Review Article

Paediatric procedural sedation for radiological imaging

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Abstract

Sedation is frequently undertaken for radiological imaging procedures in paediatric patients. Movement during procedure degrades all images of a particular sequence. A deeper level of sedation is needed. The sedation of children is different from the sedation of adult. The safe sedation of children for imaging procedure requires a systematic approach that includes the followings. Careful presedation health evaluation of the child with ASA classification. Appropriate fasting guidelines for sedation procedure. Detailed airway examination for any airway abnormalities that might increase the potential for airway obstruction. Adequqte training and skills of sedating personnel in paediatric airway management. Age and size appropriate equipment for airway management and venous access. Adequate medications to combat adverse events. Monitoring of vital parameters during and after the procedure. A properly equipped and staffed recovery area. Recovery to presedation level of consciousnessof patient before discharge from medical supervision and appropriate discharge instructions. The whole procedure should be well documented. Childrens who has contraindications to sedation should be selected for general Anaesthesia.

This review article has been made to discuss the need for sedation of children during radiological imaging, currently practiced different regimens of sedation, safe guidelines for sedation and also covers the debate between need for GA versus sedation.

Keywords : *Procedural sedation, Paediatric, Radiological Imaging.*

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Introduction

Sedation is usually a need for radiological imaging procedures in paediatric populations. Among them magnetic resonance imaging (MRI) takes a longer duration than other radiological imaging procedures and any movement usually degrades all images of a particular sequence. Mild and moderate sedation is unable to guarantee patients compliance and therefore a deeper level of sedation is required. Sedation in children is often administered to control behavior to allow safe completion of procedure. Children younger than 7 Years and those with developmental delay often require deep level of sedation to gain control their behavior.[1] Children in this group are particularly vulnerable to sedating medications due to effect on respiration, and protective reflexes. [2] However, general anaesthesia cannot be organized routinely due to need for special, costly equipments, monitors and personnel as well as general anaesthesia is not without risk.

In practice, anaesthesiologists have to deal with these patients with request from radiologist, paediatricians and other clinical staff. There are various general protocols and standard operating procedures, [3] made by medical and nursing organizations and societies. They are often general in nature, and thus the anaesthesiologists should design specific protocols to use in their own hospitals for their personnel.

The Need for Deep Sedation

As movement interferes with effective MRI, patients unable to lie still, provide a challenging problem. Moderate sedation is unable to guarantee patient compliance and therefore a deeper level of sedation is required. Infants may go to sleep with a feed and children older than 7 years can comply with instructions to remain still. [4,5-14] Intravenous deep sedation is thus required for many of those between one and 7 years, and some older children with learning difficulties or claustrophobia. [15]

Intravenous sedation is more predictable in this group as it has an immediate effect and is much less reliant on other factors such as absorption. However, it has also been suggested that there are varying levels of deep sedation at the end, which is an overlap with general anaesthesia. [16-20]

Sedation Regimens for Children

There has been debate over appropriate drugs and their dosage, and those who sedate children have their favorite regimens. It is important that persons administering the drug are familiar with them and cocktails of more than two drugs are to be avoided because of unpredictability of drug interactions and the increased incidence of important side effects. [3,21,22]

Table I : *Different sedation regimens with dose and route of administration*

Drug Regimen		Dose/route of administration
1.	Chloral hydrate	50-100 mg/kg PO
2.	Pentobarbital	4-6 mg/kg IV or PO
3.	Midazolam	0.5-0.75 mg/kg PO 0.025-0.5 mg/kg IV 0.2 mg/kg intranasal
4.	Propofol	100-200 µg/kg/min IV
5.	Methohexital	0.25-0.50 mg/kg IV 20-25 mg/kg rectal
6.	Ketamine	3-4 mg/kg IM 1-2 mg/kg IV
7.	Propofol with fentanyl	Propofol 50-150 µg /kg IV Fentanyl 1- 2 µg /kg IV
8.	Midazolam with fentanyl	Midazolam 0.02 mg/kg IV Fentanyl 1-2 µg /kg IV

PO - Per Os (Oral)
IV - Intravenous
IM - Intramuscular

Chloral hydrate is an extremely useful and safe and can be used with good effect in children upto 10 kg.[24] Pentobarbital has a long history of effective use but emergence can be prolonged. Midazolam has track record of safe use both oral and intravenous, paradoxical reactions are not frequent. Intranasal route should not be recommended due to irritation. [25] Propofol is an ideal agent for nonpainful diagnostic procedures but only for use by expert airway managers with good backup systems. [23] Methohexital gives effective sedation in intravenous route and rectal route is not recommended because of high frequency of apnoea and desatuation events.[26] Ketamine is a very popular drug for effective sedation and analgesia for painful procedures, nausea and vomiting is relatively common after procedure and there are reports of laryngospasm. [28] Propofol combined with fentanyl is best for deep sedation to anaesthesia, but risk of requiring advanced airway management is high.[27] Midazolam with fentanyl is another common combination for painful procedures but risk of apnoea and hypoxia is significant. [29]

Sedating Personnel

Present American Pediatric Guidelines [16] augmented by a literature suggests that if deep sedation is required then it should be performed by someone. [30,31]

a. Who is working to an acceptable guideline.
b. With sole responsibility for the sedation.
c. Who has been trained to an acceptable level (Such as, advanced paediatric life support provider status).
d. Who is familiar with the drugs, dosages, monitoring equipment, and requirement of the procedure.
e. Who is supported by other skilled staff such as a children's nurse.

Preparation of Patient

Children should be prepared in a similar way to child undergoing general anaesthesia.

a. Informed consent for sedation taken.
b. Children fasted by withhelding milk and solids as per direction.
c. Reliable intravenous access essential before, during, after the procedure if intravenous drugs are used, in addition, for administration of resuscitation drugs if required.

d. The paediatric patient should be accompanied to and from the scanning department by a parent, legal guardian or other responsible person.

Monitoring of Patient

Monitoring of the patient during and following procedure is the cornerstone of safe practice.[16,21] There must be one person available whose only responsibility is to constantly observe the patient's vital signs, airway potency, and adequacy of ventilation and administration of drugs. Pulse oximetry is essential during sedation and recovery; oxygen saturation should stay above 93%. Vital signs such as level of consciousness, pulse, respiratory rate and oxygen saturation readings should be taken at given minute's intervals during the procedure and any adverse events must be recorded. Non-ferromagnetic monitoring systems are available and therefore compatible with use in the MRI. [32]

Post Sedation Care

After completion of imaging procedure, monitoring and observations should be continued and recorded until recovery of consciousness. All the resuscitation equipment should be readily available in the recovery area. Post anaesthesia recovery nurses with paediatric education and experience are required. Nurses providing such care should be capable managing the paediatric airway and skilled in basic resuscitation techniques.

Recommended Discharge Criteria[33]

a. Cardiovascular function and airway patency are satisfactory and stable.
b. The patient is easily arousable, and protective reflexes are intact.
c. The patient can talk (if age appropriate).
d. The patient can sit up unaided (if age appropriate).
e. For a very young or handicapped child incapable of the usually expected responses, the presedation level of responsiveness or a level as close as possible to the normal level for that child should be achieved.
f. The state of hydration is adequate.

Documentation

As like any anaesthetic proper documentation should be done throughout the whole procedure of sedation. [34-37]

a. Documentation before sedation
   (i) Informed consent for sedation.
   (ii) Patients detail particulars.
   (iii) A complete health evaluation with ASA classification as discussed.
   (iv) Instructions and information's about fasting and sedation provided to the responsible person.
   (v) Any special instructions for individual case.
b. Documentation at the time of sedation.
   (i) Previous health evaluation will be thoroughly reviewed by sedation team.
   (ii) Baseline vital parameters of child including patients level of consciousness and responsiveness, heart rate, blood pressure, respiratory rate and oxygen saturation.
c. Documentation during sedation.
   (i) The patients chart shall contain a time based record that includes the name, route, site, time, dosage and patient effect of administered drugs.
   (ii) The patients chart shall contain documentation during sedation the patients level of consciousness, heart rate, blood pressure, respiratory rate, and oxygen saturation at regular interval. This documentation will be continued until the patient attained predetermined discharge criteria.
   (iii) Any adverse event and treatment of that shall be documented.
d. Documentation after sedation. The time and condition of the child at discharge form the sedation area or facility shall be documented; this 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.

Resuscitation Equipment

Following resuscitation equipment should be available during procedure and recovery and should include. [16,21]

a. Suction apparatus - size appropriate suction catheters and a functioning suction apparatus.
b. Oxygen - adequate oxygen supply and functioning flow meters/other devices to allow its delivery.
c. Airway – size appropriate airway equipment, nasopharyngeal and oropharyngeal airways, laryngoscope blades, endotracheal tubes, stylets, facemask, bag-valve-mask or equivalent device (functioning).
d. Monitors – functioning pulse oximeter with size appropriate oximeter probes and other monitors as appropriate for the procedure (e.g. non-invasive blood pressure, end tidal carbon dioxide, ECG and stethoscope).
e. Special equipment or drugs for a particular case (e.g. defibrillator).

Resuscitation Drugs[16,21]

Sulbutamol for nebuliztion and inhalation, Suxamethonium, Atropine, Diazepam, Adrenaline (1:1000, 1:10,000), Flumazenil, Glucose (25% or 50 %), Lignocaine (cardiac lignocaine, local infiltration), Midazolam, Hydrocortisone, Methyl-prednisolone, Naloxone, Oxygen, Vecuronium, Sodium bicarbonate,

Contraindications of Sedation

a. Potential airway obstructions for example, sleep apnoea, anatomic airway abnormalities or extreme tonsillar hypertrophy.
b. Respiratory centre abnormalities for example, brain stem tumours.
c. Respiratory centre desensitized to carbon dioxide for example, conditions with chronically raised $PaCo_2$.
d. Renal or hepatic dysfunction leading to altered drug kinetics.
e. Conditions in which a rise in $PaCo_2$ would be detrimental for example raised intracranial pressure.
f. Conditions with high risk of pulmonary aspiration of gastric content.

These candidates should be exclusively selected for general anaesthesia.

Adverse Events with Sedation in Children[38-53]

Sedation of pediatric patients has serious associated risks, such as

a. Hypoventilation.
b. Apnoea.
c. Airway obstruction.
d. Hypothermia.
e. Reaction to contrast agent.
f. Cardiopulmonary impairment.

Common Causes of Adverse Events

a. Drug overdose.
b. Inadequate monitoring.
c. Premature discharge.
d. Inadequate help.
e. Drug interaction.
f. Drug error.

These adverse responses during and after sedation can be minimized. Careful pre-procedure assessment, appropriate drug selection,appropriate monitoring, as well as the presence of a skilled individual needed to rescue a patient from an adverse responses are essential. [2,43,44,54]

Ketamine-The Most Common and Effective Paediatric Sedation Agent for Radiological Imaging

The phencyclidine derivative ketamine has been described as a safe and effective paediatric sedation agent in the developed as well as developing world.[55] Ketamine produces a dissociative state, combination of analgesia, amnesia and sedation at subanaesthetic doses, with minimal effects on the airway and vital reflexes. It is best if combined with an anticholinergic to control secretion and with a benzodiazepine like diazepam to prevent agitation and nightmares.[56]Ketamine is a safe, useful procedure sedation agent but it delays recovery when used with long acting benzodiazepine like diazepam.[57-59] Ketamine does not fit easily into standard drug classification. At low doses full general anaesthesia is not achieved rather a dissociative state in which airway and respiratory tone are maintained. The specific dangers of airway compromise and cardio respiratory instability are suggested to be less with ketamine.

In developing country like Bangladesh, cost of drug is a matter of consideration during sedation procedure. Ketamine is easily available in Bangladesh and more cost effective than other sedation agents and can safely administered for paediatric sedation during radiological imaging.

Sedation versus General Anaesthesia

MRI investigations in children can be done by safe sedation providing previously stated guidelines were followed. Newer short acting drugs like propofol, midazolam, fentanyl etc can be safely employed to provide sedation. Deep sedation has been found to cause respiratory adverse events in ASA III or IV paediatric patients. [60] Early identification of patients who are at risk of failing sedation or experiencing adverse events may help in choosing patients for whom general anaesthesia would be a safer or successful alternative. [61]Advantages may be achieved by using general anaesthesia instead of deep sedation. There should be less failure and there may be faster turn around. The disadvantages of general anaesthesia include need for costly dedicated equipment, and a greater availability of paediatric anesthesiologists.[62]

Conclusion

Providing sedation to children during radiological imaging procedures is an area of rapid change marked by evolving standards. It is possible to use deep sedation to produce satisfactory conditions for children having scans unless there is any contraindication for sedation. Anaesthesiologists have played a critical role in establishing guidelines for safe sedation, considerable work remains in defining what represents effective and safe practice. It is the time that anaesthesiologists should establish the identity as the ultimate experts in this field with a proven track record of practice improvement to assure that clinical practice, training, and safety in this field.

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