Pediatr Radiol (2008) 38 (Suppl 2):S213–S217
DOI 10.1007/s00247-008-0778-0

REVIEW

Sedating children for radiological procedures: an intensivist's perspective

Venkat R. Shankar

Keywords Deep sedation · Moderate sedation · MRI · CT scan

Introduction

There has been a phenomenal increase in the number of diagnostic and interventional radiology procedures in the past decade. Consequently, the demand for fast, effective and safe sedation for children has grown exponentially as well. The parents expect a relatively pain and anxiety free experience for their children. The radiologists expect the child to be cooperative and not move. Meanwhile, the regulatory standards for sedation have become more stringent. Moreover, with the advent of PACS and digital radiology, the radiologist reading the diagnostic studies may not be in the same room, or even in the same country as the patient undergoing the tests. The time pressures has increased tremendously on the pediatric radiologists and the 'opportunity costs' of supervising the sedation of a child is steep. The "scanner-time" is scarce and there is no scope for ineffective and inefficient sedation regimen.

Dr. Shankar has indicated that he has no relevant financial relationships or potential conflicts of interest related to the material to be presented.

V. R. Shankar (✉)
Pediatrics, Drexel University School of Medicine,
Philadelphia, PA 19134, USA
e-mail: venkat.shankar@drexelmed.edu

V. R. Shankar
Section of Pediatric Critical Care,
St. Christopher's Hospital for Children,
Erie Avenue at Front Street,
Philadelphia, PA 19134, USA

Many different models are being introduced in different institutions for providing effective, efficient and safe sedation to children undergoing radiological procedures. The following viewpoint reflects the perspective of a pediatric intensivist-based sedation program.

Goals of sedation

Depending on the planned radiological study/ procedure, the goals of sedation in a child may include [1]:

1. Anxiolysis (Child and Parent!)
2. Amnesia
3. Immobility
4. Cooperation
5. Analgesia

Any sedation plan should be safe and minimize any residual effects of sedatives after the study is accomplished.

Levels of sedation

For many years the term "Conscious Sedation" has been abused in pediatric patients. Nowadays this term has been replaced by the term Moderate Sedation. The American Society of Anesthesiologist and American Academy of Pediatrics define four levels of procedural sedation (Table 1).

Although these levels have been described as distinct stages, they often form a continuum and a child can lapse from one state to a deeper state with unexpected ease and rapidity, depending on the degree of stimulation and other factors. These states of sedation are not specific to any specific drug or any particular route of administration. Virtually any state of sedation or anesthesia could be achieved with any of the agents used for sedation.

The term "conscious sedation" has fallen into disfavor because, in children, the goal of procedural sedation often is to achieve that state in which the child is non-responsive to vocal commands and interventions. This targeted level of sedation is more accurately described as deep sedation.

JACHO and other guidelines for sedation

The personnel who provide sedation for children should have proper training and skills to assure patient safety [2]. The person providing sedation and monitoring the child should not be the person performing the procedure. In cases involving moderate sedation, the person monitoring may perform minor interruptible tasks that do not impair his or her ability to remain focused on the child's cardio-respiratory status. In cases involving deep sedation, the person responsible for monitoring should not have any other responsibilities or tasks [1, 3].

The individual monitoring a sedated child should be skilled in recognizing and intervening in partial or total airway obstruction and apnea and have the ability to maintain airway patency and assisted ventilation [1]. In addition, that individual should be familiar with the pharmacology of the sedative agents and their antagonists. The ASA recommends that a person with advanced life support skills (cardiopulmonary resuscitation and bag valve mask ventilation) should be immediately available (1–5 min away) for moderate sedation and present in the procedure room for deep sedation [3].

Recently, the JCAHO has introduced the concept of "rescue": practitioners intending to produce a given level of sedation should be able to rescue patients whose level of sedation becomes deeper than intended initially. Thus, individuals administering moderate sedation (formerly classified as conscious sedation) should be able to manage children who enter a state of deep sedation, whereas those administering deep sedation should be able to manage patients who enter a state of general anesthesia [2].

Table 2 ASA physical status classification

Class	
Class I	A normal healthy patient
Class II	A patient with mild systemic disease (no functional limitation)
Class III	A patient with severe systemic disease (with functional limitation)
Class IV	A patient with severe systemic disease that is a constant threat to life
Class V	A moribund patient who is not expected to survive without the operation

Patient selection and screening

A focused pre-sedation evaluation should include the child's medical history (Table 2):

1. Any major medical illness affecting the respiratory, cardiovascular, renal, or hepatic systems
2. History of any sedations, anesthesia exposure, surgeries, and outcomes
3. Drug allergies and current medications
4. History of snoring, sleep apnea, or hypoventilation
5. Last oral intake (nature and timing; Table 3)
6. Review of organ systems

A focused physical examination should include (1) vital signs: heart rate, respiratory rate, pulse oximetry, blood pressure, temperature; (2) weight; (3) auscultation of heart and lungs; and (4) an evaluation of airways: facial dysmorphism, retrognathia, micrognathia, trismus, macroglossia, loose teeth, dental appliances, tonsillar hypertrophy, visibility of uvula, short neck, tracheal deviation, and obesity.

Sedation monitoring and documentation

The designated personnel should closely and continuously observe the child. To the extent possible, the child's face and mouth should be visible to the observer at all times.

Table 1 Levels of sedation [3]

	Minimal sedation	Moderate sedation/analgesia ("conscious sedation")	Deep sedation	General anesthesia
Responsiveness	Normal response to verbal stimulation	Purposeful[a] response to verbal or tactile stimulation	Purposeful[a] response following repeated or painful stimulation	Unarousable, even with painful stimulus
Airway	Unaffected	No intervention required	Intervention may be required	Intervention often required
Spontaneous Ventilation	Unaffected	Adequate	May be inadequate	Frequently inadequate
Cardiovascular Function	Unaffected	Usually maintained	Usually maintained	May be impaired

[a] Reflex withdrawal from a painful stimulus is NOT considered a purposeful response (adapted from [3])

Table 3 American Society of Anesthesiologists pre-procedure fasting guidelines [3]

Type of food	Fasting period (h)
Clear liquids	2
Breast milk	4
Light solids	6

Continuous pulse oximetry with an audible and visual signal is mandatory in all cases and has been shown to decrease the likelihood of adverse outcomes [3].

Ventilatory adequacy must be monitored by observation, auscultation, or continuous nasal capnography. Impedance plethysmography may fail to detect airway obstruction and is unreliable. In situations in which direct physical observation of a child is not possible (e.g., in an MRI scanner), continuous oceanography is essential to detect airway obstruction or apnea. Ventilation and oxygenation are separate but related physiologic processes, and monitoring oxygenation by pulse oximetry is not a substitute for monitoring ventilatory function [3].

A time-based contemporaneous recording of the child's level of consciousness, pulse oximeter reading, capnography, heart rate, respiratory rate, and blood pressure is recommended for all children undergoing any level of sedation [2, 3]. A baseline pre-sedation set of vital signs should be recorded whenever possible. These parameters should be monitored continuously and documented in the records at a frequency of at least every 5 min during sedation. The names, routes, times, and doses of drugs administered should be documented.

Pediatric patients receiving sedatives often are at a significant risk for developing airway-related complications after the procedure is over. The delayed drug absorption after oral or rectal administration, slow metabolism by infants, and the absence of procedural stimulation and reduced vigilance in monitoring after the procedure may all contribute to such high risk. Children receiving any form of sedation should be observed in an appropriately staffed and equipped recovery area after the conclusion of the procedure, until they are at or near their baseline level of consciousness and are no longer at risk for a loss of airway or cardiopulmonary depression. During this period of observation, continuous pulse oximetry is recommended, and a designated care provider should monitor and document the vital signs [3]. Discharge criteria should be clearly defined and understood by the care provider.

Adverse outcomes due to sedation

The actual incidence of complications associated with pediatric procedural sedation remains uncertain. The majority of reported complications result from respiratory depression or airway obstruction leading to hypoxemia or hypoventilation.

All classes of medications and all routes of administration have been associated with adverse outcomes. The risks of adverse outcomes increase when multiple medications are used [4]. Inadequate pre-sedation medical evaluation, inadequate and inconsistent physiologic monitoring, the lack of an independent observer, medication errors, and inadequate recovery procedures have been associated with a higher risk of adverse outcomes after pediatric sedation [5]. Laryngospasm, vomiting, hypotension, inadequate sedation, prolonged sedation, and paradoxical excitation have been reported in a small number of children.

Models of providing sedation

Different institutions have different systems for providing sedation in radiology suite. Traditional paradigm was for radiologists to administer this by themselves. With the increasing complexity and number of radiological studies, tele-radiology, advent of newer potent pharmacological agents and the revised regulatory standards, many institutions are now using a dedicated team or service to provide sedation.

At many institutions, this is being done using the traditional long acting agents by teams that are primarily nursing led. At other end of the spectrum are centers where this is provided by anesthesiologists. However, due to the national shortage of Anesthesiologists, alternative paradigms of safe and effective sedation delivery have been developed using Pediatric Intensivists, Emergency Room Physicians or Hospitalists/Pediatricians.

Each system has its benefits and disadvantages—the resource utilization appears to be high for the administrators. Nevertheless, a smoothly running sedation service in radiology can vastly improve the throughput and more than recover its costs.

Some sedation plans that we use in radiology

MRI scans

For patients > 12 weeks of age, ASA I, II, some III

Propofol Induction dose: 1–1.5 mg/kg over 2–3 min; Maintenance dose 100–150 mcg/kg/min infusion (on pump); or 0.5 mg/kg every 5 min (manually).

Must be administered by MRI-compatible infusion pump and monitored using MRI-compatible monitoring systems.

For patients< 12 weeks

Consider oral pentobarbital 2–3 mg/kg

CT scans

For ages 0–24 months: ASA I or II; moderate sedation

Oral Pentobarbital Excellent safety profile, Onset 15–60 min, Variable duration of action; Generally awake in 45–60 min but t1/2 of 10–50 h; Continued parental vigilance for 24 h

8 weeks–18 months: 2–3 mg/kg
18 months: 4–6 mg/kg

Less effective/ predictable in toddlers, Hyperexciteability/ dysphoric reaction, Often need higher dose than infants, Generally longer recovery period (120–150 min). Needs good discharge planning, as above. Mix intravenous form in juice or cherry syrup.

Can be administered and monitored by Radiology Recovery RN

For most patients 2 to 4 years (excluding simple head, sinuses); for <24 months failing oral pentobarbital; and for selected patients >24 months of ASA II or III status

Propofol Intravenous only, deep sedation; 1–1.5 mg/kg slow IVP on scanner table generally adequate for 15–20 min scan; May need additional 0.25–0.5 mg/kg just prior to contrast administration.

Intravenous pentobarbital (2–5 mg/kg) For patients with propofol allergy; May require re-dosing if scan>15–20 min.

IV midazolam (0.05–0.1 mg/kg) plus fentanyl (1–3 mcg/kg) Often requires generous dosing; if pentobarbital and propofol are contraindicated; Option if unable/un-staffed to provide propofol and/or pentobarbital (Fig. 1).

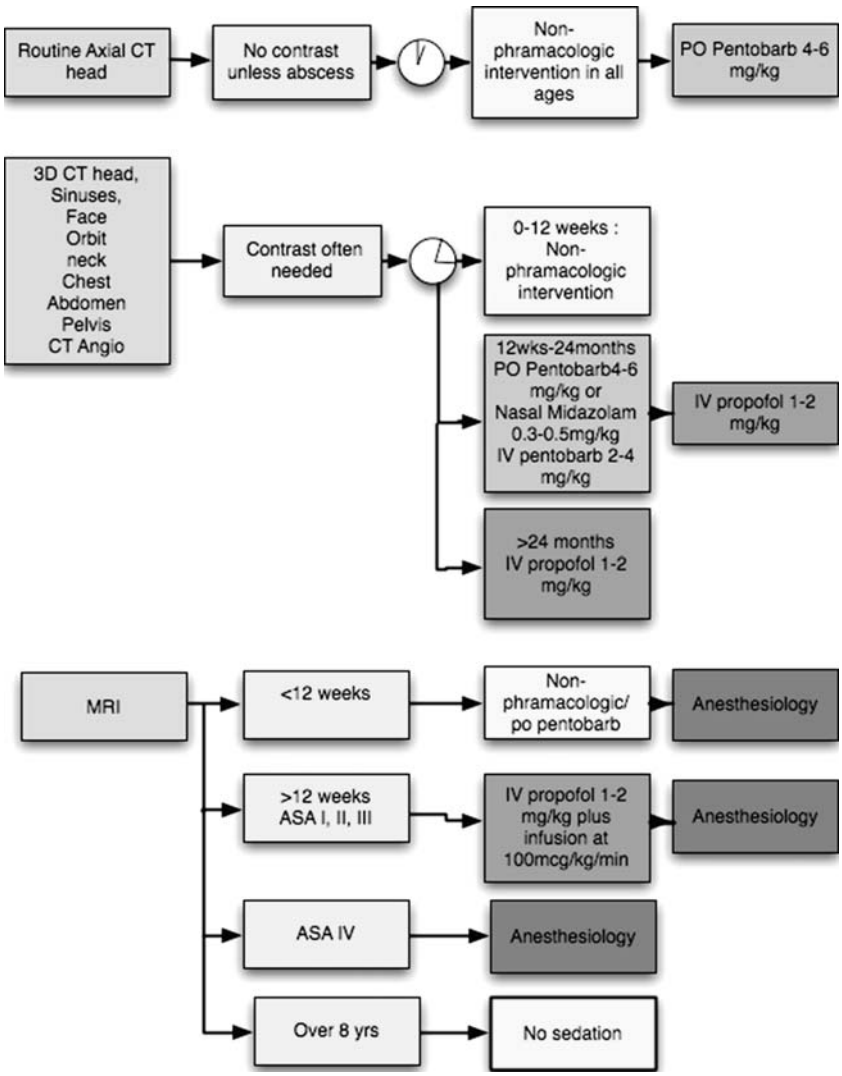

Fig. 1 Sedation plans used in radiology

References

1. Krauss B, Green SM (2000) Sedation and analgesia for procedures in children. N Engl J Med 342(13):938–945
2. Joint Commission on Accreditation of Health Care Organizations (2000) Comprehensive accreditation manual for hospitals. JCAHO, Oakbrook, IL
3. American Society of Anesthesiologists (2002) Task Force on Sedation and Analgesia by Non-Anesthesiologists. Practice guidelines for sedation and analgesia by non-anesthesiologists. Anesthesiology 96(4):1004–1017
4. Cote CJ, Karl HW, Notterman DA, Weinberg JA, McCloskey C (2000) Adverse sedation events in pediatrics: analysis of medications used for sedation. Pediatrics 106(4):633–644 (October 1)
5. Cote CJ, Notterman DA, Karl HW, Weinberg JA, McCloskey C (2000) Adverse sedation events in pediatrics: a critical incident analysis of contributing factors. Pediatrics 105(4):805–814 (April 1)