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Procedural Sedation in Children : An Overview

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Abstract

Modern day practice is aimed not only at treatment, but to provide the management at minimal discomfort to the patients. This entails various diagnostic and short therapeutic procedures that can be done at bedside or radiology suites or minor operation theaters. The discomfort to the patient includes the pain caused by the procedure and discomfort in lying still while the procedure is being performed. The anxiety is much more in pediatric patients that require administration of medication to be alleviated. The development of safe anesthetic medications has caused widespread use of such medications. The use of these medications is not free of complications and thus, various authorities have developed guidelines for safe use of procedural sedation in office setting. We here discuss the need for procedural sedation, the drugs available and the guidelines for their safe use.

Key words: Procedural sedation and analgesia (PSA), minimal sedation, moderate sedation, conscious sedation, deep sedation, general anesthesia, rescue.

Introduction

Various procedures in the ward and investigation suites require the patient to be calm and quiet. This may require an intervention (medication) especially so in children who by nature are more anxious and uncooperative than adults. The aims of analgesia, anxiolysis and amnesia are achieved by administering medications including hypnotics and anesthetic medication. The medication given aims at providing

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analgesia, anxiolysis and amnesia. By guidelines, the procedure should be under direct control or under supervision of anesthesia team. The paucity of qualified anesthetist, especially so in developing countries like India, mandates that physicians other than anesthetists take more responsibility in providing procedural sedation. The safety for the procedure has been addressed to by various authorities – American Academy of Pediatrics (AAP), American Society of Anesthesiologists (ASA), Joint Commission on the Accreditation of Healthcare Organizations (JCAHO), and American College of Emergency Physicians (ACEP) – by formulating guidelines for the physicians and other workers, who are authorized to provide procedural sedation. The development of short-acting sedatives, improved monitoring, and new regulatory requirements have led to the evolution of new paradigms of safe, effective, and resource-efficient systems for providing procedural sedation outside the operating rooms by anesthesiologists and non-anesthesiologists (including pediatricians and pediatric surgeons).

Definitions

Procedural sedation is defined by the ACEP as "a technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardio-respiratory function. Procedural sedation and analgesia (PSA) is intended to result in a depressed level of consciousness that allows the patient to maintain oxygenation and airway control independently." (1)

AAP and ASA have jointly formulated guidelines and amended it from time to time for safe administration of procedural sedation (2).

The procedural sedation requires mild to moderate sedation. As the effect of the drugs used is a continuum and the depth of sedation can vary with different doses and blood concentration, it is vital for the personnel providing the procedural anesthesia to accurately identify the plane of sedation so as to avoid complications and associated morbidity and mortality. Thus, ASA has provided the definition for levels of sedation/ analgesia.

"*Minimal Sedation (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." The patient

can maintain his airway and does not require any support.

"*Moderate Sedation / Analgesia* ("*Conscious Sedation*") is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is usually maintained." This is the plane required for most invasive procedures done outside the operation suites.

"*Deep Sedation / Analgesia* is a drug-induced depression of consciousness during which patients cannot be easily aroused but respond purposefully following repeated or painful stimulation. 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." This plane if achieved needs to be identified and appropriate action taken to prevent a mishap.

"*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." This plane of sedation/ anesthesia is used for major procedures in operation suite under controlled condition.

"***Rescue*** of a patient from a deeper level of sedation than intended is an intervention by a practitioner proficient in airway management and advanced life support. The qualified practitioner corrects adverse physiologic consequences of the deeper-than intended level of sedation (such as hypoventilation, hypoxia and hypotension) and returns the patient to the originally intended level of sedation." Any person who provides procedural sedation must be proficient with rescue.

Who should deliver "procedural sedation"?

The procedural sedation should be administered by a qualified anesthetist or any qualified non-anesthesiologist sedation practitioner (physician), or by a qualified supervised sedation professional. The qualification

requirement has been detailed by ASA and requires proficiency with procedure to take informed consent, identifying the patients who shall require specialist anesthetist, the drugs used for sedation, understanding of level of sedation, monitoring capabilities and capable of 'rescue'. The presence of professionals capable to handle emergencies is mandatory. Various studies have shown that professionals managing the emergency department and pediatricians are well-suited to provide moderate to deep sedation (3). Cote *et al* analyzed the adverse events in hospital based and non-hospital based procedural sedation in children and documented that procedural sedation provided by person other than properly trained physicians and dental surgeons resulted in increased serious adverse events including death and permanent neurological deficit (4). The factors responsible for adverse event were inadequate pre-sedation evaluation, improper dosage, lack of knowledge of drug interactions, lack of monitoring, lack of resuscitation equipment and rescue training and earlier discharge from the facility.

Indications

The procedural sedation is required for a variety of diagnostic and therapeutic procedures. This is especially true for children less than 6 years old and children with developmental delay (5).

Diagnostic:

1. Non-invasive – CT scan, MR imaging. The anxiolysis is required in children for claustrophobia and so that child does not move while the scanning is taking place.
2. Invasive – Radiological procedures like central line placement, voiding cystography, filling cystometry, fine needle aspiration cytology, biopsy, endoscopy, lumbar puncture, etc. The sedation requires anxiolysis and analgesia. The deeper plane is required.

Therapeutic:

1. Minor procedures: Suturing of wounds, abscess drainage, radiology guided intervention procedures like percutaneous nephrostomy, fracture reduction, dental procedures, wound debridement, burn dressings and other procedures done under local anesthesia.
2. Radiotherapy
3. Endoscopic shock wave lithotripsy.

The medications for procedural sedation are given with following goals:

1. guard the patient's safety and welfare;
2. minimize physical discomfort and pain;
3. control anxiety, minimize psychological trauma, and maximize the potential for amnesia;
4. control behavior and/or movement to allow the safe completion of the procedure; and
5. return the patient to a state in which safe discharge from medical supervision, as determined by recognized criteria.

Procedure to be followed while delivering procedural sedation

The patient should be evaluated pre-sedation and decide who can provide sedation to the patient. A qualified person or an anesthesiologist should be called in case of patients who are ASA grade 3 or above, child with special needs, difficult airway and tonsillar hypertrophy (higher Mallampati score). The ASA physical status classification is shown in table 1.

Other high risk factors include snoring, stridor, sleep apnea, cranio-facial malformation, history of airway

Table 1 : ASA Risk stratification system.

P1	A normal healthy patient
P2	A patient with mild systemic disease (eg, controlled reactive airway disease)
P3	A patient with severe systemic disease (eg, a child who is actively wheezing)
P4	A patient with severe systemic disease that is a constant threat to life (eg, a child with status asthmaticus)
P5	A moribund patient who is not expected to survive without the operation (eg, a patient with severe cardiomyopathy requiring heart transplantation).
P6	A declared brain-dead patient whose organs are being removed for donor purposes

All classes are given a suffix E if it is an emergency.

difficulty, vomiting, bowel obstruction, gastro-esophageal reflux, pneumonia or oxygen requirement, reactive airways disease, hypovolemia, cardiac disease, sepsis, altered mental status and history of sedation failure. One should formulate a plan and direct the personnel who shall provide the sedation. A written informed consent is to be obtained. Pre-anesthesia preparation should be followed. The decision of fasting depends on the urgency of the procedure and the kind of feeding. Rather, the need for pre-procedural fasting has been questioned in recent series showing no increase in adverse events in patients not meeting fasting guidelines (6, 7). It has been observed that it is more difficult to sedate fasting child. Although there is insufficient published evidence for supporting/ refuting safe fasting periods before anesthesia, ASA task force has formulated following guidelines (8):

1. Clear liquids – 2 hours
2. Breast milk – 4 hours
3. Infant Formula – 6 hours
4. Non-human milk – 6 hours
5. Light meal – 6 hours.

The sedation is given by the designated qualified professional with adequate monitoring. The patient is discharged by the physician with responsible adult after explaining written post-op and follow-up instructions.

Pre-anesthesia workup

Detailed history of medical status of the child should be taken. The guardian should be asked the history suggestive of major abnormalities in other major body systems. Prior history of sedation/ anesthesia, any adverse events, any drug or other allergies and current medication(s) should be asked for.

The child should be evaluated for vital signs. Heart and lung assessment and airway assessment (Mallampati score) should be done (9) (Table 2).

The procedure suite should be equipped with suction, oxygen, airway management equipment, resuscitation medication and equipment and antidotes for sedation drugs.

The child should have a functional IV access before providing sedation. The insertion of IV line itself is a painful procedure and various modalities are used to reduce the pain. These include Eutactic Mixture of Local Anesthetics – Lidocaine and procaine (EMLA) (10, 11), topical liposomal 4% lidocaine cream (12), lidocaine iontophoresis (13, 14), intradermal lidocaine and vapo-

Table 2 : Mallampati score

Class I:	Soft palate, uvula, fauces, tonsillar pillars visible (no difficulty in intubation).
Class II:	Soft palate, uvula, fauces visible (no difficulty in intubation).
Class III:	Soft palate, base of uvula visible (moderate difficulty in intubation).
Class IV:	Hard palate only visible (severe difficulty in intubation).

coolant sprays (15). In Operation Theater, the child can be induced using inhalational agents (isoflurane, sevoflurane) and the IV line established later. During the procedure the patient is to be monitored as per protocols (described later).

Drugs used in Pediatric population (Table 3)

Benzodiazepines bind to the GABA (γ-aminobutyric acid) receptors in the CNS and potentiate GABA mediated chloride influx. This potentiation of the inhibitory effect of GABA is responsible for the properties of benzodiazepines – sedation, amnesia, anxiolysis, anticonvulsant and respiratory depressant. The higher doses provide better amnesia (16).

Midazolam has a fast onset of action (1-2 min) and short half life (2.7 hours). Midazolam is hydroxylated to 1-hydroxymidazolam in liver (has 10% activity). The diazepam, on the other hand, has extremely long half-life (0.8-2.25 days) as do its metabolites – N-desmethyldizepam (1.6-4.2 days) and nordiazepam (about 8 days). Lorazepam has delayed onset of action (15-20 min) and longer half-life (6-8 hours) as compared to midazolam. Thus, midazolam is most commonly used benzodiazepine for procedural sedation. (17)(Dose: Intravenous: 0.05-0.1 mg/kg IV 3 min before procedure, not to exceed a total cumulative dose of 0.4 mg/kg or 6 mg; Intramuscular: 0.1-0.2 mg/kg IM 30-45 min before procedure; Oral: 0.25-0.5 mg/kg PO 30-45 min before procedure; Intranasal: 0.2-0.6 mg/kg/dose inhaled intranasally 10 min before procedure; Rectal: 0.3-0.5 mg/kg/dose PR 30-45 min before procedure). The main side-effect of benzodiazepines is respiratory and cardiovascular depression that is accentuated by simultaneous use of opioids (18) (reduce dose by 30-50% in combination with opioids). In case of

Table 3 : Drugs used in Procedural Sedation

Drug	Mechanism of Action	Dosage	Side Effects	Antidote	Onset of Action	Duration of Action	Contra-indication	Comments
I. Benzodiazepines								
Midazolam	Potentiates GABA receptors in CNS	*Intravenous:* 0.05-0.1 mg/kg IV 3 min before procedure, not to exceed a total cumulative dose of 0.4 mg/kg or 6 mg; *Intramuscular:* 0.1-0.2 mg/kg IM 30-45 min before procedure; *Oral:* 0.25-0.5 mg/kg PO 30-45 min before procedure; *Intranasal:* 0.2-0.6 mg/kg/ dose inhaled intranasally 10 min before procedure; Rectal: 0.3-0.5 mg/kg/dose PR 30-45 min before procedure.	Respiratory depression, cardiovascular depression. Respiratory depression more when used with opioids.	Flumazenil (0.01 mg/kg/dose IV infused over 15 sec; not to exceed 0.2 mg/dose; may repeat every min; not to exceed total cumulative dose of 0.05 mg/kg or 1 mg (whichever is lower).	1-2 min	20-30 min		Fluctuations in Vital Signs, apnea, headache, N/V, coughing, over-sedation, drowsiness, amnesia (positive effect)
Diazepam		0.04-0.1 mg/kg bolus, titrate in increments of 1-2 mg to desired effect (IM very painful)	Blood dyscrasias, thrombo-phlebitis, sedation, hypotension, bradycardia, respiratory istress, seizures		5-10 min	2-3 hours	Hyper-sensitivity, acute bronchial asthma, or airway obstruction	May initiate histamine release
Nitrazepam		5-10 mg				5-10 hours	COPD patients	Increase in nightmares and behavioral alterations
Lorazepam		Oral 50 µg/kg			15-20 min	6-8 hours		

Table 3 (Contd.)

Drug	Mechanism of Action	Dosage	Side Effects	Antidote	Onset of Action	Duration of Action	Contra-indication	Comments
Flurazepam		Oral 0.2-0.5 mg/kg			15-25 min	7-8 hours		Paradoxical stimulation, irritability and sweating
II. Opioids								
Morphine	Bind to specific receptors in CNS and increase pain threshold, alter pain perception and inhibit ascending pain pathways.	0.05-0.1mg/kg slowly over 4 min.	Respiratory depression, cardiovascular depression, pruritis, flushing	Naloxone (Post anesthetic reversal): 0.005-0.01 mg/kg IV/IM, may repeat q2-3 min; Opiate intoxication: 0.01-0.1 mg/kg dose IV/IM, may repeat every min; not to exceed 2 mg/dose)	3-5 min	3-4 hours	Hypersensitivity, acute bronchial asthma, or airway obstruction	
Meperidine		1mg/kg, titrate to desired effect max: 100mg	Hypotension, respiratory depression, truncal rigidity, seizures		3-10 min	2-4 hours	Hyper-sensitivity, MAO inhibitors	Meperidine is not used because its metabolite has neurotoxic effects.
Fentanyl		1 µg/kg/dose IV; if needed, may repeat by 1 µg/kg increments; not to exceed total cumulative dose of 4 µg/kg	Hypotension, respiratory depression, truncal rigidity, seizures		1-2 min	2-4 hours	Hyper-sensitivity	Unlike morphine, fentanyl has minimal cardiovascular depression and hypotension rarely occurs.
III. Barbiturate								
Pheno-barbital	Potentiates GABA action	*Intravenous:* 1-2 mg/kg/dose IV; if needed may repeat dose; not to exceed a cumulative dose of 6 mg/kg or 150-200 mg; *Intramuscular:* 1-6 mg/kg IM; not to exceed						

Table 3 (Contd.)

Drug	Mechanism of Action	Dosage	Side Effects	Antidote	Onset of Action	Duration of Action	Contra-indication	Comments
		100 mg/dose; *Oral:* 4-6 mg/kg PO; not to exceed 100 mg/dose		Not available				Paradoxical excitation may occur. Induce hepatic microsomal enzymes.
Metho-hexital		25 mg/kg/dose PR 15 min before procedure; not to exceed 500 mg/dose; Intravenous 1mg/kg					Porphyria, hypersensitivity	
IV. Imidazoline agonist								
Dexmedito-midine	Alpha 2 agonist	1 mg/kg IV given as a 10 minute infusion then 0.2-0.7 mg/kg/hr OR 2.5 mg/kg IV given at least over 2 minutes	Arrhythmia, cardiovascular instability, nausea, vomiting, hypoxia.	Atipamezole (3750-5000 $\mu g/m^2$ IM)	30 min	2-3 hours		
Etomidate	Increase affinity of GABA receptors for GABA	0.1-0.2 mg/kg slow IV push over 30-60 sec	Reduces seizure threshold. Reduces cerebral blood flow. Causes adrenocortical suppression, myoclonic involuntary movements, pain on injection nausea and vomiting.		<1min	3-5 min		Cardiovascular stability. Decreases intraocular tension. Causes nausea and vomiting.
V. Inhalational Anesthetics								
Halothane	Progressive depression of CNS, Exact mechanism not known.		Hepato-toxicity					Has sweet odor. An intermediate solubility in blood combined with a high potency permits rapid onset and recovery from anesthesia.

Table 3 (Contd.)

Drug	Mechanism of Action	Dosage	Side Effects	Antidote	Onset of Action	Duration of Action	Contra-indication	Comments
Sevoflurane			Compound A formation with soda lime can lead nephro-toxicity, hepatotoxicity.					Is non-pungent, has minimal odor, produces bronchodilation and causes least degree of A/W irritation among currently available volatile/ inhaled anesthetics.
Nitrous oxide	Endorphins may be involved.	As adjunct (in low concentration – 50%) or isolated hypnotic (higher concentration – 70%)					Middle ear surgery, gut surgery, air embolism.	It increases the volume of gas in space – pneumothorax, air embolus, increases pressure - sinuses, middle ear, pneumo-encephalo-graphy.
VI. Miscellaneous								
Ketamine	Dissociative anesthesia - dissociation between thalamo-cortical and limbic system	Intravenous: 1-2 mg/kg loading dose IV; 0.25-1 mg/kg IV q10-15min; administer slowly, not to exceed 0.5 mg/kg/min; Intramuscular: 2-5 mg/kg/dose IM; Oral: 6-10 mg/kg/dose PO mixed in cola or other beverage 30 min before procedure	It increases bronchial and salivary secretions. Increased skeletal muscle tone.	Not available	IV - within 1 min. IM - 3-5 min.	IV duration of action lasts about 5-10 min. IM - 20-30 min.	It is relatively contraindicated in hypertensive patients and in patients with coronary artery disease, open eye injury and raised intracranial tension.	It does not affect cough reflex or cause respiratory depression, so is favored in emergency non-fasting state.
Propofol	Unknown; ? through GABA receptors	1-1.5 mg/kg IV loading dose; 0.25-0.5 mg/kg IV q3-5min or 50-150 µg/kg/min continuous IV infusion	Respiratory and cardiovascular depression. Causes irritation and burning on IV administration.	Not available	<1min	3-10 min		Preferred because of short duration of action and short hospital stay.

Table 3 (Contd.)

Drug	Mechanism of Action	Dosage	Side Effects	Antidote	Onset of Action	Duration of Action	Contra-indication	Comments
Chloral hydrate	Exact mechanism not known.	25-75 mg/kg/dose PO/PR; not to exceed 1 g/dose (infants) or 2 g/dose (children); administer 30 min before procedure	Respiratory depression.	Not available	30-40 min	2 hours	ASA class III, Leigh encephalopathy, tonsillar and adenoidal hypertrophy, obstructive sleep apnea, severe hepatic or renal impairment.	Unpredictable result. May cause nausea and vomiting. Induces hepatic cytochrome P450, irritant to skin and gastric mucosa, burning taste.
Triclofos	Hydrolysed in body to trichloro-ethanol which is probably the active metabolite.	Upto 1 year – 25 – 30 mg/kg; 1 – 5 year – 250 – 500 mg; 6 – 12 years – 500 mg – 1 g; adults and children > 12 years – 1 – 2 g.					Cardiac disease, hepatic impairment, hypersensitivity, nursing mother and pregnancy, renal impairment.	

overdose, flumazenil may be given (0.01 mg/kg/dose IV infused over 15 sec; not to exceed 0.2 mg/dose; may repeat every min; not to exceed total cumulative dose of 0.05 mg/kg or 1 mg (whichever is lower).

Opioids bind to specific receptors in CNS and increase pain threshold, alter pain perception and inhibit ascending pain pathways. Morphine is long acting with significant respiratory depression. Fentanyl is the most favored opioid because of early onset of action (1-2 min) and short half-life (2-4 hours). Also, unlike morphine, fentanyl has minimal cardiovascular depression and hypotension rarely occurs. It should be given slow IV as rapid push may cause chest wall rigidity and apnea. (Dose: 1 μg/kg/dose IV; if needed, may repeat by 1μg/kg increments; not to exceed total cumulative dose of 4 μg/kg). Meperidine is not used because its metabolite has neurotoxic effects.

Naloxone (antidote – partial agonist) should be at hand while administering opioids so that it can be given in case of severe respiratory depression. (Post-anesthetic reversal: 0.005-0.01 mg/kg IV/IM, may repeat q2-3min; Opiate intoxication: 0.01-0.1 mg/kg dose IV/IM, may repeat every min; not to exceed 2 mg/dose).

Ketamine has dissociative and amnesic properties. It does not affect cough reflex or cause respiratory depression, so is favored in emergency

non-fasting state. It causes cardiovascular and respiratory stimulation (transient respiratory depression if injected too rapidly or in high doses) with normal or increased skeletal muscle tone. It is thus relatively contraindicated in hypertensive patients. It increases bronchial and salivary secretions, so should be pre-medicated with anti-cholinergics like glycopyrrolate. Onset of action for intravenous (IV) administration is within 1 min, and duration of action lasts about 5-10 min. If administered intramuscularly (IM), the onset of action is observed between 3-5 min, and duration of procedural conditions lasts about 20-30 min. (Dose: Intravenous: 1-2 mg/kg loading dose IV; 0.25-1 mg/kg IV q10-15min; administer slowly, not to exceed 0.5 mg/kg/min; Intramuscular: 2-5 mg/kg/dose IM; Oral: 6-10 mg/kg/dose PO mixed in cola or other beverage 30 min before procedure). The relationship between serum concentration and dissociative effect is poorly defined in children (19). Roback *et al* showed that 4mg/kg IM ketamine was more effective than 2mg/kg IV although it also had more incidence of vomiting and required prolonged post-procedural monitoring (20). It is not favored in adults as sole anesthetic due to emergence delirium (rarely seen in children below 1 year of age). As no specific antidote is available, pharmacologic effects are not reversible. The safety profile has been studied and ketamine has been recommended by various authors for procedural sedation in children (21- 23).

Propofol is a sedative with no analgesic action. The mechanism of action is unknown, although it appears to mediate through GABA receptors. It is ultra-short acting (onset <1min; duration 3-10min). As the plane of sedation rapidly progresses to deep sedation and can cause cardiovascular depression and hypotension, close monitoring is essential. (Dose: 1-1.5 mg/kg IV loading dose; 0.25-0.5 mg/kg IV q3-5min or 50-150 μg/kg/min continuous IV infusion). It causes irritation and burning on IV administration. No specific antidote is available. Propofol is favored by most anesthetists for short procedures because of faster, smoother recovery, lack of need for prolonged post-procedure monitoring and short hospital stay (24, 25). But because of transient respiratory depression and hypotension it is safe only in monitored environment (26, 27). In a cost-effectiveness study, propofol + fentanyl was the most cost-effective regimen followed by axillary block, ketamine + midazolam and fentanyl + midazolam respectively (28).

Etomidate is an ultra–short-acting nonbarbiturate hypnotic. It produces

rapid induction (onset <1min; duration 3-5min) without histamine release and with minimal cardiovascular and respiratory effects. As with ketamine or barbiturates, etomidate transiently lowers cerebral blood flow by 20-30% and slightly reduces intracranial and intraocular pressure. It has no analgesic properties. It may cause nausea or vomiting and reduces seizure threshold. (Dose: 0.1-0.2 mg/kg slow IV push over 30-60 sec).

Barbiturates have been used since long for as hypnotics. They are particularly useful for procedures requiring immobilization like radiologic procedures. Paradoxical excitation may occur. (Dose: Phenobarbital: Intravenous: 1-2 mg/kg/dose IV; if needed may repeat dose; not to exceed a cumulative dose of 6 mg/kg or 150-200 mg; Intramuscular: 1-6 mg/kg IM; not to exceed 100 mg/dose; Oral: 4-6 mg/kg PO; not to exceed 100 mg/dose; Methohexital: 25 mg/kg/dose PR 15 min before procedure; not to exceed 500 mg/dose; Intravenous 1mg/kg) (29). No specific antidote is available.

Chloral hydrate is oral sedative used earlier. It has unpredictable effect, paradoxical hyperactivity may occur, may cause nausea and vomiting, respiratory compromise has resulted in permanent neurological damage and deaths. (Dose: 25-75 mg/kg/dose PO/PR; not to exceed 1 g/dose (infants) or 2 g/dose (children); administer 30 min before procedure). It should no longer be used especially in patients with ASA class III, Leigh encephalopathy, tonsillar and adenoidal hypertrophy, obstructive sleep apnea. Hoffman *et al* documented that chloral hydrate provides inadequate sedation (esp. deep sedation) with increased incidence of side-effects (2).

Methoxyflurane has been studied in a small group of 14 patients as analgesic in emergency department delivered through a hand-held device. It was concluded from the study that methoxyflurane can be used with minimal side effects in patients after extremity trauma. It appears less useful as a procedural agent when patients are unable to anticipate and achieve a sufficient level of analgesia before painful stimulus infliction. Pre- and intraprocedure coaching is an important aspect of its use especially if initial pain scores are low.

Nitrous oxide is an inhalational agent that has been used as adjunct (in low concentration – 50%) or isolated hypnotic (higher concentration – 70%) with minimal side effects. (30).

Dexmedetomidine is a new oral drug used as pre-medication before anesthesia and procedural sedation (including IV line insertion) and has shown promising results (31).

High concentrations of sucrose have been used as adjunct in neonates. It has been shown to suppress EEG responses in brain in response to bedside procedures like heel-prick. The exact mechanism is unknown. (Dose: 0.012 to 0.12 g (0.05– 0.5 mL of 24% solution)).

For older and cooperative children, other non-pharmacological modalities, such as parental presence, hypnosis, distraction, topical local anesthetics, and guided imagery, may reduce the need for or the needed depth of pharmacologic sedation. Use of distraction techniques is effective in reducing situational anxiety in children more than 10 years old and lowering parental perception of pain distress in younger children. (32- 34).

Monitoring during Procedural Sedation

The level of sedation should be carefully monitored. It is common for children to pass from the intended level of sedation to a deeper, unintended level of sedation (5). Various scoring systems have been developed to accurately differentiate the depth of sedation objectively. These scores include Children's Hospital of Wisconsin sedation scale (Table 4) (2), Ramsay Sedation Scale Score (Table 5) and Bispectral Index Monitor (35, 36).

Table 4 : The Children's Hospital of Wisconsin Sedation Scale

Sedation Classification	Sedation Score	Description
Inadequate	6	Anxious, agitated, or in pain
Minimal–conscious	5	Spontaneously awake without stimulus
Conscious–moderate	4	Drowsy, eyes open or closed, but easily arouses to consciousness with verbal stimulus
Moderate–deep	3	Arouses to consciousness with moderate tactile or loud verbal stimulus
Deep	2	Arouses slowly to consciousness with sustained painful stimulus
	1	Arouses, but not to consciousness, with painful stimulus
Anesthesia	0	Unresponsive to painful stimulus

Table 5 : Ramsey Sedation Scale Score

Sedation score	Clinical response
1	Fully awake
2	Drowsy but awakens spontaneously
3	Asleep but arouses and responds appropriately to simple verbal commands
4	Asleep, unresponsive to commands, but arouses to shoulder tap or loud verbal stimulus
5	Asleep and only responds to firm facial tap and loud verbal stimulus
6	Asleep and unresponsive to both firm facial tap and loud verbal stimulus

All patients need continuous monitoring for the color (to assess adequacy of perfusion), respiratory excursions (adequate ventilation), vitals monitoring and pulse oximetry. The high risk patients should also have ECG monitoring and capnography. Microstream capnography is a new armamentarium for the personnel monitoring the patient given sedation that monitors pCO_2 in a non-intubated patient to pick up the hypoventilation early and intervene before hypoxemia manifests (37). In case the patient cannot be directly observed (like in MRI suite/ radiotherapy), the monitors with audible alarms are mandatory.

When to Discharge a Patient after Procedural Sedation

ASA in its guidelines on procedural sedation delegates the discharge responsibility with the physician but the exact safe timing of discharge after procedural sedation has not been studied in detail (Table 6). In a study on 1367 patients, Newman *et al* found 92% of side effects occurred during the procedure with median time 2 min after final medication dose. Post-procedural side-effects occurred only in those patients who had observed these effects during the procedure. They found that serious side-effects rarely occur after 25 minutes of last dose (38). Broadly it can be said that the child should be monitored in the recovery till he attains the level of consciousness same as pre-sedation level or that the child remains awake for 20 minutes in quiet environment (5). The discharge criteria recommended by AAP are:

1. Cardiovascular function and airway patency are satisfactory and stable.

Table 6 : Aldrete Recovery Score

Activity

- Voluntary movement of all limbs to command — 2 points
- Voluntary movement of 2 extremities to command — 1 point
- Unable to move — 0 points

Respiration

- Breathe deeply and cough — 2 points
- Dyspnea, hypoventilation — 1 point
- Apneic — 0 points

Circulation

- BP ± 20 mm Hg of preanesthesia level — 2 points
- BP ±20-50 mm Hg of preanesthesia level — 1 point
- BP ±> 50 mm Hg of preanesthesia level — 0 points

Consciousness

- Fully awake — 2 points
- Arousable — 1 point
- Unresponsive — 0 points

Color

- Pink — 2 points
- Pale, blotchy — 1 point
- Cyanotic — 0 points

Total score must be > 8 at conclusion of monitoring.

2. The patient is easily arousable, and protective reflexes are intact.
3. The patient can talk (if age appropriate).
4. The patient can sit up unaided (if age appropriate).
5. For a very young or handicapped child incapable of the usually expected responses, the pre-sedation level of responsiveness or a level as close as possible to the normal level for that child should be achieved

6. The state of hydration is adequate.

Conclusion

Procedural sedation is an advanced science in itself. The patients need to get the benefit of the availability of new drugs and advanced techniques for monitoring by properly trained personnel. The drugs when used by adequately trained personnel with adequate mentoring can alleviate pain in children during painful procedures and increase patients and parents satisfaction. This holds true especially for oncology patients who require repeated interventions. The sedation should be provided by trained physicians and monitored as per guidelines so as to ensure safety and prevent mishaps.

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