous midazolam 0.1–0.2 mg/kg); avoid propofol if cardiovascular instability.
4. Administer 1.5 mL/kg 20% lipid emulsion over ∼1 minute to trap unbound amide local anesthetics. Repeat bolus once or twice for persistent cardiovascular collapse.
5. Initiate 20% lipid infusion (0.25 mL/kg per minute) until circulation is restored; double the infusion rate if blood pressure remains low. Continue infusion for at least 10 minutes after attaining circulatory stability. Recommended upper limit of ∼10 mL/kg.
6. A fluid bolus of 10–20 mL/kg balanced salt solution and an infusion of phenylephrine (0.1 μg/kg per minute to start) may be needed to correct peripheral vasodilation.

Source: https://www.asra.com/advisory-guidelines/article/3/checklist-for-treatment-of-local-anesthetic-systemic-toxicity.

anesthetic drugs, the practitioner should aspirate frequently to minimize the likelihood that the needle is in a blood vessel; lower doses should be used when injecting into vascular tissues.[401] If high doses or injection of amide local anesthetics (bupivacaine and ropivacaine) into vascular tissues is anticipated, then the immediate availability of a 20% lipid emulsion for the treatment of local anesthetic toxicity is recommended (Tables 3 and 5).[402–409] Topical local anesthetics are commonly used and encouraged, but the practitioner should avoid applying excessive doses to mucosal surfaces where systemic uptake and possible toxicity (seizures, methemoglobinemia) could result and to remain within the manufacturer's recommendations regarding allowable surface area application.[410–415]

### *Pulse Oximetry*

Newer pulse oximeters are less susceptible to motion artifacts and may be more useful than older oximeters that do not contain updated software.[416–420] Oximeters that change tone with changes in hemoglobin saturation provide immediate aural warning to everyone within hearing distance. The oximeter probe must be properly positioned; clip-on devices are easy to displace, which may produce artifactual data (under- or overestimation of oxygen saturation).[361,362]

### *Capnography*

Expired carbon dioxide monitoring is valuable to diagnose the simple presence or absence of respirations, airway obstruction, or respiratory depression, particularly in patients sedated in less-accessible locations, such as in MRI machines or darkened rooms.[64,66,67,72,90,96,110,159–162,164–170,372–375,421–427] In patients receiving supplemental oxygen, capnography facilitates the recognition of apnea or airway obstruction several minutes before the situation would be detected just by pulse oximetry. In this situation, desaturation would be delayed due to increased oxygen reserves; capnography would enable earlier intervention.[161] One study in children sedated in the emergency department found that the use of capnography reduced the incidence of hypoventilation and desaturation

Downloaded from by guest on June 28, 2016

(7% to 1%).[174] The use of expired carbon dioxide monitoring devices is now required for almost all deeply sedated children (with rare exceptions), particularly in situations in which other means of assessing the adequacy of ventilation are limited. Several manufacturers have produced nasal cannulae that allow simultaneous delivery of oxygen and measurement of expired carbon dioxide values.[421,422,427] Although these devices can have a high degree of false-positive alarms, they are also very accurate for the detection of complete airway obstruction or apnea.[164,168,169] Taping the sampling line under the nares under an oxygen face mask or nasal hood will provide similar information. The exact measured value is less important than the simple answer to the question: Is the child exchanging air with each breath?

### *Processed EEG (Bispectral Index)*

Although not new to the anesthesia community, the processed EEG (bispectral index [BIS]) monitor is slowly finding its way into the sedation literature.[428] Several studies have attempted to use BIS monitoring as a means of noninvasively assessing the depth of sedation. This technology was designed to examine EEG signals and, through a variety of algorithms, correlate a number with depth of unconsciousness: that is, the lower the number, the deeper the sedation. Unfortunately, these algorithms are based on adult patients and have not been validated in children of varying ages and varying brain development. Although the readings correspond quite well with the depth of propofol sedation, the numbers may paradoxically go up rather than down with sevoflurane and ketamine because of central excitation despite a state of general anesthesia or deep sedation.[429,430] Opioids and benzodiazepines have minimal and variable effects on the BIS. Dexmedetomidine has minimal effect with EEG patterns, consistent with stage 2 sleep.[431] Several sedation studies have examined the utility of this device and degree of correlation with standard sedation scales.[347,363,432–435] It appears that there is some correlation with BIS values in moderate sedation, but there is not a reliable ability to distinguish between deep sedation and moderate sedation or deep sedation from general anesthesia.[432] Presently, it would appear that BIS monitoring might provide useful information only when used for sedation with propofol[363]; in general, it is still considered a research tool and not recommended for routine use.

### *Adjuncts to Airway Management and Resuscitation*

The vast majority of sedation complications can be managed with simple maneuvers, such as supplemental oxygen, opening the airway, suctioning, placement of an oral or nasopharyngeal airway, and bag-mask-valve ventilation. Rarely, tracheal intubation is required for more prolonged ventilatory support. In addition to standard tracheal intubation techniques, a number of supraglottic devices are available for the management of patients with abnormal airway anatomy or airway obstruction. Examples include the LMA, the cuffed oropharyngeal airway, and a variety of kits to perform an emergency cricothyrotomy.[436,437]

The largest clinical experience in pediatrics is with the LMA, which is available in multiple sizes, including those for late preterm and term neonates. The use of the LMA is now an essential addition to advanced airway training courses, and familiarity with insertion techniques can be life-saving.[438–442] The LMA can also serve as a bridge to secure airway management in children with anatomic airway abnormalities.[443,444] Practitioners are encouraged to gain experience with these techniques as they become incorporated into PALS courses.

Another valuable emergency technique is intraosseous needle placement for vascular access. Intraosseous needles are available in several sizes; insertion can be life-saving when rapid intravenous access is difficult. A relatively new intraosseous device (EZ-IO Vidacare, now part of Teleflex, Research Triangle Park, NC) is similar to a hand-held battery-powered drill. It allows rapid placement with minimal chance of misplacement; it also has a low-profile intravenous adapter.[445–450] Familiarity with the use of these emergency techniques can be gained by keeping current with resuscitation courses, such as PALS and advanced pediatric life support.

### *Patient Simulators*

High-fidelity patient simulators are now available that allow physicians, dentists, and other health care providers to practice managing a variety of programmed adverse events, such as apnea, bronchospasm, and laryngospasm.[133,220,450–452,] The use of such devices is encouraged to better train medical professionals and teams to respond more effectively to rare events.[128,131,451,453–455] One study that simulated the quality of cardiopulmonary resuscitation compared standard management of ventricular fibrillation versus rescue with the EZ-IO for the rapid establishment of intravenous access and placement of an LMA for establishing a patent airway in adults; the use of these devices resulted in more rapid establishment of vascular access and securing of the airway.[456]

### *Monitoring During MRI*

The powerful magnetic field and the generation of radiofrequency emissions necessitate the use of special equipment to provide

Downloaded from by guest on June 28, 2016

continuous patient monitoring throughout the MRI scanning procedure.[457–459] MRI-compatible pulse oximeters and capnographs capable of continuous function during scanning should be used in any sedated or restrained pediatric patient. Thermal injuries can result if appropriate precautions are not taken; the practitioner is cautioned to avoid coiling of all wires (oximeter, ECG) and to place the oximeter probe as far from the magnetic coil as possible to diminish the possibility of injury. ECG monitoring during MRI has been associated with thermal injury; special MRI-compatible ECG pads are essential to allow safe monitoring.[460–463] If sedation is achieved by using an infusion pump, then either an MRI-compatible pump is required or the pump must be situated outside of the room with long infusion tubing so as to maintain infusion accuracy. All equipment must be MRI compatible, including laryngoscope blades and handles, oxygen tanks, and any ancillary equipment. All individuals, including parents, must be screened for ferromagnetic materials, phones, pagers, pens, credit cards, watches, surgical implants, pacemakers, etc, before entry into the MRI suite.

### *Nitrous Oxide*

Inhalation sedation/analgesia equipment that delivers nitrous oxide must have the capacity of delivering 100% and never less than 25% oxygen concentration at a flow rate appropriate to the size of the patient. Equipment that delivers variable ratios of nitrous oxide >50% to oxygen that covers the mouth and nose must be used in conjunction with a calibrated and functional oxygen analyzer. All nitrous oxide-to-oxygen inhalation devices should be calibrated in accordance with appropriate state and local requirements. Consideration should be given to the National Institute of Occupational Safety and Health Standards for the scavenging of waste gases.[464] Newly constructed or reconstructed treatment facilities, especially those with piped-in nitrous oxide and oxygen, must have appropriate state or local inspections to certify proper function of inhalation sedation/analgesia systems before any delivery of patient care.

Nitrous oxide in oxygen, with varying concentrations, has been successfully used for many years to provide analgesia for a variety of painful procedures in children.[14,36,49,98,465–493] The use of nitrous oxide for minimal sedation is defined as the administration of nitrous oxide of ≤50% with the balance as oxygen, without any other sedative, opioid, or other depressant drug before or concurrent with the nitrous oxide to an otherwise healthy patient in ASA class I or II. The patient is able to maintain verbal communication throughout the procedure. It should be noted that although local anesthetics have sedative properties, for purposes of this guideline they are not considered sedatives in this circumstance. If nitrous oxide in oxygen is combined with other sedating medications, such as chloral hydrate, midazolam, or an opioid, or if nitrous oxide is used in concentrations >50%, the likelihood for moderate or deep sedation increases.[107,197,492,494,495] In this situation, the practitioner is advised to institute the guidelines for moderate or deep sedation, as indicated by the patient's response.[496]


## ACKNOWLEDMENTS

The lead authors thank Dr Corrie Chumpitazi and Dr Mary Hegenbarth for their contributions to this document.



## LEAD AUTHORS

Charles J. Coté, MD, FAAP
Stephen Wilson, DMD, MA, PhD

## AMERICAN ACADEMY OF PEDIATRICS

## AMERICAN ACADEMY OF PEDIATRIC DENTISTRY

## STAFF

Jennifer Riefe, MEd
Raymond J. Koteras, MHA


## ABBREVIATIONS

AAP: American Academy of Pediatrics
AAPD: American Academy of Pediatric Dentistry
ASA: American Society of Anesthesiologists
BIS: bispectral index
CPAP: continuous positive airway pressure
ECG: electrocardiography
EEG: electroencephalogram/electroencephalography
EMS: emergency medical services
LMA: laryngeal mask airway
MRI: magnetic resonance imaging
OSA: obstructive sleep apnea
PALS: pediatric advanced life support


**FINANCIAL DISCLOSURE:** The authors have indicated they do not have a financial relationship relevant to this article to disclose.

**FUNDING:** No external funding.

**POTENTIAL CONFLICT OF INTEREST:** The authors have indicated they have no potential conflicts of interest to disclose.


Downloaded from by guest on June 28, 2016

## REFERENCES


1. Milnes AR. Intravenous procedural sedation: an alternative to general anesthesia in the treatment of early childhood caries. *J Can Dent Assoc*. 2003;69:298–302
2. Law AK, Ng DK, Chan KK. Use of intramuscular ketamine for endoscopy sedation in children. *Pediatr Int*. 2003;45(2):180–185
3. Flood RG, Krauss B. Procedural sedation and analgesia for children in the emergency department. *Emerg Med Clin North Am*. 2003;21(1):121–139
4. Jaggar SI, Haxby E. Sedation, anaesthesia and monitoring for bronchoscopy. *Paediatr Respir Rev*. 2002;3(4):321–327
5. de Blic J, Marchac V, Scheinmann P. Complications of flexible bronchoscopy in children: prospective study of 1,328 procedures. *Eur Respir J*. 2002;20(5):1271–1276
6. Mason KP, Michna E, DiNardo JA, et al. Evolution of a protocol for ketamine-induced sedation as an alternative to general anesthesia for interventional radiologic procedures in pediatric patients. *Radiology*. 2002;225(2):457–465
7. Houpt M. Project USAP 2000—use of sedative agents by pediatric dentists: a 15-year follow-up survey. *Pediatr Dent*. 2002;24(4):289–294
8. Vinson DR, Bradbury DR. Etomidate for procedural sedation in emergency medicine. *Ann Emerg Med*. 2002;39(6):592–598
9. Everitt IJ, Barnett P. Comparison of two benzodiazepines used for sedation of children undergoing suturing of a laceration in an emergency department. *Pediatr Emerg Care*. 2002;18(2):72–74
10. Karian VE, Burrows PE, Zurakowski D, Connor L, Poznauskis L, Mason KP. The development of a pediatric radiology sedation program. *Pediatr Radiol*. 2002;32(5):348–353
11. Kaplan RF, Yang CI. Sedation and analgesia in pediatric patients for procedures outside the operating room. *Anesthesiol Clin North America*. 2002;20(1):181–194, vii
12. Wheeler DS, Jensen RA, Poss WB. A randomized, blinded comparison of chloral hydrate and midazolam sedation in children undergoing echocardiography. *Clin Pediatr (Phila)*. 2001;40(7):381–387
13. Hain RD, Campbell C. Invasive procedures carried out in conscious children: contrast between North American and European paediatric oncology centres. *Arch Dis Child*. 2001;85(1):12–15
14. Kennedy RM, Luhmann JD. Pharmacological management of pain and anxiety during emergency procedures in children. *Paediatr Drugs*. 2001;3(5):337–354
15. Kanagasundaram SA, Lane LJ, Cavalletto BP, Keneally JP, Cooper MG. Efficacy and safety of nitrous oxide in alleviating pain and anxiety during painful procedures. *Arch Dis Child*. 2001;84(6):492–495
16. Younge PA, Kendall JM. Sedation for children requiring wound repair: a randomised controlled double blind comparison of oral midazolam and oral ketamine. *Emerg Med J*. 2001;18(1):30–33
17. Ljungman G, Gordh T, Sörensen S, Kreuger A. Lumbar puncture in pediatric oncology: conscious sedation vs. general anesthesia. *Med Pediatr Oncol*. 2001;36(3):372–379
18. Poe SS, Nolan MT, Dang D, et al. Ensuring safety of patients receiving sedation for procedures: evaluation of clinical practice guidelines. *Jt Comm J Qual Improv*. 2001;27(1):28–41
19. D'Agostino J, Terndrup TE. Chloral hydrate versus midazolam for sedation of children for neuroimaging: a randomized clinical trial. *Pediatr Emerg Care*. 2000;16(1):1–4
20. Green SM, Kuppermann N, Rothrock SG, Hummel CB, Ho M. Predictors of adverse events with intramuscular ketamine sedation in children. *Ann Emerg Med*. 2000;35(1):35–42
21. Hopkins KL, Davis PC, Sanders CL, Churchill LH. Sedation for pediatric imaging studies. *Neuroimaging Clin N Am*. 1999;9(1):1–10
22. Bauman LA, Kish I, Baumann RC, Politis GD. Pediatric sedation with analgesia. *Am J Emerg Med*. 1999;17(1):1–3
23. Bhatt-Mehta V, Rosen DA. Sedation in children: current concepts. *Pharmacotherapy*. 1998;18(4):790–807
24. Morton NS, Oomen GJ. Development of a selection and monitoring protocol for safe sedation of children. *Paediatr Anaesth*. 1998;8(1):65–68
25. Murphy MS. Sedation for invasive procedures in paediatrics. *Arch Dis Child*. 1997;77(4):281–284
26. Webb MD, Moore PA. Sedation for pediatric dental patients. *Dent Clin North Am*. 2002;46(4):803–814, xi
27. Malviya S, Voepel-Lewis T, Tait AR, Merkel S. Sedation/analgesia for diagnostic and therapeutic procedures in children. *J Perianesth Nurs*. 2000;15(6):415–422
28. Zempsky WT, Schechter NL. Office-based pain managemen: the 15-minute consultation. *Pediatr Clin North Am*. 2000;47(3):601–615
29. Kennedy RM, Luhmann JD. The "ouchless emergency department": getting closer: advances in decreasing distress during painful procedures in the emergency department. *Pediatr Clin North Am*. 1999;46(6):1215–1247, vii–viii
30. Rodriguez E, Jordan R. Contemporary trends in pediatric sedation and analgesia. *Emerg Med Clin North Am*. 2002;20(1):199–222
31. Ruess L, O'Connor SC, Mikita CP, Creamer KM. Sedation for pediatric diagnostic imaging: use of pediatric and nursing resources as an alternative to a radiology department sedation team. *Pediatr Radiol*. 2002;32(7):505–510
32. Weiss S. Sedation of pediatric patients for nuclear medicine procedures. *Semin Nucl Med*. 1993;23(3):190–198
33. Wilson S. Pharmacologic behavior management for pediatric dental treatment. *Pediatr Clin North Am*. 2000;47(5):1159–1175
34. McCarty EC, Mencio GA, Green NE. Anesthesia and analgesia for the ambulatory management of fractures in children. *J Am Acad Orthop Surg*. 1999;7(2):81–91
35. Egelhoff JC, Ball WS Jr, Koch BL, Parks TD. Safety and efficacy of sedation in children using a structured sedation


Downloaded from by guest on June 28, 2016

program. *AJR Am J Roentgenol*. 1997;168(5):1259–1262

36. Heinrich M, Menzel C, Hoffmann F, Berger M, Schweinitz DV. Self-administered procedural analgesia using nitrous oxide/oxygen (50:50) in the pediatric surgery emergency room: effectiveness and limitations. *Eur J Pediatr Surg*. 2015;25(3):250–256
37. Hoyle JD Jr, Callahan JM, Badawy M, et al; Traumatic Brain Injury Study Group for the Pediatric Emergency Care Applied Research Network (PECARN). Pharmacological sedation for cranial computed tomography in children after minor blunt head trauma. *Pediatr Emerg Care*. 2014;30(1):1–7
38. Chiaretti A, Benini F, Pierri F, et al. Safety and efficacy of propofol administered by paediatricians during procedural sedation in children. *Acta Paediatr*. 2014;103(2):182–187
39. Pacheco GS, Ferayorni A. Pediatric procedural sedation and analgesia. *Emerg Med Clin North Am*. 2013;31(3):831–852
40. Griffiths MA, Kamat PP, McCracken CE, Simon HK. Is procedural sedation with propofol acceptable for complex imaging? A comparison of short vs. prolonged sedations in children. *Pediatr Radiol*. 2013;43(10):1273–1278
41. Doctor K, Roback MG, Teach SJ. An update on pediatric hospital-based sedation. *Curr Opin Pediatr*. 2013;25(3):310–316
42. Alletag MJ, Auerbach MA, Baum CR. Ketamine, propofol, and ketofol use for pediatric sedation. *Pediatr Emerg Care*. 2012;28(12):1391–1395; quiz: 1396–1398
43. Jain R, Petrillo-Albarano T, Parks WJ, Linzer JF Sr, Stockwell JA. Efficacy and safety of deep sedation by non-anesthesiologists for cardiac MRI in children. *Pediatr Radiol*. 2013;43(5):605–611
44. Nelson T, Nelson G. The role of sedation in contemporary pediatric dentistry. *Dent Clin North Am*. 2013;57(1):145–161
45. Monroe KK, Beach M, Reindel R, et al. Analysis of procedural sedation provided by pediatricians. *Pediatr Int*. 2013;55(1):17–23
46. Alexander M. Managing patient stress in pediatric radiology. *Radiol Technol*. 2012;83(6):549–560
47. Macias CG, Chumpitazi CE. Sedation and anesthesia for CT: emerging issues for providing high-quality care. *Pediatr Radiol*. 2011;41(suppl 2):517–522
48. Andolfatto G, Willman E. A prospective case series of pediatric procedural sedation and analgesia in the emergency department using single-syringe ketamine-propofol combination (ketofol). *Acad Emerg Med*. 2010;17(2):194–201
49. Brown SC, Hart G, Chastain DP, Schneeweiss S, McGrath PA. Reducing distress for children during invasive procedures: randomized clinical trial of effectiveness of the PediSedate. *Paediatr Anaesth*. 2009;19(8):725–731
50. Yamamoto LG. Initiating a hospital-wide pediatric sedation service provided by emergency physicians. *Clin Pediatr (Phila)*. 2008;47(1):37–48
51. Doyle L, Colletti JE. Pediatric procedural sedation and analgesia. *Pediatr Clin North Am*. 2006;53(2):279–292
52. Todd DW. Pediatric sedation and anesthesia for the oral surgeon. *Oral Maxillofac Surg Clin North Am*. 2013;25(3):467–478, vi–vii
53. Committee on Drugs, Section on Anesthesiology, American Academy of Pediatrics. Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. *Pediatrics*. 1985;76(2):317–321
54. American Academy of Pediatric Dentistry. Guidelines for the elective use of conscious sedation, deep sedation, and general anesthesia in pediatric patients. *ASDC J Dent Child*. 1986;53(1):21–22
55. Committee on Drugs, American Academy of Pediatrics. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures. *Pediatrics*. 1992;89(6 pt 1):1110–1115
56. Committee on Drugs, American Academy of Pediatrics. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: addendum. *Pediatrics*. 2002;110(4):836–838
57. American Academy of Pediatrics, American Academy of Pediatric Dentistry. Guidelines on the elective use of minimal, moderate, and deep sedation and general anesthesia for pediatric dental patients. 2011. Available at: http://www.aapd.org/media/policies_guidelines/g_sedation.pdf. Accessed May 27, 2016
58. Coté CJ, Wilson S; American Academy of Pediatrics; American Academy of Pediatric Dentistry; Work Group on Sedation. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update. *Pediatrics*. 2006;118(6):2587–2602
59. The Joint Commission. Comprehensive Accreditation Manual for Hospitals (CAMH): the official handbook. Oakbrook Terrace, IL: The Joint Commission; 2014
60. American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. *Anesthesiology*. 2002;96(4):1004–1017
61. Committee of Origin: Ad Hoc on Non-Anesthesiologist Privileging. Statement on granting privileges for deep sedation to non-anesthesiologist sedation practitioners. 2010. Available at: http://www.asahq.org/~/media/sites/asahq/files/public/resources/standards-guidelines/advisory-on-granting-privileges-for-deep-sedation-to-non-anesthesiologist.pdf. Accessed May 27, 2016
62. Coté CJ, Karl HW, Notterman DA, Weinberg JA, McCloskey C. Adverse sedation events in pediatrics: analysis of medications used for sedation. *Pediatrics*. 2000;106(4):633–644
63. Coté CJ, Notterman DA, Karl HW, Weinberg JA, McCloskey C. Adverse sedation events in pediatrics: a critical incident analysis of contributing factors. *Pediatrics*. 2000;105(4 pt 1):805–814
64. Kim G, Green SM, Denmark TK, Krauss B. Ventilatory response during

Downloaded from by guest on June 28, 2016

dissociative sedation in children-a pilot study. *Acad Emerg Med*. 2003;10(2):140–145

65. Coté CJ. Sedation for the pediatric patient: a review. *Pediatr Clin North Am*. 1994;41(1):31–58
66. Mason KP, Burrows PE, Dorsey MM, Zurakowski D, Krauss B. Accuracy of capnography with a 30 foot nasal cannula for monitoring respiratory rate and end-tidal CO2 in children. *J Clin Monit Comput*. 2000;16(4):259–262
67. McQuillen KK, Steele DW. Capnography during sedation/analgesia in the pediatric emergency department. *Pediatr Emerg Care*. 2000;16(6):401–404
68. Malviya S, Voepel-Lewis T, Tait AR. Adverse events and risk factors associated with the sedation of children by nonanesthesiologists. *Anesth Analg*. 1997;85(6):1207–1213
69. Coté CJ, Rolf N, Liu LM, et al. A single-blind study of combined pulse oximetry and capnography in children. *Anesthesiology*. 1991;74(6):980–987
70. Guideline SIGN; Scottish Intercollegiate Guidelines Network. SIGN Guideline 58: safe sedation of children undergoing diagnostic and therapeutic procedures. *Paediatr Anaesth*. 2008;18(1):11–12
71. Peña BM, Krauss B. Adverse events of procedural sedation and analgesia in a pediatric emergency department. *Ann Emerg Med*. 1999;34(4 pt 1):483–491
72. Smally AJ, Nowicki TA. Sedation in the emergency department. *Curr Opin Anaesthesiol*. 2007;20(4):379–383
73. Ratnapalan S, Schneeweiss S. Guidelines to practice: the process of planning and implementing a pediatric sedation program. *Pediatr Emerg Care*. 2007;23(4):262–266
74. Hoffman GM, Nowakowski R, Troshynski TJ, Berens RJ, Weisman SJ. Risk reduction in pediatric procedural sedation by application of an American Academy of Pediatrics/American Society of Anesthesiologists process model. *Pediatrics*. 2002;109(2):236–243
75. Krauss B. Management of acute pain and anxiety in children undergoing procedures in the emergency department. *Pediatr Emerg Care*. 2001;17(2):115–122; quiz: 123–125
76. Slovis TL. Sedation and anesthesia issues in pediatric imaging. *Pediatr Radiol*. 2011;41(suppl 2):514–516
77. Babl FE, Krieser D, Belousoff J, Theophilos T. Evaluation of a paediatric procedural sedation training and credentialing programme: sustainability of change. *Emerg Med J*. 2010;27(8):577–581
78. Meredith JR, O'Keefe KP, Galwankar S. Pediatric procedural sedation and analgesia. *J Emerg Trauma Shock*. 2008;1(2):88–96
79. Priestley S, Babl FE, Krieser D, et al. Evaluation of the impact of a paediatric procedural sedation credentialing programme on quality of care. *Emerg Med Australas*. 2006;18(5–6):498–504
80. Babl F, Priestley S, Krieser D, et al. Development and implementation of an education and credentialing programme to provide safe paediatric procedural sedation in emergency departments. *Emerg Med Australas*. 2006;18(5–6):489–497
81. Cravero JP, Blike GT. Pediatric sedation. *Curr Opin Anaesthesiol*. 2004;17(3):247–251
82. Shavit I, Keidan I, Augarten A. The practice of pediatric procedural sedation and analgesia in the emergency department. *Eur J Emerg Med*. 2006;13(5):270–275
83. Langhan ML, Mallory M, Hertzog J, Lowrie L, Cravero J; Pediatric Sedation Research Consortium. Physiologic monitoring practices during pediatric procedural sedation: a report from the Pediatric Sedation Research Consortium. *Arch Pediatr Adolesc Med*. 2012;166(11):990–998
84. Primosch RE. Lidocaine toxicity in children—prevention and intervention. *Todays FDA*. 1992;4:4C–5C
85. Dial S, Silver P, Bock K, Sagy M. Pediatric sedation for procedures titrated to a desired degree of immobility results in unpredictable depth of sedation. *Pediatr Emerg Care*. 2001;17(6):414–420
86. Maxwell LG, Yaster M. The myth of conscious sedation. *Arch Pediatr Adolesc Med*. 1996;150(7):665–667
87. Coté CJ. "Conscious sedation": time for this oxymoron to go away! *J Pediatr*. 2001;139(1):15–17; discussion: 18–19
88. Motas D, McDermott NB, VanSickle T, Friesen RH. Depth of consciousness and deep sedation attained in children as administered by nonanaesthesiologists in a children's hospital. *Paediatr Anaesth*. 2004;14(3):256–260
89. Cudny ME, Wang NE, Bardas SL, Nguyen CN. Adverse events associated with procedural sedation in pediatric patients in the emergency department. *Hosp Pharm*. 2013;48(2):134–142
90. Mora Capín A, Míguez Navarro C, López López R, Marañón Pardillo R. Usefulness of capnography for monitoring sedoanalgesia: influence of oxygen on the parameters monitored [in Spanish]. *An Pediatr (Barc)*. 2014;80(1):41–46
91. Frieling T, Heise J, Kreysel C, Kuhlen R, Schepke M. Sedation-associated complications in endoscopy—prospective multicentre survey of 191142 patients. *Z Gastroenterol*. 2013;51(6):568–572
92. Khutia SK, Mandal MC, Das S, Basu SR. Intravenous infusion of ketamine-propofol can be an alternative to intravenous infusion of fentanyl-propofol for deep sedation and analgesia in paediatric patients undergoing emergency short surgical procedures. *Indian J Anaesth*. 2012;56(2):145–150
93. Kannikeswaran N, Chen X, Sethuraman U. Utility of endtidal carbon dioxide monitoring in detection of hypoxia during sedation for brain magnetic resonance imaging in children with developmental disabilities. *Paediatr Anaesth*. 2011;21(12):1241–1246
94. McGrane O, Hopkins G, Nielson A, Kang C. Procedural sedation with propofol: a retrospective review of the experiences of an emergency medicine residency program 2005 to 2010. *Am J Emerg Med*. 2012;30(5):706–711
95. Mallory MD, Baxter AL, Yanosky DJ, Cravero JP; Pediatric Sedation Research Consortium. Emergency physician-administered propofol sedation: a report on 25,433 sedations from the Pediatric Sedation Research

Downloaded from by guest on June 28, 2016

Consortium. *Ann Emerg Med*. 2011;57(5):462–468.e1

96. Langhan ML, Chen L, Marshall C, Santucci KA. Detection of hypoventilation by capnography and its association with hypoxia in children undergoing sedation with ketamine. *Pediatr Emerg Care*. 2011;27(5):394–397
97. David H, Shipp J. A randomized controlled trial of ketamine/propofol versus propofol alone for emergency department procedural sedation. *Ann Emerg Med*. 2011;57(5):435–441
98. Babl FE, Belousoff J, Deasy C, Hopper S, Theophilos T. Paediatric procedural sedation based on nitrous oxide and ketamine: sedation registry data from Australia. *Emerg Med J*. 2010;27(8):607–612
99. Lee-Jayaram JJ, Green A, Siembieda J, et al. Ketamine/midazolam versus etomidate/fentanyl: procedural sedation for pediatric orthopedic reductions. *Pediatr Emerg Care*. 2010;26(6):408–412
100. Melendez E, Bachur R. Serious adverse events during procedural sedation with ketamine. *Pediatr Emerg Care*. 2009;25(5):325–328
101. Misra S, Mahajan PV, Chen X, Kannikeswaran N. Safety of procedural sedation and analgesia in children less than 2 years of age in a pediatric emergency department. *Int J Emerg Med*. 2008;1(3):173–177
102. Green SM, Roback MG, Krauss B, et al; Emergency Department Ketamine Meta-Analysis Study Group. Predictors of airway and respiratory adverse events with ketamine sedation in the emergency department: an individual-patient data meta-analysis of 8,282 children. *Ann Emerg Med*. 2009;54(2):158–168.e1–e4
103. Kannikeswaran N, Mahajan PV, Sethuraman U, Groebe A, Chen X. Sedation medication received and adverse events related to sedation for brain MRI in children with and without developmental disabilities. *Paediatr Anaesth*. 2009;19(3):250–256
104. Ramaswamy P, Babl FE, Deasy C, Sharwood LN. Pediatric procedural sedation with ketamine: time to discharge after intramuscular versus intravenous administration. *Acad Emerg Med*. 2009;16(2):101–107
105. Vardy JM, Dignon N, Mukherjee N, Sami DM, Balachandran G, Taylor S. Audit of the safety and effectiveness of ketamine for procedural sedation in the emergency department. *Emerg Med J*. 2008;25(9):579–582
106. Capapé S, Mora E, Mintegui S, García S, Santiago M, Benito J. Prolonged sedation and airway complications after administration of an inadvertent ketamine overdose in emergency department. *Eur J Emerg Med*. 2008;15(2):92–94
107. Babl FE, Oakley E, Seaman C, Barnett P, Sharwood LN. High-concentration nitrous oxide for procedural sedation in children: adverse events and depth of sedation. *Pediatrics*. 2008;121(3). Available at: www.pediatrics.org/cgi/content/full/121/3/e528
108. Mahar PJ, Rana JA, Kennedy CS, Christopher NC. A randomized clinical trial of oral transmucosal fentanyl citrate versus intravenous morphine sulfate for initial control of pain in children with extremity injuries. *Pediatr Emerg Care*. 2007;23(8):544–548
109. Sacchetti A, Stander E, Ferguson N, Maniar G, Valko P. Pediatric Procedural Sedation in the Community Emergency Department: results from the ProSCED registry. *Pediatr Emerg Care*. 2007;23(4):218–222
110. Anderson JL, Junkins E, Pribble C, Guenther E. Capnography and depth of sedation during propofol sedation in children. *Ann Emerg Med*. 2007;49(1):9–13
111. Luhmann JD, Schootman M, Luhmann SJ, Kennedy RM. A randomized comparison of nitrous oxide plus hematoma block versus ketamine plus midazolam for emergency department forearm fracture reduction in children. *Pediatrics*. 2006;118(4). Available at: www.pediatrics.org/cgi/content/full/118/4/e1078
112. Waterman GD Jr, Leder MS, Cohen DM. Adverse events in pediatric ketamine sedations with or without morphine pretreatment. *Pediatr Emerg Care*. 2006;22(6):408–411
113. Moore PA, Goodson JM. Risk appraisal of narcotic sedation for children. *Anesth Prog*. 1985;32(4):129–139
114. Nahata MC, Clotz MA, Krogg EA. Adverse effects of meperidine, promethazine, and chlorpromazine for sedation in pediatric patients. *Clin Pediatr (Phila)*. 1985;24(10):558–560
115. Brown ET, Corbett SW, Green SM. Iatrogenic cardiopulmonary arrest during pediatric sedation with meperidine, promethazine, and chlorpromazine. *Pediatr Emerg Care*. 2001;17(5):351–353
116. Benusis KP, Kapaun D, Furnam LJ. Respiratory depression in a child following meperidine, promethazine, and chlorpromazine premedication: report of case. *ASDC J Dent Child*. 1979;46(1):50–53
117. Garriott JC, Di Maio VJ. Death in the dental chair: three drug fatalities in dental patients. *J Toxicol Clin Toxicol*. 1982;19(9):987–995
118. Goodson JM, Moore PA. Life-threatening reactions after pedodontic sedation: an assessment of narcotic, local anesthetic, and antiemetic drug interaction. *J Am Dent Assoc*. 1983;107(2):239–245
119. Jastak JT, Pallasch T. Death after chloral hydrate sedation: report of case. *J Am Dent Assoc*. 1988;116(3):345–348
120. Jastak JT, Peskin RM. Major morbidity or mortality from office anesthetic procedures: a closed-claim analysis of 13 cases. *Anesth Prog*. 1991;38(2):39–44
121. Kaufman E, Jastak JT. Sedation for outpatient dental procedures. *Compend Contin Educ Dent*. 1995;16(5):462–466; quiz: 480
122. Wilson S. Pharmacological management of the pediatric dental patient. *Pediatr Dent*. 2004;26(2):131–136
123. Sams DR, Thornton JB, Wright JT. The assessment of two oral sedation drug regimens in pediatric dental patients. *ASDC J Dent Child*. 1992;59(4):306–312
124. Geelhoed GC, Landau LI, Le Souëf PN. Evaluation of SaO2 as a predictor of outcome in 280 children presenting

Downloaded from by guest on June 28, 2016

with acute asthma. *Ann Emerg Med*. 1994;23(6):1236–1241

125. Chicka MC, Dembo JB, Mathu-Muju KR, Nash DA, Bush HM. Adverse events during pediatric dental anesthesia and sedation: a review of closed malpractice insurance claims. *Pediatr Dent*. 2012;34(3):231–238

126. Lee HH, Milgrom P, Starks H, Burke W. Trends in death associated with pediatric dental sedation and general anesthesia. *Paediatr Anaesth*. 2013;23(8):741–746

127. Sanborn PA, Michna E, Zurakowski D, et al. Adverse cardiovascular and respiratory events during sedation of pediatric patients for imaging examinations. *Radiology*. 2005;237(1):288–294

128. Shavit I, Keidan I, Hoffmann Y, et al. Enhancing patient safety during pediatric sedation: the impact of simulation-based training of nonanesthesiologists. *Arch Pediatr Adolesc Med*. 2007;161(8):740–743

129. Cravero JP, Beach ML, Blike GT, Gallagher SM, Hertzog JH; Pediatric Sedation Research Consortium. The incidence and nature of adverse events during pediatric sedation/anesthesia with propofol for procedures outside the operating room: a report from the Pediatric Sedation Research Consortium. *Anesth Analg*. 2009;108(3):795–804

130. Blike GT, Christoffersen K, Cravero JP, Andeweg SK, Jensen J. A method for measuring system safety and latent errors associated with pediatric procedural sedation. *Anesth Analg*. 2005;101(1):48–58

131. Cravero JP, Havidich JE. Pediatric sedation—evolution and revolution. *Paediatr Anaesth*. 2011;21(7):800–809

132. Havidich JE, Cravero JP. The current status of procedural sedation for pediatric patients in out-of-operating room locations. *Curr Opin Anaesthesiol*. 2012;25(4):453–460

133. Hollman GA, Banks DM, Berkenbosch JW, et al. Development, implementation, and initial participant feedback of a pediatric sedation provider course. *Teach Learn Med*. 2013;25(3):249–257

134. Scherrer PD, Mallory MD, Cravero JP, Lowrie L, Hertzog JH, Berkenbosch JW; Pediatric Sedation Research Consortium. The impact of obesity on pediatric procedural sedation-related outcomes: results from the Pediatric Sedation Research Consortium. *Paediatr Anaesth*. 2015;25(7):689–697

135. Emrath ET, Stockwell JA, McCracken CE, Simon HK, Kamat PP. Provision of deep procedural sedation by a pediatric sedation team at a freestanding imaging center. *Pediatr Radiol*. 2014;44(8):1020–1025

136. Kamat PP, McCracken CE, Gillespie SE, et al. Pediatric critical care physician-administered procedural sedation using propofol: a report from the Pediatric Sedation Research Consortium Database. *Pediatr Crit Care Med*. 2015;16(1):11–20

137. Couloures KG, Beach M, Cravero JP, Monroe KK, Hertzog JH. Impact of provider specialty on pediatric procedural sedation complication rates. *Pediatrics*. 2011;127(5). Available at: www.pediatrics.org/cgi/content/full/127/5/e1154

138. Metzner J, Domino KB. Risks of anesthesia or sedation outside the operating room: the role of the anesthesia care provider. *Curr Opin Anaesthesiol*. 2010;23(4):523–531

139. Patel KN, Simon HK, Stockwell CA, et al. Pediatric procedural sedation by a dedicated nonanesthesiology pediatric sedation service using propofol. *Pediatr Emerg Care*. 2009;25(3):133–138

140. Koo SH, Lee DG, Shin H. Optimal initial dose of chloral hydrate in management of pediatric facial laceration. *Arch Plast Surg*. 2014;41(1):40–44

141. Ivaturi V, Kriel R, Brundage R, Loewen G, Mansbach H, Cloyd J. Bioavailability of intranasal vs. rectal diazepam. *Epilepsy Res*. 2013;103(2–3):254–261

142. Mandt MJ, Roback MG, Bajaj L, Galinkin JL, Gao D, Wathen JE. Etomidate for short pediatric procedures in the emergency department. *Pediatr Emerg Care*. 2012;28(9):898–904

143. Tsze DS, Steele DW, Machan JT, Akhlaghi F, Linakis JG. Intranasal ketamine for procedural sedation in pediatric laceration repair: a preliminary report. *Pediatr Emerg Care*. 2012;28(8):767–770

144. Jasiak KD, Phan H, Christich AC, Edwards CJ, Skrepnek GH, Patanwala AE. Induction dose of propofol for pediatric patients undergoing procedural sedation in the emergency department. *Pediatr Emerg Care*. 2012;28(5):440–442

145. McMorrow SP, Abramo TJ. Dexmedetomidine sedation: uses in pediatric procedural sedation outside the operating room. *Pediatr Emerg Care*. 2012;28(3):292–296

146. Sahyoun C, Krauss B. Clinical implications of pharmacokinetics and pharmacodynamics of procedural sedation agents in children. *Curr Opin Pediatr*. 2012;24(2):225–232

147. Sacchetti A, Jachowski J, Heisler J, Cortese T. Remifentanil use in emergency department patients: initial experience. *Emerg Med J*. 2012;29(11):928–929

148. Shah A, Mosdossy G, McLeod S, Lehnhardt K, Peddle M, Rieder M. A blinded, randomized controlled trial to evaluate ketamine/propofol versus ketamine alone for procedural sedation in children. *Ann Emerg Med*. 2011;57(5):425–433.e2

149. Herd DW, Anderson BJ, Keene NA, Holford NH. Investigating the pharmacodynamics of ketamine in children. *Paediatr Anaesth*. 2008;18(1):36–42

150. Sharieff GQ, Trocinski DR, Kanegaye JT, Fisher B, Harley JR. Ketamine-propofol combination sedation for fracture reduction in the pediatric emergency department. *Pediatr Emerg Care*. 2007;23(12):881–884

151. Herd DW, Anderson BJ, Holford NH. Modeling the norketamine metabolite in children and the implications for analgesia. *Paediatr Anaesth*. 2007;17(9):831–840

152. Herd D, Anderson BJ. Ketamine disposition in children presenting for procedural sedation and analgesia in a children's emergency department. *Paediatr Anaesth*. 2007;17(7):622–629

153. Heard CM, Joshi P, Johnson K. Dexmedetomidine for pediatric MRI

Downloaded from by guest on June 28, 2016

sedation: a review of a series of cases. *Paediatr Anaesth*. 2007;17(9):888–892

154. Heard C, Burrows F, Johnson K, Joshi P, Houck J, Lerman J. A comparison of dexmedetomidine-midazolam with propofol for maintenance of anesthesia in children undergoing magnetic resonance imaging. *Anesth Analg*. 2008;107(6):1832–1839

155. Hertzog JH, Havidich JE. Non-anesthesiologist-provided pediatric procedural sedation: an update. *Curr Opin Anaesthesiol*. 2007;20(4):365–372

156. Petroz GC, Sikich N, James M, et al. A phase I, two-center study of the pharmacokinetics and pharmacodynamics of dexmedetomidine in children. *Anesthesiology*. 2006;105(6):1098–1110

157. Potts AL, Anderson BJ, Warman GR, Lerman J, Diaz SM, Vilo S. Dexmedetomidine pharmacokinetics in pediatric intensive care—a pooled analysis. *Paediatr Anaesth*. 2009;19(11):1119–1129

158. Mason KP, Lerman J. Dexmedetomidine in children: current knowledge and future applications [review]. *Anesth Analg*. 2011;113(5):1129–1142

159. Sammartino M, Volpe B, Sbaraglia F, Garra R, D'Addessi A. Capnography and the bispectral index—their role in pediatric sedation: a brief review. *Int J Pediatr*. 2010;2010:828347

160. Yarchi D, Cohen A, Umansky T, Sukhotnik I, Shaoul R. Assessment of end-tidal carbon dioxide during pediatric and adult sedation for endoscopic procedures. *Gastrointest Endosc*. 2009;69(4):877–882

161. Lightdale JR, Goldmann DA, Feldman HA, Newburg AR, DiNardo JA, Fox VL. Microstream capnography improves patient monitoring during moderate sedation: a randomized, controlled trial. *Pediatrics*. 2006;117(6). Available at: www.pediatrics.org/cgi/content/full/117/6/e1170

162. Yldzdaş D, Yapcoglu H, Yılmaz HL. The value of capnography during sedation or sedation/analgesia in pediatric minor procedures. *Pediatr Emerg Care*. 2004;20(3):162–165

163. Connor L, Burrows PE, Zurakowski D, Bucci K, Gagnon DA, Mason KP. Effects of IV pentobarbital with and without fentanyl on end-tidal carbon dioxide levels during deep sedation of pediatric patients undergoing MRI. *AJR Am J Roentgenol*. 2003;181(6):1691–1694

164. Primosch RE, Buzzi IM, Jerrell G. Monitoring pediatric dental patients with nasal mask capnography. *Pediatr Dent*. 2000;22(2):120–124

165. Tobias JD. End-tidal carbon dioxide monitoring during sedation with a combination of midazolam and ketamine for children undergoing painful, invasive procedures. *Pediatr Emerg Care*. 1999;15(3):173–175

166. Hart LS, Berns SD, Houck CS, Boenning DA. The value of end-tidal CO2 monitoring when comparing three methods of conscious sedation for children undergoing painful procedures in the emergency department. *Pediatr Emerg Care*. 1997;13(3):189–193

167. Marx CM, Stein J, Tyler MK, Nieder ML, Shurin SB, Blumer JL. Ketamine-midazolam versus meperidine-midazolam for painful procedures in pediatric oncology patients. *J Clin Oncol*. 1997;15(1):94–102

168. Croswell RJ, Dilley DC, Lucas WJ, Vann WF Jr. A comparison of conventional versus electronic monitoring of sedated pediatric dental patients. *Pediatr Dent*. 1995;17(5):332–339

169. Iwasaki J, Vann WF Jr, Dilley DC, Anderson JA. An investigation of capnography and pulse oximetry as monitors of pediatric patients sedated for dental treatment. *Pediatr Dent*. 1989;11(2):111–117

170. Anderson JA, Vann WF Jr. Respiratory monitoring during pediatric sedation: pulse oximetry and capnography. *Pediatr Dent*. 1988;10(2):94–101

171. Rothman DL. Sedation of the pediatric patient. *J Calif Dent Assoc*. 2013;41(8):603–611

172. Scherrer PD. Safe and sound: pediatric procedural sedation and analgesia. *Minn Med*. 2011;94(3):43–47

173. Srinivasan M, Turmelle M, Depalma LM, Mao J, Carlson DW. Procedural sedation for diagnostic imaging in children by pediatric hospitalists using propofol: analysis of the nature, frequency, and predictors of adverse events and interventions. *J Pediatr*. 2012;160(5):801–806.e1

174. Langhan ML, Shabanova V, Li FY, Bernstein SL, Shapiro ED. A randomized controlled trial of capnography during sedation in a pediatric emergency setting. *Am J Emerg Med*. 2015;33(1):25–30

175. Vetri Buratti C, Angelino F, Sansoni J, Fabriani L, Mauro L, Latina R. Distraction as a technique to control pain in pediatric patients during venipuncture: a narrative review of literature. *Prof Inferm*. 2015;68(1):52–62

176. Robinson PS, Green J. Ambient versus traditional environment in pediatric emergency department. *HERD*. 2015;8(2):71–80

177. Singh D, Samadi F, Jaiswal J, Tripathi AM. Stress reduction through audio distraction in anxious pediatric dental patients: an adjunctive clinical study. *Int J Clin Pediatr Dent*. 2014;7(3):149–152

178. Attar RH, Baghdadi ZD. Comparative efficacy of active and passive distraction during restorative treatment in children using an iPad versus audiovisual eyeglasses: a randomised controlled trial. *Eur Arch Paediatr Dent*. 2015;16(1):1–8

179. McCarthy AM, Kleiber C, Hanrahan K, et al. Matching doses of distraction with child risk for distress during a medical procedure: a randomized clinical trial. *Nurs Res*. 2014;63(6):397–407

180. Guinot Jimeno F, Mercadé Bellido M, Cuadros Fernández C, Lorente Rodríguez AI, Llopis Pérez J, Boj Quesada JR. Effect of audiovisual distraction on children's behaviour, anxiety and pain in the dental setting. *Eur J Paediatr Dent*. 2014;15(3):297–302

181. Gupta HV, Gupta VV, Kaur A, et al. Comparison between the analgesic effect of two techniques on the level of pain perception during venipuncture in children up to 7 years of age: a quasi-experimental study. *J Clin Diagn Res*. 2014;8(8):PC01–PC04

182. Newton JT, Shah S, Patel H, Sturmey P. Non-pharmacological approaches to

Downloaded from by guest on June 28, 2016

behaviour management in children. *Dent Update*. 2003;30(4):194–199

183. Peretz B, Bimstein E. The use of imagery suggestions during administration of local anesthetic in pediatric dental patients. *ASDC J Dent Child*. 2000;67(4):263–267, 231
184. Iserson KV. Hypnosis for pediatric fracture reduction. *J Emerg Med*. 1999;17(1):53–56
185. Rusy LM, Weisman SJ. Complementary therapies for acute pediatric pain management. *Pediatr Clin North Am*. 2000;47(3):589–599
186. Langley P. Guided imagery: a review of effectiveness in the care of children. *Paediatr Nurs*. 1999;11(3):18–21
187. Ott MJ. Imagine the possibilities! Guided imagery with toddlers and pre-schoolers. *Pediatr Nurs*. 1996;22(1):34–38
188. Singer AJ, Stark MJ. LET versus EMLA for pretreating lacerations: a randomized trial. *Acad Emerg Med*. 2001;8(3):223–230
189. Taddio A, Gurguis MG, Koren G. Lidocaine-prilocaine cream versus tetracaine gel for procedural pain in children. *Ann Pharmacother*. 2002;36(4):687–692
190. Eichenfield LF, Funk A, Fallon-Friedlander S, Cunningham BB. A clinical study to evaluate the efficacy of ELA-Max (4% liposomal lidocaine) as compared with eutectic mixture of local anesthetics cream for pain reduction of venipuncture in children. *Pediatrics*. 2002;109(6):1093–1099
191. Shaw AJ, Welbury RR. The use of hypnosis in a sedation clinic for dental extractions in children: report of 20 cases. *ASDC J Dent Child*. 1996;63(6):418–420
192. Stock A, Hill A, Babl FE. Practical communication guide for paediatric procedures. *Emerg Med Australas*. 2012;24(6):641–646
193. Barnea-Goraly N, Weinzimer SA, Ruedy KJ, et al; Diabetes Research in Children Network (DirecNet). High success rates of sedation-free brain MRI scanning in young children using simple subject preparation protocols with and without a commercial mock scanner—the Diabetes Research in Children Network (DirecNet) experience. *Pediatr Radiol*. 2014;44(2):181–186
194. Ram D, Shapira J, Holan G, Magora F, Cohen S, Davidovich E. Audiovisual video eyeglass distraction during dental treatment in children. *Quintessence Int*. 2010;41(8):673–679
195. Lemaire C, Moran GR, Swan H. Impact of audio/visual systems on pediatric sedation in magnetic resonance imaging. *J Magn Reson Imaging*. 2009;30(3):649–655
196. Nordahl CW, Simon TJ, Zierhut C, Solomon M, Rogers SJ, Amaral DG. Brief report: methods for acquiring structural MRI data in very young children with autism without the use of sedation. *J Autism Dev Disord*. 2008;38(8):1581–1590
197. Denman WT, Tuason PM, Ahmed MI, Brennen LM, Cepeda MS, Carr DB. The PediSedate device, a novel approach to pediatric sedation that provides distraction and inhaled nitrous oxide: clinical evaluation in a large case series. *Paediatr Anaesth*. 2007;17(2):162–166
198. Harned RK II, Strain JD. MRI-compatible audio/visual system: impact on pediatric sedation. *Pediatr Radiol*. 2001;31(4):247–250
199. Slifer KJ. A video system to help children cooperate with motion control for radiation treatment without sedation. *J Pediatr Oncol Nurs*. 1996;13(2):91–97
200. Krauss BS, Krauss BA, Green SM. Videos in clinical medicine: procedural sedation and analgesia in children. *N Engl J Med*. 2014;370(15):e23
201. Wilson S. Management of child patient behavior: quality of care, fear and anxiety, and the child patient. *Pediatr Dent*. 2013;35(2):170–174
202. Kamath PS. A novel distraction technique for pain management during local anesthesia administration in pediatric patients. *J Clin Pediatr Dent*. 2013;38(1):45–47
203. Asl Aminabadi N, Erfanparast L, Sohrabi A, Ghertasi Oskouei S, Naghili A. The impact of virtual reality distraction on pain and anxiety during dental treatment in 4-6 year-old children: a randomized controlled clinical trial. *J Dent Res Dent Clin Dent Prospect*. 2012;6(4):117–124
204. El-Sharkawi HF, El-Housseiny AA, Aly AM. Effectiveness of new distraction technique on pain associated with injection of local anesthesia for children. *Pediatr Dent*. 2012;34(2):e35–e38
205. Adinolfi B, Gava N. Controlled outcome studies of child clinical hypnosis. *Acta Biomed*. 2013;84(2):94–97
206. Peretz B, Bercovich R, Blumer S. Using elements of hypnosis prior to or during pediatric dental treatment. *Pediatr Dent*. 2013;35(1):33–36
207. Huet A, Lucas-Polomeni MM, Robert JC, Sixou JL, Wodey E. Hypnosis and dental anesthesia in children: a prospective controlled study. *Int J Clin Exp Hypn*. 2011;59(4):424–440
208. Al-Harasi S, Ashley PF, Moles DR, Parekh S, Walters V. Hypnosis for children undergoing dental treatment. *Cochrane Database Syst Rev*. 2010;8:CD007154
209. McQueen A, Cress C, Tothy A. Using a tablet computer during pediatric procedures: a case series and review of the "apps". *Pediatr Emerg Care*. 2012;28(7):712–714
210. Heilbrunn BR, Wittern RE, Lee JB, Pham PK, Hamilton AH, Nager AL. Reducing anxiety in the pediatric emergency department: a comparative trial. *J Emerg Med*. 2014;47(6):623–631
211. Tyson ME, Bohl DD, Blickman JG. A randomized controlled trial: child life services in pediatric imaging. *Pediatr Radiol*. 2014;44(11):1426–1432
212. Malviya S, Voepel-Lewis T, Tait AR, Merkel S, Tremper K, Naughton N. Depth of sedation in children undergoing computed tomography: validity and reliability of the University of Michigan Sedation Scale (UMSS). *Br J Anaesth*. 2002;88(2):241–245
213. Gamble C, Gamble J, Seal R, Wright RB, Ali S. Bispectral analysis during procedural sedation in the pediatric emergency department. *Pediatr Emerg Care*. 2012;28(10):1003–1008
214. Domino KB. Office-based anesthesia: lessons learned from the closed claims project. *ASA Newsl*. 2001;65:9–15

Downloaded from by guest on June 28, 2016

215. American Heart Association. *Pediatric Advance Life Support Provider Manual*. Dallas, TX: American Heart Association; 2011

216. American Academy of Pediatrics, American College of Emergency Physicians. *Advanced Pediatric Life Support*, 5th ed.. Boston, MA: Jones and Bartlett Publishers; 2012

217. Cheng A, Brown LL, Duff JP, et al; International Network for Simulation-Based Pediatric Innovation, Research, and Education (INSPIRE) CPR Investigators. Improving cardiopulmonary resuscitation with a CPR feedback device and refresher simulations (CPR CARES Study): a randomized clinical trial. *JAMA Pediatr*. 2015;169(2):137–144

218. Nishisaki A, Nguyen J, Colborn S, et al. Evaluation of multidisciplinary simulation training on clinical performance and team behavior during tracheal intubation procedures in a pediatric intensive care unit. *Pediatr Crit Care Med*. 2011;12(4):406–414

219. Howard-Quijano KJ, Stiegler MA, Huang YM, Canales C, Steadman RH. Anesthesiology residents' performance of pediatric resuscitation during a simulated hyperkalemic cardiac arrest. *Anesthesiology*. 2010;112(4):993–997

220. Chen MI, Edler A, Wald S, DuBois J, Huang YM. Scenario and checklist for airway rescue during pediatric sedation. *Simul Healthc*. 2007;2(3):194–198

221. Wheeler M. Management strategies for the difficult pediatric airway. In: Riazi J, ed. *The Difficult Pediatric Airway*. 16th ed. Philadelphia, PA: W.B. Saunders Company; 1998:743–761

222. Sullivan KJ, Kissoon N. Securing the child's airway in the emergency department. *Pediatr Emerg Care*. 2002;18(2):108–121; quiz: 122–124

223. Levy RJ, Helfaer MA. Pediatric airway issues. *Crit Care Clin*. 2000;16(3):489–504

224. Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet*. 2006; 367(9512):766–780

225. Krauss B, Green SM. Sedation and analgesia for procedures in children. *N Engl J Med*. 2000;342(13):938–945

226. Ferrari L, ed . *Anesthesia and Pain Management for the Pediatrician*, 1st ed. Baltimore, MD: John Hopkins University Press; 1999

227. Malvyia S. *Sedation Analgesia for Diagnostic and Therapeutic Procedures*, 1st ed. Totowa, NJ: Humana Press; 2001

228. Yaster M, Krane EJ, Kaplan RF, Coté CJ, Lappe DG. *Pediatric Pain Management and Sedation Handbook*. 1st ed. St. Louis, MO: Mosby-Year Book, Inc.; 1997

229. Cravero JP, Blike GT. Review of pediatric sedation. *Anesth Analg*. 2004;99(5):1355–1364

230. Deshpande JK, Tobias JD. *The Pediatric Pain Handbook*. 1st ed. St. Louis, MO: Mosby; 1996

231. Mace SE, Barata IA, Cravero JP, et al; American College of Emergency Physicians. Clinical policy: evidence-based approach to pharmacologic agents used in pediatric sedation and analgesia in the emergency department. *Ann Emerg Med*. 2004;44(4):342–377

232. Alcaino EA. Conscious sedation in paediatric dentistry: current philosophies and techniques. *Ann R Australas Coll Dent Surg*. 2000;15:206–210

233. Tobias JD, Cravero JP. *Procedural Sedation for Infants, Children, and Adolescents*. Elk Grove Village, IL: American Academy of Pediatrics; 2015

234. Committee on Standards and Practice Parameters. *Standards for Basic Anesthetic Monitoring*. Chicago, IL: American Society of Anesthesiologists; 2011

235. Mitchell AA, Louik C, Lacouture P, Slone D, Goldman P, Shapiro S. Risks to children from computed tomographic scan premedication. *JAMA*. 1982;247(17):2385–2388

236. Wolfe TR, Braude DA. Intranasal medication delivery for children: a brief review and update. *Pediatrics*. 2010;126(3):532–537

237. Bührer M, Maitre PO, Crevoisier C, Stanski DR. Electroencephalographic effects of benzodiazepines. II. Pharmacodynamic modeling of the electroencephalographic effects of midazolam and diazepam. *Clin Pharmacol Ther*. 1990;48(5):555–567

238. Malviya S, Voepel-Lewis T, Ludomirsky A, Marshall J, Tait AR. Can we improve the assessment of discharge readiness? A comparative study of observational and objective measures of depth of sedation in children. *Anesthesiology*. 2004;100(2):218–224

239. Coté CJ. Discharge criteria for children sedated by nonanesthesiologists: is "safe" really safe enough? *Anesthesiology*. 2004;100(2):207–209

240. Pershad J, Palmisano P, Nichols M. Chloral hydrate: the good and the bad. *Pediatr Emerg Care*. 1999;15(6):432–435

241. McCormack L, Chen JW, Trapp L, Job A. A comparison of sedation-related events for two multiagent oral sedation regimens in pediatric dental patients. *Pediatr Dent*. 2014;36(4):302–308

242. Kinane TB, Murphy J, Bass JL, Corwin MJ. Comparison of respiratory physiologic features when infants are placed in car safety seats or car beds. *Pediatrics*. 2006;118(2):522–527

243. Wyeth Pharmaceuticals. *Wyeth Phenergan (Promethazine HCL) Tablets and Suppositories* [package insert]. Philadelphia, PA: Wyeth Pharmaceuticals; 2012

244. Caperell K, Pitetti R. Is higher ASA class associated with an increased incidence of adverse events during procedural sedation in a pediatric emergency department? *Pediatr Emerg Care*. 2009;25(10):661–664

245. Dar AQ, Shah ZA. Anesthesia and sedation in pediatric gastrointestinal endoscopic procedures: a review. *World J Gastrointest Endosc*. 2010;2(7):257–262

246. Kiringoda R, Thurm AE, Hirschtritt ME, et al. Risks of propofol sedation/anesthesia for imaging studies in pediatric research: eight years of experience in a clinical research center. *Arch Pediatr Adolesc Med*. 2010;164(6):554–560

247. Thakkar K, El-Serag HB, Mattek N, Gilger MA. Complications of pediatric EGD: a 4-year experience


Downloaded from by guest on June 28, 2016

in PEDS-CORI. *Gastrointest Endosc*. 2007;65(2):213–221

248. Jackson DL, Johnson BS. Conscious sedation for dentistry: risk management and patient selection. *Dent Clin North Am*. 2002;46(4):767–780
249. Malviya S, Voepel-Lewis T, Eldevik OP, Rockwell DT, Wong JH, Tait AR. Sedation and general anaesthesia in children undergoing MRI and CT: adverse events and outcomes. *Br J Anaesth*. 2000;84(6):743–748
250. O'Neil J, Yonkman J, Talty J, Bull MJ. Transporting children with special health care needs: comparing recommendations and practice. *Pediatrics*. 2009;124(2):596–603
251. Committee on Bioethics, American Academy of Pediatrics. Informed consent, parental permission, and assent in pediatric practice *Pediatrics*. 1995;95(2):314–317
252. Committee on Pediatric Emergency Medicine; Committee on Bioethics. Consent for emergency medical services for children and adolescents. *Pediatrics*. 2011;128(2):427–433
253. Martinez D, Wilson S. Children sedated for dental care: a pilot study of the 24-hour postsedation period. *Pediatr Dent*. 2006;28(3):260–264
254. Kaila R, Chen X, Kannikeswaran N. Postdischarge adverse events related to sedation for diagnostic imaging in children. *Pediatr Emerg Care*. 2012;28(8):796–801
255. Treston G, Bell A, Cardwell R, Fincher G, Chand D, Cashion G. What is the nature of the emergence phenomenon when using intravenous or intramuscular ketamine for paediatric procedural sedation? *Emerg Med Australas*. 2009;21(4):315–322
256. Malviya S, Voepel-Lewis T, Prochaska G, Tait AR. Prolonged recovery and delayed side effects of sedation for diagnostic imaging studies in children. *Pediatrics*. 2000;105(3):E42
257. Nordt SP, Rangan C, Hardmaslani M, Clark RF, Wendler C, Valente M. Pediatric chloral hydrate poisonings and death following outpatient procedural sedation. *J Med Toxicol*. 2014;10(2):219–222
258. Walker RW. Pulmonary aspiration in pediatric anesthetic practice in the UK: a prospective survey of specialist pediatric centers over a one-year period. *Paediatr Anaesth*. 2013;23(8):702–711
259. Babl FE, Puspitadewi A, Barnett P, Oakley E, Spicer M. Preprocedural fasting state and adverse events in children receiving nitrous oxide for procedural sedation and analgesia. *Pediatr Emerg Care*. 2005;21(11):736–743
260. Roback MG, Bajaj L, Wathen JE, Bothner J. Preprocedural fasting and adverse events in procedural sedation and analgesia in a pediatric emergency department: are they related? *Ann Emerg Med*. 2004;44(5):454–459
261. Vespasiano M, Finkelstein M, Kurachek S. Propofol sedation: intensivists' experience with 7304 cases in a children's hospital. *Pediatrics*. 2007;120(6). Available at: www.pediatrics.org/cgi/content/full/120/6/e1411
262. Warner MA, Warner ME, Warner DO, Warner LO, Warner EJ. Perioperative pulmonary aspiration in infants and children. *Anesthesiology*. 1999;90(1):66–71
263. Borland LM, Sereika SM, Woelfel SK, et al. Pulmonary aspiration in pediatric patients during general anesthesia: incidence and outcome. *J Clin Anesth*. 1998;10(2):95–102
264. Agrawal D, Manzi SF, Gupta R, Krauss B. Preprocedural fasting state and adverse events in children undergoing procedural sedation and analgesia in a pediatric emergency department. *Ann Emerg Med*. 2003;42(5):636–646
265. Green SM. Fasting is a consideration—not a necessity—for emergency department procedural sedation and analgesia. *Ann Emerg Med*. 2003;42(5):647–650
266. Green SM, Krauss B. Pulmonary aspiration risk during emergency department procedural sedation—an examination of the role of fasting and sedation depth. *Acad Emerg Med*. 2002;9(1):35–42
267. Treston G. Prolonged pre-procedure fasting time is unnecessary when using titrated intravenous ketamine for paediatric procedural sedation. *Emerg Med Australas*. 2004;16(2):145–150
268. Pitetti RD, Singh S, Pierce MC. Safe and efficacious use of procedural sedation and analgesia by nonanesthesiologists in a pediatric emergency department. *Arch Pediatr Adolesc Med*. 2003;157(11):1090–1096
269. Thorpe RJ, Benger J. Pre-procedural fasting in emergency sedation. *Emerg Med J*. 2010;27(4):254–261
270. Paris PM, Yealy DM. A procedural sedation and analgesia fasting consensus advisory: one small step for emergency medicine, one giant challenge remaining. *Ann Emerg Med*. 2007;49(4):465–467
271. American Society of Anesthesiologists Committee. Practice guidelines for preoperative fasting and the use of pharmacologic agents to reduce the risk of pulmonary aspiration: application to healthy patients undergoing elective procedures: an updated report by the American Society of Anesthesiologists Committee on Standards and Practice Parameters. *Anesthesiology*. 2011;114(3):495–511
272. Mace SE, Brown LA, Francis L, et al Clinical policy: Critical issues in the sedation of pediatric patients in the emergency department. *Ann Emerg Med*. 2008;51:378–399
273. Green SM, Roback MG, Miner JR, Burton JH, Krauss B. Fasting and emergency department procedural sedation and analgesia: a consensus-based clinical practice advisory. *Ann Emerg Med*. 2007;49(4):454–461
274. Duchicela S, Lim A. Pediatric nerve blocks: an evidence-based approach. *Pediatr Emerg Med Pract*. 2013;10(10):1–19; quiz: 19–20
275. Beach ML, Cohen DM, Gallagher SM, Cravero JP. Major adverse events and relationship to nil per os status in pediatric sedation/anesthesia outside the operating room: a report of the Pediatric Sedation Research Consortium. *Anesthesiology*. 2016;124(1):80–88
276. Green SM, Krauss B. Ketamine is a safe, effective, and appropriate technique for emergency department

Downloaded from by guest on June 28, 2016

paediatric procedural sedation. *Emerg Med J*. 2004;21(3):271–272

277. American Academy of Pediatrics Committee on Pediatric Emergency Medicine. The use of physical restraint interventions for children and adolescents in the acute care setting. *Pediatrics*. 1997;99(3):497–498

278. American Academy of Pediatrics Committee on Child Abuse and Neglect. Behavior management of pediatric dental patients. *Pediatrics*. 1992;90(4):651–652

279. American Academy of Pediatric Dentistry. Guideline on protective stabilization for pediatric dental patients. *Pediatr Dent*. 2013;35(5):E169–E173

280. Loo CY, Graham RM, Hughes CV. Behaviour guidance in dental treatment of patients with autism spectrum disorder. *Int J Paediatr Dent*. 2009;19(6):390–398

281. McWhorter AG, Townsend JA; American Academy of Pediatric Dentistry. Behavior symposium workshop A report—current guidelines/revision. *Pediatr Dent*. 2014;36(2):152–153

282. American Society of Anesthesiologists CoSaPP. Practice advisory for preanesthesia evaluation an updated report by the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. *Anesthesiology*. 2012;116:1–17

283. Gorski JC, Huang SM, Pinto A, et al. The effect of echinacea (Echinacea purpurea root) on cytochrome P450 activity in vivo. *Clin Pharmacol Ther*. 2004;75(1):89–100

284. Hall SD, Wang Z, Huang SM, et al. The interaction between St John's wort and an oral contraceptive. *Clin Pharmacol Ther*. 2003;74(6):525–535

285. Markowitz JS, Donovan JL, DeVane CL, et al. Effect of St John's wort on drug metabolism by induction of cytochrome P450 3A4 enzyme. *JAMA*. 2003;290(11):1500–1504

286. Spinella M. Herbal medicines and epilepsy: the potential for benefit and adverse effects. *Epilepsy Behav*. 2001;2(6):524–532

287. Wang Z, Gorski JC, Hamman MA, Huang SM, Lesko LJ, Hall SD. The effects of St John's wort (Hypericum perforatum) on human cytochrome P450 activity. *Clin Pharmacol Ther*. 2001;70(4):317–326

288. Xie HG, Kim RB. St John's wort-associated drug interactions: short-term inhibition and long-term induction? *Clin Pharmacol Ther*. 2005;78(1):19–24

289. Chen XW, Sneed KB, Pan SY, et al. Herb-drug interactions and mechanistic and clinical considerations. *Curr Drug Metab*. 2012;13(5):640–651

290. Chen XW, Serag ES, Sneed KB, et al. Clinical herbal interactions with conventional drugs: from molecules to maladies. *Curr Med Chem*. 2011;18(31):4836–4850

291. Shi S, Klotz U. Drug interactions with herbal medicines. *Clin Pharmacokinet*. 2012;51(2):77–104

292. Saxena A, Tripathi KP, Roy S, Khan F, Sharma A. Pharmacovigilance: effects of herbal components on human drugs interactions involving cytochrome P450. *Bioinformation*. 2008;3(5):198–204

293. Yang X, Salminen WF. Kava extract, an herbal alternative for anxiety relief, potentiates acetaminophen-induced cytotoxicity in rat hepatic cells. *Phytomedicine*. 2011;18(7):592–600

294. Teschke R. Kava hepatotoxicity: pathogenetic aspects and prospective considerations. *Liver Int*. 2010;30(9):1270–1279

295. Izzo AA, Ernst E. Interactions between herbal medicines and prescribed drugs: an updated systematic review. *Drugs*. 2009;69(13):1777–1798

296. Ang-Lee MK, Moss J, Yuan CS. Herbal medicines and perioperative care. *JAMA*. 2001;286(2):208–216

297. Abebe W. Herbal medication: potential for adverse interactions with analgesic drugs. *J Clin Pharm Ther*. 2002;27(6):391–401

298. Mooiman KD, Maas-Bakker RF, Hendrikx JJ, et al. The effect of complementary and alternative medicines on CYP3A4-mediated metabolism of three different substrates: 7-benzyloxy-4-trifluoromethyl-coumarin, midazolam and docetaxel. *J Pharm Pharmacol*. 2014;66(6):865–874

299. Carrasco MC, Vallejo JR, Pardo-de-Santayana M, Peral D, Martín MA, Altimiras J. Interactions of Valeriana officinalis L. and Passiflora incarnata L. in a patient treated with lorazepam. *Phytother Res*. 2009;23(12):1795–1796

300. von Rosensteil NA, Adam D. Macrolide antibacterials: drug interactions of clinical significance. *Drug Saf*. 1995;13(2):105–122

301. Hiller A, Olkkola KT, Isohanni P, Saarnivaara L. Unconsciousness associated with midazolam and erythromycin. *Br J Anaesth*. 1990;65(6):826–828

302. Mattila MJ, Idänpään-Heikkilä JJ, Törnwall M, Vanakoski J. Oral single doses of erythromycin and roxithromycin may increase the effects of midazolam on human performance. *Pharmacol Toxicol*. 1993;73(3):180–185

303. Olkkola KT, Aranko K, Luurila H, et al. A potentially hazardous interaction between erythromycin and midazolam. *Clin Pharmacol Ther*. 1993;53(3):298–305

304. Senthilkumaran S, Subramanian PT. Prolonged sedation related to erythromycin and midazolam interaction: a word of caution. *Indian Pediatr*. 2011;48(11):909

305. Flockhart DA, Oesterheld JR. Cytochrome P450-mediated drug interactions. *Child Adolesc Psychiatr Clin N Am*. 2000;9(1):43–76

306. Yuan R, Flockhart DA, Balian JD. Pharmacokinetic and pharmacodynamic consequences of metabolism-based drug interactions with alprazolam, midazolam, and triazolam. *J Clin Pharmacol*. 1999;39(11):1109–1125

307. Young B. Review: mixing new cocktails: drug interactions in antiretroviral regimens. *AIDS Patient Care STDS*. 2005;19(5):286–297

308. Gonçalves LS, Gonçalves BM, de Andrade MA, Alves FR, Junior AS. Drug interactions during periodontal therapy in HIV-infected subjects. *Mini Rev Med Chem*. 2010;10(8):766–772

309. Brown KC, Paul S, Kashuba AD. Drug interactions with new and investigational antiretrovirals. *Clin Pharmacokinet*. 2009;48(4):211–241

310. Pau AK. Clinical management of drug interaction with antiretroviral agents. *Curr Opin HIV AIDS*. 2008;3(3):319–324

Downloaded from by guest on June 28, 2016

311. Moyal WN, Lord C, Walkup JT. Quality of life in children and adolescents with autism spectrum disorders: what is known about the effects of pharmacotherapy? *Paediatr Drugs*. 2014;16(2):123–128

312. van den Anker JN. Developmental pharmacology. *Dev Disabil Res Rev*. 2010;16(3):233–238

313. Pichini S, Papaseit E, Joya X, et al. Pharmacokinetics and therapeutic drug monitoring of psychotropic drugs in pediatrics. *Ther Drug Monit*. 2009;31(3):283–318

314. Tibussek D, Distelmaier F, Schönberger S, Göbel U, Mayatepek E. Antiepileptic treatment in paediatric oncology—an interdisciplinary challenge. *Klin Padiatr*. 2006;218(6):340–349

315. Wilkinson GR. Drug metabolism and variability among patients in drug response. *N Engl J Med*. 2005;352(21):2211–2221

316. Salem F, Rostami-Hodjegan A, Johnson TN. Do children have the same vulnerability to metabolic drug–drug interactions as adults? A critical analysis of the literature. *J Clin Pharmacol*. 2013;53(5):559–566

317. Funk RS, Brown JT, Abdel-Rahman SM. Pediatric pharmacokinetics: human development and drug disposition. *Pediatr Clin North Am*. 2012;59(5):1001–1016

318. Anderson BJ. My child is unique: the pharmacokinetics are universal. *Paediatr Anaesth*. 2012;22(6):530–538

319. Elie V, de Beaumais T, Fakhoury M, Jacqz-Aigrain E. Pharmacogenetics and individualized therapy in children: immunosuppressants, antidepressants, anticancer and anti-inflammatory drugs. *Pharmacogenomics*. 2011;12(6):827–843

320. Chen ZR, Somogyi AA, Reynolds G, Bochner F. Disposition and metabolism of codeine after single and chronic doses in one poor and seven extensive metabolisers. *Br J Clin Pharmacol*. 1991;31(4):381–390

321. Gasche Y, Daali Y, Fathi M, et al. Codeine intoxication associated with ultrarapid CYP2D6 metabolism. *N Engl J Med*. 2004;351(27):2827–2831

322. Kirchheiner J, Schmidt H, Tzvetkov M, et al. Pharmacokinetics of codeine and its metabolite morphine in ultra-rapid metabolizers due to CYP2D6 duplication. *Pharmacogenomics J*. 2007;7(4):257–265

323. Voronov P, Przybylo HJ, Jagannathan N. Apnea in a child after oral codeine: a genetic variant—an ultra-rapid metabolizer. *Paediatr Anaesth*. 2007;17(7):684–687

324. Kelly LE, Rieder M, van den Anker J, et al. More codeine fatalities after tonsillectomy in North American children. *Pediatrics*. 2012;129(5). Available at: www.pediatrics.org/cgi/content/full/129/5/e1343

325. Farber JM. Clinical practice guideline: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2002;110(6):1255–1257; author reply: 1255–1257

326. Schechter MS; Section on Pediatric Pulmonology, Subcommittee on Obstructive Sleep Apnea Syndrome. Technical report: diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2002;109(4). Available at: www.pediatrics.org/cgi/content/full/109/4/e69

327. Marcus CL, Brooks LJ, Draper KA, et al; American Academy of Pediatrics. Diagnosis and management of childhood obstructive sleep apnea syndrome. *Pediatrics*. 2012;130(3):576–584

328. Coté CJ, Posner KL, Domino KB. Death or neurologic injury after tonsillectomy in children with a focus on obstructive sleep apnea: Houston, we have a problem! *Anesth Analg*. 2014;118(6):1276–1283

329. Wheeler M, Coté CJ. Preoperative pregnancy testing in a tertiary care children's hospital: a medico-legal conundrum. *J Clin Anesth*. 1999;11(1):56–63

330. Neuman G, Koren G. Safety of procedural sedation in pregnancy. *J Obstet Gynaecol Can*. 2013;35(2):168–173

331. Larcher V. Developing guidance for checking pregnancy status in adolescent girls before surgical, radiological or other procedures. *Arch Dis Child*. 2012;97(10):857–860

332. August DA, Everett LL. Pediatric ambulatory anesthesia. *Anesthesiol Clin*. 2014;32(2):411–429

333. Maxwell LG. Age-associated issues in preoperative evaluation, testing, and planning: pediatrics. *Anesthesiol Clin North America*. 2004;22(1):27–43

334. Davidson AJ. Anesthesia and neurotoxicity to the developing brain: the clinical relevance. *Paediatr Anaesth*. 2011;21(7):716–721

335. Reddy SV. Effect of general anesthetics on the developing brain. *J Anaesthesiol Clin Pharmacol*. 2012;28(1):6–10

336. Nemergut ME, Aganga D, Flick RP. Anesthetic neurotoxicity: what to tell the parents? *Paediatr Anaesth*. 2014;24(1):120–126

337. Olsen EA, Brambrink AM. Anesthesia for the young child undergoing ambulatory procedures: current concerns regarding harm to the developing brain. *Curr Opin Anaesthesiol*. 2013;26(6):677–684

338. Green SM, Coté CJ. Ketamine and neurotoxicity: clinical perspectives and implications for emergency medicine. *Ann Emerg Med*. 2009;54(2):181–190

339. Brown KA, Laferrière A, Moss IR. Recurrent hypoxemia in young children with obstructive sleep apnea is associated with reduced opioid requirement for analgesia. *Anesthesiology*. 2004;100(4):806–810; discussion: 5A

340. Moss IR, Brown KA, Laferrière A. Recurrent hypoxia in rats during development increases subsequent respiratory sensitivity to fentanyl. *Anesthesiology*. 2006;105(4):715–718

341. Litman RS, Kottra JA, Berkowitz RJ, Ward DS. Upper airway obstruction during midazolam/nitrous oxide sedation in children with enlarged tonsils. *Pediatr Dent*. 1998;20(5):318–320

342. Fishbaugh DF, Wilson S, Preisch JW, Weaver JM II. Relationship of tonsil size on an airway blockage maneuver in children during sedation. *Pediatr Dent*. 1997;19(4):277–281

343. Heinrich S, Birkholz T, Ihmsen H, Irouschek A, Ackermann A, Schmidt J. Incidence and predictors of difficult laryngoscopy in 11,219 pediatric

Downloaded from by guest on June 28, 2016

anesthesia procedures. *Paediatr Anaesth*. 2012;22(8):729–736

344. Kumar HV, Schroeder JW, Gang Z, Sheldon SH. Mallampati score and pediatric obstructive sleep apnea. *J Clin Sleep Med*. 2014;10(9):985–990

345. Anderson BJ, Meakin GH. Scaling for size: some implications for paediatric anaesthesia dosing. *Paediatr Anaesth*. 2002;12(3):205–219

346. Ramsay MA, Savege TM, Simpson BR, Goodwin R. Controlled sedation with alphaxalone-alphadolone. *BMJ*. 1974;2(5920):656–659

347. Agrawal D, Feldman HA, Krauss B, Waltzman ML. Bispectral index monitoring quantifies depth of sedation during emergency department procedural sedation and analgesia in children. *Ann Emerg Med*. 2004;43(2):247–255

348. Cravero JP, Blike GT, Surgenor SD, Jensen J. Development and validation of the Dartmouth Operative Conditions Scale. *Anesth Analg*. 2005;100(6):1614–1621

349. Mayers DJ, Hindmarsh KW, Sankaran K, Gorecki DK, Kasian GF. Chloral hydrate disposition following single-dose administration to critically ill neonates and children. *Dev Pharmacol Ther*. 1991;16(2):71–77

350. Terndrup TE, Dire DJ, Madden CM, Davis H, Cantor RM, Gavula DP. A prospective analysis of intramuscular meperidine, promethazine, and chlorpromazine in pediatric emergency department patients. *Ann Emerg Med*. 1991;20(1):31–35

351. Macnab AJ, Levine M, Glick N, Susak L, Baker-Brown G. A research tool for measurement of recovery from sedation: the Vancouver Sedative Recovery Scale. *J Pediatr Surg*. 1991;26(11):1263–1267

352. Chernik DA, Gillings D, Laine H, et al. Validity and reliability of the Observer's Assessment of Alertness/Sedation Scale: study with intravenous midazolam. *J Clin Psychopharmacol*. 1990;10(4):244–251

353. Bagian JP, Lee C, Gosbee J, et al. Developing and deploying a patient safety program in a large health care delivery system: you can't fix what you don't know about. *Jt Comm J Qual Improv*. 2001;27(10):522–532

354. May T, Aulisio MP. Medical malpractice, mistake prevention, and compensation. *Kennedy Inst Ethics J*. 2001;11(2):135–146

355. Kazandjian VA. When you hear hoofs, think horses, not zebras: an evidence-based model of health care accountability. *J Eval Clin Pract*. 2002;8(2):205–213

356. Connor M, Ponte PR, Conway J. Multidisciplinary approaches to reducing error and risk in a patient care setting. *Crit Care Nurs Clin North Am*. 2002;14(4):359–367, viii

357. Gosbee J. Human factors engineering and patient safety. *Qual Saf Health Care*. 2002;11(4):352–354

358. Tuong B, Shnitzer Z, Pehora C, et al. The experience of conducting Mortality and Morbidity reviews in a pediatric interventional radiology service: a retrospective study. *J Vasc Interv Radiol*. 2009;20(1):77–86

359. Tjia I, Rampersad S, Varughese A, et al. Wake Up Safe and root cause analysis: quality improvement in pediatric anesthesia. *Anesth Analg*. 2014;119(1):122–136

360. Bhatt M, Kennedy RM, Osmond MH, et al; Consensus Panel on Sedation Research of Pediatric Emergency Research Canada (PERC);Pediatric Emergency Care Applied Research Network (PECARN). Consensus-based recommendations for standardizing terminology and reporting adverse events for emergency department procedural sedation and analgesia in children. *Ann Emerg Med*. 2009;53(4):426–435.e4

361. Barker SJ, Hyatt J, Shah NK, Kao YJ. The effect of sensor malpositioning on pulse oximeter accuracy during hypoxemia. *Anesthesiology*. 1993;79(2):248–254

362. Kelleher JF, Ruff RH. The penumbra effect: vasomotion-dependent pulse oximeter artifact due to probe malposition. *Anesthesiology*. 1989;71(5):787–791

363. Reeves ST, Havidich JE, Tobin DP. Conscious sedation of children with propofol is anything but conscious. *Pediatrics*. 2004;114(1). Available at: www.pediatrics.org/cgi/content/full/114/1/e74

364. Maher EN, Hansen SF, Heine M, Meers H, Yaster M, Hunt EA. Knowledge of procedural sedation and analgesia of emergency medicine physicians. *Pediatr Emerg Care*. 2007;23(12):869–876

365. Fehr JJ, Boulet JR, Waldrop WB, Snider R, Brockel M, Murray DJ. Simulation-based assessment of pediatric anesthesia skills. *Anesthesiology*. 2011;115(6):1308–1315

366. McBride ME, Waldrop WB, Fehr JJ, Boulet JR, Murray DJ. Simulation in pediatrics: the reliability and validity of a multiscenario assessment. *Pediatrics*. 2011;128(2):335–343

367. Fehr JJ, Honkanen A, Murray DJ. Simulation in pediatric anesthesiology. *Paediatr Anaesth*. 2012;22(10):988–994

368. Martinez MJ, Siegelman L. The new era of pretracheal/precordial stethoscopes. *Pediatr Dent*. 1999;21(7):455–457

369. Biro P. Electrically amplified precordial stethoscope. *J Clin Monit*. 1994;10(6):410–412

370. Philip JH, Raemer DB. An electronic stethoscope is judged better than conventional stethoscopes for anesthesia monitoring. *J Clin Monit*. 1986;2(3):151–154

371. Hochberg MG, Mahoney WK. Monitoring of respiration using an amplified pretracheal stethoscope. *J Oral Maxillofac Surg*. 1999;57(7):875–876

372. Fredette ME, Lightdale JR. Endoscopic sedation in pediatric practice. *Gastrointest Endosc Clin N Am*. 2008;18(4):739–751, ix

373. Deitch K, Chudnofsky CR, Dominici P. The utility of supplemental oxygen during emergency department procedural sedation and analgesia with midazolam and fentanyl: a randomized, controlled trial. *Ann Emerg Med*. 2007;49(1):1–8

374. Burton JH, Harrah JD, Germann CA, Dillon DC. Does end-tidal carbon dioxide monitoring detect respiratory events prior to current sedation monitoring practices? *Acad Emerg Med*. 2006;13(5):500–504

Downloaded from by guest on June 28, 2016

375. Wilson S, Farrell K, Griffen A, Coury D. Conscious sedation experiences in graduate pediatric dentistry programs. *Pediatr Dent*. 2001;23(4):307–314

376. Allegaert K, van den Anker JN. Clinical pharmacology in neonates: small size, huge variability. *Neonatology*. 2014;105(4):344–349

377. Coté CJ, Zaslavsky A, Downes JJ, et al. Postoperative apnea in former preterm infants after inguinal herniorrhaphy: a combined analysis. *Anesthesiology*. 1995;82(4):809–822

378. Havidich JE, Beach M, Dierdorf SF, Onega T, Suresh G, Cravero JP. Preterm versus term children: analysis of sedation/anesthesia adverse events and longitudinal risk. *Pediatrics*. 2016;137(3):1–9

379. Nasr VG, Davis JM. Anesthetic use in newborn infants: the urgent need for rigorous evaluation. *Pediatr Res*. 2015;78(1):2–6

380. Sinner B, Becke K, Engelhard K. General anaesthetics and the developing brain: an overview. *Anaesthesia*. 2014;69(9):1009–1022

381. Yu CK, Yuen VM, Wong GT, Irwin MG. The effects of anaesthesia on the developing brain: a summary of the clinical evidence. *F1000 Res*. 2013;2:166

382. Davidson A, Flick RP. Neurodevelopmental implications of the use of sedation and analgesia in neonates. *Clin Perinatol*. 2013;40(3):559–573

383. Lönnqvist PA. Toxicity of local anesthetic drugs: a pediatric perspective. *Paediatr Anaesth*. 2012;22(1):39–43

384. Wahl MJ, Brown RS. Dentistry's wonder drugs: local anesthetics and vasoconstrictors. *Gen Dent*. 2010;58(2):114–123; quiz: 124–125

385. Bernards CM, Hadzic A, Suresh S, Neal JM. Regional anesthesia in anesthetized or heavily sedated patients. *Reg Anesth Pain Med*. 2008;33(5):449–460

386. Ecoffey C. Pediatric regional anesthesia—update. *Curr Opin Anaesthesiol*. 2007;20(3):232–235

387. Aubuchon RW. Sedation liabilities in pedodontics. *Pediatr Dent*. 1982;4:171–180

388. Fitzmaurice LS, Wasserman GS, Knapp JF, Roberts DK, Waeckerle JF, Fox M. TAC use and absorption of cocaine in a pediatric emergency department. *Ann Emerg Med*. 1990;19(5):515–518

389. Tipton GA, DeWitt GW, Eisenstein SJ. Topical TAC (tetracaine, adrenaline, cocaine) solution for local anesthesia in children: prescribing inconsistency and acute toxicity. *South Med J*. 1989;82(11):1344–1346

390. Gunter JB. Benefit and risks of local anesthetics in infants and children. *Paediatr Drugs*. 2002;4(10):649–672

391. Resar LM, Helfaer MA. Recurrent seizures in a neonate after lidocaine administration. *J Perinatol*. 1998;18(3):193–195

392. Yagiela JA. Local anesthetics. In: Yagiela JA, Dowd FJ, Johnson BS, Mariotti AJ, Neidle EA, eds. *Pharmacology and Therapeutics for Dentistry*. 6th ed. St. Louis, MO: Mosby, Elsevier; 2011:246–265

393. Haas DA. An update on local anesthetics in dentistry. *J Can Dent Assoc*. 2002;68(9):546–551

394. Malamed SF. Anesthetic considerations in dental specialties. In: Malamed SF, ed. *Handbook of Local Anesthesia*. 6th ed. St. Louis, MO: Elsevier; 2013:277–291

395. Malamed SF. The needle. In: Malamed SF, ed. *Handbook of Local Anesthetics*. 6th ed. St Louis, MO: Elsevier; 2013:92–100

396. Malamed SF. Pharmacology of local anesthetics. In: Malamed SF, ed. *Handbook of Local Anesthesia*. 6th ed. St. Louis, MO: Elsevier; 2013:25–38

397. Ram D, Amir E. Comparison of articaine 4% and lidocaine 2% in paediatric dental patients. *Int J Paediatr Dent*. 2006;16(4):252–256

398. Jakobs W, Ladwig B, Cichon P, Ortel R, Kirch W. Serum levels of articaine 2% and 4% in children. *Anesth Prog*. 1995;42(3–4):113–115

399. Wright GZ, Weinberger SJ, Friedman CS, Plotzke OB. Use of articaine local anesthesia in children under 4 years of age—a retrospective report. *Anesth Prog*. 1989;36(6):268–271

400. Malamed SF, Gagnon S, Leblanc D. A comparison between articaine HCl and lidocaine HCl in pediatric dental patients. *Pediatr Dent*. 2000;22(4):307–311

401. American Academy of Pediatric Dentistry, Council on Clinical Affairs. Guidelines on use of local anesthesia for pediatric dental patients. Chicago, IL: American Academy of Pediatric Dentistry; 2015. Available at: http://www.aapd.org/media/policies_guidelines/g_localanesthesia.pdf. Accessed May 27, 2016

402. Ludot H, Tharin JY, Belouadah M, Mazoit JX, Malinovsky JM. Successful resuscitation after ropivacaine and lidocaine-induced ventricular arrhythmia following posterior lumbar plexus block in a child. *Anesth Analg*. 2008;106(5):1572–1574

403. Eren CS, Tasyurek T, Guneysel O. Intralipid emulsion treatment as an antidote in lipophilic drug intoxications: a case series. *Am J Emerg Med*. 2014;32(9):1103–1108

404. Evans JA, Wallis SC, Dulhunty JM, Pang G. Binding of local anaesthetics to the lipid emulsion Clinoleic™ 20%. *Anaesth Intensive Care*. 2013;41(5):618–622

405. Presley JD, Chyka PA. Intravenous lipid emulsion to reverse acute drug toxicity in pediatric patients. *Ann Pharmacother*. 2013;47(5):735–743

406. Li Z, Xia Y, Dong X, et al. Lipid resuscitation of bupivacaine toxicity: long-chain triglyceride emulsion provides benefits over long- and medium-chain triglyceride emulsion. *Anesthesiology*. 2011;115(6):1219–1228

407. Maher AJ, Metcalfe SA, Parr S. Local anaesthetic toxicity. *Foot*. 2008;18(4):192–197

408. Corman SL, Skledar SJ. Use of lipid emulsion to reverse local anesthetic-induced toxicity. *Ann Pharmacother*. 2007;41(11):1873–1877

409. Litz RJ, Popp M, Stehr SN, Koch T. Successful resuscitation of a patient with ropivacaine-induced asystole after axillary plexus block using lipid infusion. *Anaesthesia*. 2006;61(8):800–801

410. Raso SM, Fernandez JB, Beobide EA, Landaluce AF. Methemoglobinemia and CNS toxicity after topical application of EMLA to a 4-year-old girl with

Downloaded from by guest on June 28, 2016

molluscum contagiosum. *Pediatr Dermatol*. 2006;23(6):592–593

411. Larson A, Stidham T, Banerji S, Kaufman J. Seizures and methemoglobinemia in an infant after excessive EMLA application. *Pediatr Emerg Care*. 2013;29(3):377–379
412. Tran AN, Koo JY. Risk of systemic toxicity with topical lidocaine/prilocaine: a review. *J Drugs Dermatol*. 2014;13(9):1118–1122
413. Young KD. Topical anaesthetics: what's new? *Arch Dis Child Educ Pract Ed*. 2015;100(2):105–110
414. Gaufberg SV, Walta MJ, Workman TP. Expanding the use of topical anesthesia in wound management: sequential layered application of topical lidocaine with epinephrine. *Am J Emerg Med*. 2007;25(4):379–384
415. Eidelman A, Weiss JM, Baldwin CL, Enu IK, McNicol ED, Carr DB. Topical anaesthetics for repair of dermal laceration. *Cochrane Database Syst Rev*. 2011;6:CD005364
416. Next-generation pulse oximetry. *Health Devices*. 2003;32(2):49–103
417. Barker SJ. "Motion-resistant" pulse oximetry: a comparison of new and old models. *Anesth Analg*. 2002;95(4):967–972
418. Malviya S, Reynolds PI, Voepel-Lewis T, et al. False alarms and sensitivity of conventional pulse oximetry versus the Masimo SET technology in the pediatric postanesthesia care unit. *Anesth Analg*. 2000;90(6):1336–1340
419. Barker SJ, Shah NK. Effects of motion on the performance of pulse oximeters in volunteers. *Anesthesiology*. 1996;85(4):774–781
420. Barker SJ, Shah NK. The effects of motion on the performance of pulse oximeters in volunteers (revised publication). *Anesthesiology*. 1997;86(1):101–108
421. Colman Y, Krauss B. Microstream capnograpy technology: a new approach to an old problem. *J Clin Monit Comput*. 1999;15(6):403–409
422. Wright SW. Conscious sedation in the emergency department: the value of capnography and pulse oximetry. *Ann Emerg Med*. 1992;21(5):551–555
423. Roelofse J. Conscious sedation: making our treatment options safe and sound. *SADJ*. 2000;55(5):273–276
424. Wilson S, Creedon RL, George M, Troutman K. A history of sedation guidelines: where we are headed in the future. *Pediatr Dent*. 1996;18(3):194–199
425. Miner JR, Heegaard W, Plummer D. End-tidal carbon dioxide monitoring during procedural sedation. *Acad Emerg Med*. 2002;9(4):275–280
426. Vascello LA, Bowe EA. A case for capnographic monitoring as a standard of care. *J Oral Maxillofac Surg*. 1999;57(11):1342–1347
427. Coté CJ, Wax DF, Jennings MA, Gorski CL, Kurczak-Klippstein K. Endtidal carbon dioxide monitoring in children with congenital heart disease during sedation for cardiac catheterization by nonanesthesiologists. *Paediatr Anaesth*. 2007;17(7):661–666
428. Bowdle TA. Depth of anesthesia monitoring. *Anesthesiol Clin*. 2006;24(4):793–822
429. Rodriguez RA, Hall LE, Duggan S, Splinter WM. The bispectral index does not correlate with clinical signs of inhalational anesthesia during sevoflurane induction and arousal in children. *Can J Anaesth*. 2004;51(5):472–480
430. Overly FL, Wright RO, Connor FA Jr, Fontaine B, Jay G, Linakis JG. Bispectral analysis during pediatric procedural sedation. *Pediatr Emerg Care*. 2005;21(1):6–11
431. Mason KP, O'Mahony E, Zurakowski D, Libenson MH. Effects of dexmedetomidine sedation on the EEG in children. *Paediatr Anaesth*. 2009;19(12):1175–1183
432. Malviya S, Voepel-Lewis T, Tait AR, Watcha MF, Sadhasivam S, Friesen RH. Effect of age and sedative agent on the accuracy of bispectral index in detecting depth of sedation in children. *Pediatrics*. 2007;120(3). Available at: www.pediatrics.org/cgi/content/full/120/3/e461
433. Sadhasivam S, Ganesh A, Robison A, Kaye R, Watcha MF. Validation of the bispectral index monitor for measuring the depth of sedation in children. *Anesth Analg*. 2006;102(2):383–388
434. Messieha ZS, Ananda RC, Hoffman WE, Punwani IC, Koenig HM. Bispectral Index System (BIS) monitoring reduces time to discharge in children requiring intramuscular sedation and general anesthesia for outpatient dental rehabilitation. *Pediatr Dent*. 2004;26(3):256–260
435. McDermott NB, VanSickle T, Motas D, Friesen RH. Validation of the bispectral index monitor during conscious and deep sedation in children. *Anesth Analg*. 2003;97(1):39–43
436. Schmidt AR, Weiss M, Engelhardt T. The paediatric airway: basic principles and current developments. *Eur J Anaesthesiol*. 2014;31(6):293–299
437. Nagler J, Bachur RG. Advanced airway management. *Curr Opin Pediatr*. 2009;21(3):299–305
438. Berry AM, Brimacombe JR, Verghese C. The laryngeal mask airway in emergency medicine, neonatal resuscitation, and intensive care medicine. *Int Anesthesiol Clin*. 1998;36(2):91–109
439. Patterson MD. Resuscitation update for the pediatrician. *Pediatr Clin North Am*. 1999;46(6):1285–1303
440. Diggs LA, Yusuf JE, De Leo G. An update on out-of-hospital airway management practices in the United States. *Resuscitation*. 2014;85(7):885–892
441. Wang HE, Mann NC, Mears G, Jacobson K, Yealy DM. Out-of-hospital airway management in the United States. *Resuscitation*. 2011;82(4):378–385
442. Ritter SC, Guyette FX. Prehospital pediatric King LT-D use: a pilot study. *Prehosp Emerg Care*. 2011;15(3):401–404
443. Selim M, Mowafi H, Al-Ghamdi A, Adu-Gyamfi Y. Intubation via LMA in pediatric patients with difficult airways. *Can J Anaesth*. 1999;46(9):891–893
444. Munro HM, Butler PJ, Washington EJ. Freeman-Sheldon (whistling face) syndrome: anaesthetic and airway management. *Paediatr Anaesth*. 1997;7(4):345–348
445. Horton MA, Beamer C. Powered intraosseous insertion provides safe

Downloaded from by guest on June 28, 2016

and effective vascular access for pediatric emergency patients. *Pediatr Emerg Care*. 2008;24(6):347–350

446. Gazin N, Auger H, Jabre P, et al. Efficacy and safety of the EZ-IO™ intraosseous device: out-of-hospital implementation of a management algorithm for difficult vascular access. *Resuscitation*. 2011;82(1):126–129

447. Frascone RJ, Jensen J, Wewerka SS, Salzman JG. Use of the pediatric EZ-IO needle by emergency medical services providers. *Pediatr Emerg Care*. 2009;25(5):329–332

448. Neuhaus D. Intraosseous infusion in elective and emergency pediatric anesthesia: when should we use it? *Curr Opin Anaesthesiol*. 2014;27(3):282–287

449. Oksan D, Ayfer K. Powered intraosseous device (EZ-IO) for critically ill patients. *Indian Pediatr*. 2013;50(7):689–691

450. Santos D, Carron PN, Yersin B, Pasquier M. EZ-IO(®) intraosseous device implementation in a pre-hospital emergency service: a prospective study and review of the literature. *Resuscitation*. 2013;84(4):440–445

451. Tan GM. A medical crisis management simulation activity for pediatric dental residents and assistants. *J Dent Educ*. 2011;75(6):782–790

452. Schinasi DA, Nadel FM, Hales R, Boswinkel JP, Donoghue AJ. Assessing pediatric residents' clinical performance in procedural sedation: a simulation-based needs assessment. *Pediatr Emerg Care*. 2013;29(4):447–452

453. Rowe R, Cohen RA. An evaluation of a virtual reality airway simulator. *Anesth Analg*. 2002;95(1):62–66

454. Medina LS, Racadio JM, Schwid HA. Computers in radiology—the sedation, analgesia, and contrast media computerized simulator: a new approach to train and evaluate radiologists' responses to critical incidents. *Pediatr Radiol*. 2000;30(5):299–305

455. Blike G, Cravero J, Nelson E. Same patients, same critical events—different systems of care, different outcomes: description of a human factors approach aimed at improving the efficacy and safety of sedation/analgesia care. *Qual Manag Health Care*. 2001;10(1):17–36

456. Reiter DA, Strother CG, Weingart SD. The quality of cardiopulmonary resuscitation using supraglottic airways and intraosseous devices: a simulation trial. *Resuscitation*. 2013;84(1):93–97

457. Schulte-Uentrop L, Goepfert MS. Anaesthesia or sedation for MRI in children. *Curr Opin Anaesthesiol*. 2010;23(4):513–517

458. Schmidt MH, Downie J. Safety first: recognizing and managing the risks to child participants in magnetic resonance imaging research. *Account Res*. 2009;16(3):153–173

459. Chavhan GB, Babyn PS, Singh M, Vidarsson L, Shroff M. MR imaging at 3.0 T in children: technical differences, safety issues, and initial experience. *Radiographics*. 2009;29(5):1451–1466

460. Kanal E, Shellock FG, Talagala L. Safety considerations in MR imaging. *Radiology*. 1990;176(3):593–606

461. Shellock FG, Kanal E. Burns associated with the use of monitoring equipment during MR procedures. *J Magn Reson Imaging*. 1996;6(1):271–272

462. Shellock FG. Magnetic resonance safety update 2002: implants and devices. *J Magn Reson Imaging*. 2002;16(5):485–496

463. Dempsey MF, Condon B, Hadley DM. MRI safety review. *Semin Ultrasound CT MR*. 2002;23(5):392–401

464. Department of Health and Human Services, Centers for Disease Control and PreventionCriteria for a Recommended Standard: Waste Anesthetic Gases: Occupational Hazards in Hospitals. 2007. Publication 2007-151. Available at: http://www.cdc.gov/niosh/docs/2007-151/pdfs/2007-151.pdf. Accessed May 27, 2016

465. O'Sullivan I, Benger J. Nitrous oxide in emergency medicine. *Emerg Med J*. 2003;20(3):214–217

466. Kennedy RM, Luhmann JD, Luhmann SJ. Emergency department management of pain and anxiety related to orthopedic fracture care: a guide to analgesic techniques and procedural sedation in children. *Paediatr Drugs*. 2004;6(1):11–31

467. Frampton A, Browne GJ, Lam LT, Cooper MG, Lane LG. Nurse administered relative analgesia using high concentration nitrous oxide to facilitate minor procedures in children in an emergency department. *Emerg Med J*. 2003;20(5):410–413

468. Everitt I, Younge P, Barnett P. Paediatric sedation in emergency department: what is our practice? *Emerg Med (Fremantle)*. 2002;14(1):62–66

469. Krauss B. Continuous-flow nitrous oxide: searching for the ideal procedural anxiolytic for toddlers. *Ann Emerg Med*. 2001;37(1):61–62

470. Otley CC, Nguyen TH. Conscious sedation of pediatric patients with combination oral benzodiazepines and inhaled nitrous oxide. *Dermatol Surg*. 2000;26(11):1041–1044

471. Luhmann JD, Kennedy RM, Jaffe DM, McAllister JD. Continuous-flow delivery of nitrous oxide and oxygen: a safe and cost-effective technique for inhalation analgesia and sedation of pediatric patients. *Pediatr Emerg Care*. 1999;15(6):388–392

472. Burton JH, Auble TE, Fuchs SM. Effectiveness of 50% nitrous oxide/50% oxygen during laceration repair in children. *Acad Emerg Med*. 1998;5(2):112–117

473. Gregory PR, Sullivan JA. Nitrous oxide compared with intravenous regional anesthesia in pediatric forearm fracture manipulation. *J Pediatr Orthop*. 1996;16(2):187–191

474. Hennrikus WL, Shin AY, Klingelberger CE. Self-administered nitrous oxide and a hematoma block for analgesia in the outpatient reduction of fractures in children. *J Bone Joint Surg Am*. 1995;77(3):335–339

475. Hennrikus WL, Simpson RB, Klingelberger CE, Reis MT. Self-administered nitrous oxide analgesia for pediatric fracture reductions. *J Pediatr Orthop*. 1994;14(4):538–542

476. Wattenmaker I, Kasser JR, McGravey A. Self-administered nitrous oxide for fracture reduction in children in an emergency room setting. *J Orthop Trauma*. 1990;4(1):35–38

477. Gamis AS, Knapp JF, Glenski JA. Nitrous oxide analgesia in a pediatric emergency department. *Ann Emerg Med*. 1989;18(2):177–181

Downloaded from by guest on June 28, 2016

478. Kalach N, Barbier C, el Kohen R, et al. Tolerance of nitrous oxide-oxygen sedation for painful procedures in emergency pediatrics: report of 600 cases [in French]. *Arch Pediatr*. 2002;9(11):1213–1215

479. Michaud L, Gottrand F, Ganga-Zandzou PS, et al. Nitrous oxide sedation in pediatric patients undergoing gastrointestinal endoscopy. *J Pediatr Gastroenterol Nutr*. 1999;28(3):310–314

480. Baskett PJ. Analgesia for the dressing of burns in children: a method using neuroleptanalgesia and Entonox. *Postgrad Med J*. 1972;48(557):138–142

481. Veerkamp JS, van Amerongen WE, Hoogstraten J, Groen HJ. Dental treatment of fearful children, using nitrous oxide. Part I: treatment times. *ASDC J Dent Child*. 1991;58(6):453–457

482. Veerkamp JS, Gruythuysen RJ, van Amerongen WE, Hoogstraten J. Dental treatment of fearful children using nitrous oxide. Part 2: the parent's point of view. *ASDC J Dent Child*. 1992;59(2):115–119

483. Veerkamp JS, Gruythuysen RJ, van Amerongen WE, Hoogstraten J. Dental treatment of fearful children using nitrous oxide. Part 3: anxiety during sequential visits. *ASDC J Dent Child*. 1993;60(3):175–182

484. Veerkamp JS, Gruythuysen RJ, Hoogstraten J, van Amerongen WE. Dental treatment of fearful children using nitrous oxide. Part 4: anxiety after two years. *ASDC J Dent Child*. 1993;60(4):372–376

485. Houpt MI, Limb R, Livingston RL. Clinical effects of nitrous oxide conscious sedation in children. *Pediatr Dent*. 2004;26(1):29–36

486. Shapira J, Holan G, Guelmann M, Cahan S. Evaluation of the effect of nitrous oxide and hydroxyzine in controlling the behavior of the pediatric dental patient. *Pediatr Dent*. 1992;14(3):167–170

487. Primosch RE, Buzzi IM, Jerrell G. Effect of nitrous oxide-oxygen inhalation with scavenging on behavioral and physiological parameters during routine pediatric dental treatment. *Pediatr Dent*. 1999;21(7):417–420

488. McCann W, Wilson S, Larsen P, Stehle B. The effects of nitrous oxide on behavior and physiological parameters during conscious sedation with a moderate dose of chloral hydrate and hydroxyzine. *Pediatr Dent*. 1996;18(1):35–41

489. Wilson S, Matusak A, Casamassimo PS, Larsen P. The effects of nitrous oxide on pediatric dental patients sedated with chloral hydrate and hydroxyzine. *Pediatr Dent*. 1998;20(4):253–258

490. Pedersen RS, Bayat A, Steen NP, Jacobsson ML. Nitrous oxide provides safe and effective analgesia for minor paediatric procedures—a systematic review [abstract]. *Dan Med J*. 2013;60(6):A4627

491. Lee JH, Kim K, Kim TY, et al. A randomized comparison of nitrous oxide versus intravenous ketamine for laceration repair in children. *Pediatr Emerg Care*. 2012;28(12):1297–1301

492. Seith RW, Theophilos T, Babl FE. Intranasal fentanyl and high-concentration inhaled nitrous oxide for procedural sedation: a prospective observational pilot study of adverse events and depth of sedation. *Acad Emerg Med*. 2012;19(1):31–36

493. Klein U, Robinson TJ, Allshouse A. End-expired nitrous oxide concentrations compared to flowmeter settings during operative dental treatment in children. *Pediatr Dent*. 2011;33(1):56–62

494. Litman RS, Kottra JA, Berkowitz RJ, Ward DS. Breathing patterns and levels of consciousness in children during administration of nitrous oxide after oral midazolam premedication. *J Oral Maxillofac Surg*. 1997;55(12):1372–1377; discussion: 1378–1379

495. Litman RS, Kottra JA, Verga KA, Berkowitz RJ, Ward DS. Chloral hydrate sedation: the additive sedative and respiratory depressant effects of nitrous oxide. *Anesth Analg*. 1998;86(4):724–728

496. American Academy of Pediatric Dentistry, Council on Clinical Affairs. Guideline on use of nitrous oxide for pediatric dental patients. Chicago, IL: American Academy of Pediatric Dentistry; 2013. Available at: http://www.aapd.org/media/policies_guidelines/g_nitrous.pdf. Accessed May 27, 2016

Downloaded from by guest on June 28, 2016

# Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016

Charles J. Coté, Stephen Wilson, AMERICAN ACADEMY OF PEDIATRICS and AMERICAN ACADEMY OF PEDIATRIC DENTISTRY

*Pediatrics*; originally published online June 27, 2016;
DOI: 10.1542/peds.2016-1212

| | |
|---|---|
| **Updated Information & Services** | including high resolution figures, can be found at: /content/early/2016/06/24/peds.2016-1212.full.html |
| **Supplementary Material** | Supplementary material can be found at: /content/suppl/2016/06/22/peds.2016-1212.DCSupplemental.html |
| **References** | This article cites 473 articles, 60 of which can be accessed free at: /content/early/2016/06/24/peds.2016-1212.full.html#ref-list-1 |
| **Subspecialty Collections** | This article, along with others on similar topics, appears in the following collection(s): **Anesthesiology/Pain Medicine** /cgi/collection/anesthesiology:pain_medicine_sub |
| **Permissions & Licensing** | Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at: /site/misc/Permissions.xhtml |
| **Reprints** | Information about ordering reprints can be found online: /site/misc/reprints.xhtml |

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2016 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Downloaded from by guest on June 28, 2016

PEDIATRICS®
OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

# Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016

Charles J. Coté, Stephen Wilson, AMERICAN ACADEMY OF PEDIATRICS and AMERICAN ACADEMY OF PEDIATRIC DENTISTRY

*Pediatrics*; originally published online June 27, 2016;
DOI: 10.1542/peds.2016-1212

The online version of this article, along with updated information and services, is located on the World Wide Web at:
**/content/early/2016/06/24/peds.2016-1212.full.html**

PEDIATRICS is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. PEDIATRICS is owned, published, and trademarked by the American Academy of Pediatrics, 141 Northwest Point Boulevard, Elk Grove Village, Illinois, 60007. Copyright © 2016 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 0031-4005. Online ISSN: 1098-4275.

American Academy of Pediatrics
DEDICATED TO THE HEALTH OF ALL CHILDREN™

Downloaded from by guest on June 28, 2016