Chapter 16

Sedation for Procedures in Children*

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Introduction

Children often need support to cooperate with medical professionals for clinical procedures. This may be due to their age, developmental immaturity, illnesses or anxiety. In most circumstances, it is not acceptable to forcibly restrain a child. Clinicians have therefore developed a variety of non-pharmacological and pharmacological techniques (including sedation and general anaesthesia) to help facilitate procedural comfort for children (Table 16.1).

Recent years have seen an increase in the demand for paediatric sedation, particularly for painless imaging procedures such as MRI, which has become the standard of care for investigation, diagnosis, staging, surgical planning and postoperative monitoring or surveillance of many medical conditions. Sedation can also be a useful tool in clinical situations when general anaesthesia is a high-risk option. This increasing demand, the availability of newer drugs and sedation techniques and the reality that sedation is being practised by an array of health care professionals (anaesthetists, intensivists, nurse specialists, dentists, emergency physicians, gastroenterologists) for increasingly complex patients in varied locations have necessitated recent international guideline changes and consensus statements on this topic. It is vital for paediatric anaesthetists to have a comprehensive understanding of sedation techniques and to take the lead in maintaining and advancing the standards of safety and education of health care teams providing sedation for children.

Background Knowledge

Definitions

Sedation is a spectrum between being fully awake and cooperative and being fully anaesthetised. Current definitions of the depth of sedation (Table 16.2) attempt to identify where on this spectrum a patient's level of sedation might fall. Identifying the depth of sedation based on these definitions is not always easy, as stimulating a child undergoing procedural sedation might be counterintuitive. Ideally a minimal sedation drug technique should have a margin of safety wide enough to make loss of consciousness unlikely. It remains possible, though, for a patient's depth of sedation to vary between moderate and deep during a sedation episode depending on factors, including patient comorbidities, the drugs and doses given, and the presence of stimuli around them.

Special Considerations for Moderate Sedation

In moderate sedation, the child should be easily rousable and be able to show some degree of cooperation. Failure can be common. Moderate sedation requires patience and skill, and the time invested is worthwhile when the failure rate is low. If a child will not cooperate, the dose of sedative can be increased or an additional sedative administered, but this risks deep sedation. In general, it is not possible to be certain what dose of sedation can cause deep sedation. Nitrous oxide alone is the exception – 50% nitrous oxide does not cause an unrousable state in otherwise normal children. Sedation may therefore be unpredictable, varying between conscious and deep depending on the sedative dose administered, drug combinations used and degree of stimulation. Techniques combining an opioid

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Table 16.1 Management options for procedural anxiety in children

Non-pharmacological techniques	Pharmacological options for sedation
Prehospital information and preparation • Child friendly information leaflets, books or videos • Hospital tours (e.g. MRI suite) • Engagement with clinical psychologists • Cognitive behavioral therapy	Simple oral sedatives • Chloral hydrate • Melatonin • Trimeprazine, chlorphenamine and other sedating antihistamines
Communication aids • Information about child's needs, routines and communication strategies • Makaton and symbol charts	Nitrous oxide (in oxygen)
Play therapy and preparation • Interaction with child life specialists • 'Medical games' that mimic the procedure • Immersive reality play (MRI machine becomes the child's rocket ship)	Benzodiazepines • Midazolam • Diazepam • Temazepam
Involvement of parents/carers • Parental presence and role for sedation period	Ketamine
Distraction techniques • Toys, videos, video games, phones/tablets, virtual reality • Immersive games • Blowing bubbles • Clowns and magic	Alpha 2 adrenergic agonists • Clonidine • Dexmedetomidine
Environmental adjustment • Sleep promoting behaviors • Adopt the child's normal nighttime routine (toys/stories) • Reduce sensory input • Soft lighting • Minimise ambient noise and avoid unnecessary staff • Soft music therapy • Hypnosis	Opioids • Morphine • Fentanyl • Sufentanil
Relaxation techniques • Breathing and relaxation exercises • Hypnosis • Acupuncture	Barbiturates • Pentobarbitol
Engagement with sedation technique • Allow child to engage with or help with aspects of the procedure	Anaesthetic agents • Sevoflurane • Propofol

and benzodiazepine are notorious for causing delayed respiratory depression after the pain of a procedure has subsided.

Special Considerations for Deep Sedation

Potent drugs, such as propofol and sevoflurane, can be used to achieve moderate to deep sedation, and these advanced techniques can be used by anaesthetists in hospital practice. For anaesthetists, the boundary between sedation and anaesthesia need not be clear. If the facilities and personnel can deliver anaesthesia, the sedation level achieved is not important provided the child is safe, comfortable and recovers quickly. This can be achieved using short-acting potent drugs. These specialist

Table 16.2 The American Society of Anesthesiologists (ASA) levels of sedation and some historical terms

	Conscious state	Respiratory depression
Minimal sedation	• Remains awake, calmed by sedative • Normal response to verbal commands • Cognitive function and coordination may be impaired	• None
Moderate sedation	• Sleepy • Responds purposefully to verbal commands or light tactile stimulation • Reflex withdrawal from a painful stimulus is not a purposeful response	• Detected • Intervention rarely necessary
Deep sedation	• Asleep • Cannot be easily roused • Responds purposefully to repeated or painful stimulation	• Common • Intervention often necessary • Cardiovascular function is usually maintained
Anaesthesia	• Asleep • Unrousable	• Usual • Routine airway intervention • Cardiovascular depression common
Some alternative and outdated terms to describe sedation		
	Conscious state	**Respiratory and circulatory intervention**
Conscious sedation	• Sleepy • Opens mouth to verbal commands (see 'Dental Procedures')	• Rarely necessary with basic techniques • To be expected with advanced techniques
Safe sleep	• Asleep • Rousability not tested	• Rarely necessary
Ketamine sedation	• Eyes open • Unresponsive • Immobile	• 1% brief apnoea and/or laryngospasm
Minimal anaesthesia	• Asleep with short-acting drug/s • Not easily roused or briefly unrousable • Rapid recovery when drug delivery stops	• Routine airway intervention • Cardiovascular depression common but intervention unnecessary

techniques which cause a state that fluctuates between sedation and anaesthesia are valuable and are described in this chapter. They have been called minimal anaesthesia, and this may be a more appropriate term depending upon the circumstances.

Patient Preparation

Assessment

All children must have a full medical assessment and focused examination prior to sedation. Some medical conditions require caution and specialist advice should be sought before proceeding; these are described in Table 16.3.

It is important to evaluate a child's ability to cooperate. This may be influenced by age, anxiety, behavioural disorders or learning difficulties. It is also important to consider the nature of the procedure, how long it will take, how immobile they need to be, any pain or noise involved, the need for intravenous access and the need for airway protection.

Part of an assessment should consider if the child would benefit from psychological preparation. Do they know what to expect or what they will experience? What should they do during the procedure? How will they cope? Can their parents be around to provide reassurance and help during the procedure? The time invested in gaining a child's trust and cooperation is invaluable. The

Table 16.3 Conditions requiring caution and specialist advice prior to sedation

System	Details
General factors	• ASA III or greater • Neonates and Infants less than 1 year old • Severe anxiety • Autistic spectrum disorder • Developmental delay
Difficult airway or risk of airway obstruction	• Snoring or stridor • Blocked nose • Obstructive sleep apnoeas • Small mandible • Large tongue
Respiratory compromise	• SpO_2 less than 94% in air • High respiratory rate • Oxygen treatment • Unable to cough or cry • Apnoeic spells • Recent respiratory tract infection (within 2 weeks)
High intracranial pressure	• Drowsiness • Headache • Vomiting
Epilepsy	• Major neurological or neuromuscular disease • Previous adverse reaction to sedation • Requiring resuscitation within the past month • Cyanosis more frequent than once per day • Convulsion less than 4 hours before sedation • Failure to regain full consciousness and mobility after a recent convulsion
Risk of pulmonary aspiration of gastric contents	• Abdominal distension • Appreciable volumes draining from nasogastric (NG) tube • Vomiting • Oesophageal disease • Polyhandicap • Unfasted
Severe metabolic, liver or renal disease	• Requiring IV fluids or dextrose • Jaundice or abdominal distension • Requiring peritoneal or haemodialysis

assistance of child life specialists and play preparation are useful tools at this stage.

Fasting

Fasting is rarely required for minimal sedation, nitrous oxide or moderate sedation techniques, and hungry and thirsty children are less likely to be cooperative. Nil by mouth status has not been shown to be a predictor of aspiration or major adverse events for paediatric sedation, and children having procedural sedation are often unintentionally fasted for longer than instructed.

A recent international multidisciplinary consensus statement on fasting before procedural sedation in adults and children has provided evidence-based guidelines. The patient's fasting recommendations are based on and stratified according to their individual risk factors and those of the proposed procedure and sedation technique (Figure 16.1).

Consent

Parents, and if appropriate the child, should understand what the procedure involves, the

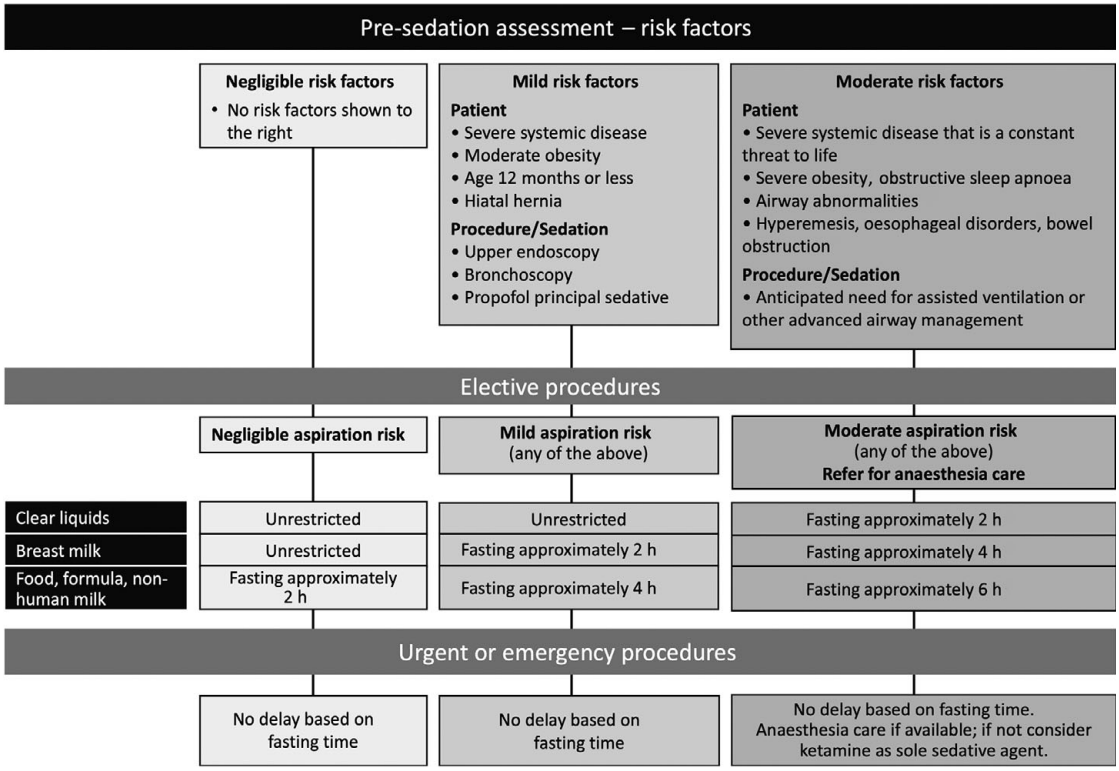

Figure 16.1 Fasting for procedural sedation risk stratification algorithm.
Source: Used with permission from John Wiley & Sons Ltd from *Anaesthesia* 2020; 75:376.

proposed sedation technique, the risks and benefits involved and alternatives to sedation. Informed consent should be documented in writing.

Safety in Sedation

It is essential that practitioners of sedation have a comprehensive knowledge of the pharmacology of the drugs that they use. They must understand and have practical experience of the medical assessment, monitoring, recovery care and complications of sedation and their immediate management. They must have life support skills training and be able to manage an airway. Where agents such as sevoflurane and propofol are used as sedatives, these clinicians must be appropriately trained to deliver anaesthetic agents.

Children must be monitored whilst undergoing sedation. For moderate sedation, monitoring should include a regular assessment of:

- Depth of sedation, pain, coping and distress
- Respiration
- Pulse oximetry
- Heart rate

For patients having deep sedation, high-risk patients (ASA III–IV), or when using drugs that have a narrow margin of safety, additional monitoring should include:

- Electrocardiogram (ECG)
- Capnography
- Blood pressure

Resuscitation equipment should be available including oxygen supply and delivery equipment, oro-/nasopharyngeal airways, face masks, supraglottic airway devices, self-inflating bags, tracheal tubes, laryngoscopes, suction apparatus, intravenous access equipment, blood gas analysis, emergency drugs and defibrillators.

Most complications related to sedation can be managed simply by opening the airway, giving supplemental oxygen and occasionally supporting breathing.

Common Scenarios in Paediatric Sedation

Sedation should meet the needs of the procedure. Some require immobility, others require

analgesia. Any chosen technique will also vary depending on the patient's requirements and the sedationist and their hospital's experience and preferences; individual case-by-case judgement is always required. Examples of sedation techniques for four common procedural scenarios are described in the following subsections. The procedures are:

- Painless imaging (e.g. magnetic resonance imaging [MRI])
- Painful procedures (e.g. suture of laceration, manipulation of a fracture)
- Gastrointestinal endoscopy (e.g. gastroscopy and colonoscopy)
- Dental procedures

Painless Imaging

MRI and similar imaging techniques need the child to keep sufficiently still in a confined noisy space. There are four methods to achieve this:

- The 'feed and wrap' technique. Infants less than three months old may naturally sleep deeply after a feed, and this technique can be attempted if the scan is not urgent. Feed the infant 30 minutes before the scan and wrap them up warmly. If this fails, sedation or anaesthesia must be delayed for at least six hours (four hours after breast milk).
- Awake imaging. Some younger children and most older children will lie still without the need for sedation or anaesthesia. It is possible to select children who can be calmed by behavioral techniques, and play specialists are remarkably successful. If the scan is not urgent, this allows time for the child to get used to what is expected of them. It may take several sessions, and the principle of encouragement and reward helps. If this is not possible or practical, the child will require pharmacological interventions.
- Procedural sedation.
- General anaesthesia.

Within a busy radiology department, there will need to be an efficient selection process to identify the best strategy. Remember that intravenous contrast agents may be necessary, and so it is important to establish the need for intravenous access and how best to site it in advance.

Moderate Sedation versus Deep Sedation (Minimal Anaesthesia)

If an anaesthesia service is available, the depth of sedation is not important, as deeper sedation can be safely delivered, and it is rather the success and complication rates that dictate the technique. Potent short-acting drugs such as propofol or sevoflurane are familiar to anaesthetists, and, unless contraindicated, there is no need to use low doses of either to sedate the child. In most cases, anaesthetic doses are recommended to achieve sleep and immobility. Where these doses are not advisable, then sedation doses could be considered. An example might be in a child with cardiomyopathy (low-dose propofol is useful) or an infant with poor venous access (sevoflurane delivered by nasal cannulae could be considered) – but these situations are rare.

Deep Sedation (Minimal Anaesthesia) Techniques

Propofol infusion (bolus dose 2–3 mg kg^{-1} followed by 10 mg kg^{-1} h^{-1} IV) has the advantage of a high success rate and rapid pleasant recovery; the disadvantage is the need for IV access. An artificial airway is unnecessary for the majority of children who have normal airway anatomy. If an airway device is used, the dose of propofol may need to be higher in order to tolerate it. Remote monitoring of breathing using capnography is essential (use nasal speculae).

Occasionally propofol does not immobilise the child, and the addition of ketamine, an opioid or midazolam, is necessary; use low doses to maintain spontaneous breathing.

Sevoflurane inhalational anaesthesia has obvious advantages in those with needle phobia or difficult venous access. Once anaesthesia is induced, it can be converted to a propofol technique if necessary. Propofol has the advantage over sevoflurane of being associated with less post-procedural emergence delirium.

Moderate Sedation Techniques

If non-anaesthetists provide a service, the depth of sedation is important, and the technique should ideally be limited to moderate sedation. Frequently testing the level of sedation with stimulation is counterproductive when scanning though.

Vigilance is therefore always required, as the true level of sedation might be unclear.

The following sedation methods can be considered:

- Chloral hydrate. Use 100 mg kg^{-1} PO (maximum dose 1 g). Limited to children less than 15 kg. Sleep begins within 10 minutes in most cases and lasts for up to 60 minutes. Vomiting is common. Intravenous cannulation and top-up with midazolam is necessary in 5–10% of children. Expect a failure rate of 5%.
- Midazolam. Intravenous doses should be titrated to effect. Start with 25–50 mcg kg^{-1} and increase in small steps (maximum of 6 mg, 7.5 mg and 10 mg for children aged <6 years, 6–12 years and 12–18 years respectively).

Dexmedetomidine Sedation Techniques

The use and popularity of this highly specific alpha-2 adrenergic agonist for sedation has grown in the past decade, although it is not yet incorporated into national guidance in the United Kingdom and its use for paediatric sedation remains off-label. Dexmedetomidine's sedative action simulates natural non-rapid eye movement sleep whilst maintaining respiratory function, making it a very safe and desirable drug for procedural sedation, especially for painless imaging. The effects of dexmedetomidine include haemodynamic changes. There is a biphasic blood pressure response (initial increase in blood pressure, followed by a decrease from baseline) and reduction of heart rate or bradycardia. These cardiovascular effects are rarely clinically significant and if associated with other concerning changes in vital signs can be attenuated by stopping the drug and administering 10 ml kg^{-1} of a balanced salt solution. Bradycardias are rarely associated with a reduction in blood pressure; anticholinergic treatment is not recommended and is associated with a significant hypertensive response.

It is particularly important when using dexmedetomidine that attention is taken to provide a 'sleep-promoting' environment, including soft lighting, minimising ambient noises and reducing stimulation of the patient; treat these children as you would a normal sleeping child, as they are very rousable. If roused, the child should settle down with calm reassurance, although additional boluses are sometimes needed. Suggested sedation strategies with dexmedetomidine include:

- Undiluted atomised intranasal dexmedetomidine 4 mcg kg^{-1} to a maximum of 200 mcg. The dose may need to be limited by what is a reasonable volume to give via the intranasal route. This technique is useful for children having short scans who do not require intravenous access. A dose of 0.2 mcg kg^{-1} of buccal midazolam may be needed if the dexmedetomidine alone fails to achieve the desired level of sedation. This combination has been found to be reliable and safe.
- For longer scans and when intravenous access is required for contrast agents, an intravenous loading dose of 3 mcg kg^{-1} dexmedetomidine over 10 minutes followed by a 2mcg kg^{-1} hr^{-1} maintenance infusion can be given. These children usually fall asleep around five minutes into the loading dose and can be taken into the scanner after the loading dose has been completed. Occasionally a second loading dose is necessary if the desired level of sedation is not achieved. The recovery period for dexmedetomidine can vary between one and two hours, as these children remain rousable but very sleepy. Allow an initial 30-minute rest and recovery period following completion of the scan, then encourage active engagement and stimulation of the child, including play, eating and drinking.

Painful Procedures

Some painful procedures in emergency departments and in hospital wards can be managed using moderate sedation. Manipulation of a fracture and suturing of a wound are common examples. Local anaesthetic should be used whenever possible. In addition, the following may be required:

Minimal sedation is appropriate in cooperative children and can be achieved with:

- Nitrous oxide. In a maximum concentration of 50% in oxygen, it should be 'self-administered' by the patient.
- Oral midazolam (0.5 mg kg^{-1}) is an effective anxiolytic, acting within 30 minutes. The buccal route is also useful.

When these are not effective, two techniques can be considered:

- Ketamine causes a unique 'dissociative' sedation. Children are immobile, calm and unreactive to pain, yet their eyes may remain

open. Airway and breathing reflexes are usually maintained. Ketamine is not considered to be conscious sedation, yet appreciable airway and respiratory effects are uncommon at recommended doses. It can be administered by the intravenous or intramuscular routes. Expect a low incidence of laryngospasm caused by airway secretions. Recovery is usually within 90 minutes.
    - IV: 2 mg kg^{-1}; give additional doses of 1 mg kg^{-1} if necessary.
    - IM: 5–10 mg kg^{-1}.
- Intravenous midazolam with or without fentanyl is an effective conscious sedation technique but is less reliable than ketamine, and respiratory interventions are more likely. Titrate both drugs carefully.
    - A starting dose of midazolam is 25–50 mcg kg^{-1}.
    - A starting dose of fentanyl is 0.25–0.5 mcg kg^{-1}. The effect of fentanyl may outlast the pain of the procedure and may cause respiratory depression once the procedure is over.

When these techniques are unsuitable or ineffective, a specialist technique or anaesthesia should be used. A combination of propofol and an opioid such as fentanyl, alfentanil or remifentanil is effective and suitable for short procedures. Lumbar puncture and bone marrow aspirate procedures, common in oncology departments, can be achieved using short-acting anaesthesia with propofol (2–3 mg kg^{-1}) and remifentanil (1 mcg kg^{-1}). Apnoea almost always occurs with remifentanil, and a short period of assisted ventilation is necessary. Delivered via indwelling central venous catheters, this technique allows fast recovery, and children can eat and drink shortly afterwards. Postoperative analgesia other than local anaesthesia is not usually necessary.

Dental Procedures

In the United Kingdom, conscious sedation for dentistry is divided into basic and advanced techniques. Basic conscious sedation requires the cooperation of the child and involves one of two techniques:

- Nitrous oxide is administered via a nasal mask in concentrations up to 70%. Usually only 30% is necessary. Higher concentrations cause dysphoria.
- Midazolam, titrated intravenously, is recommended for anxious adolescent children and young people. A starting dose is 25–50 mcg kg^{-1} IV.

Both techniques are effective and safe. If they are not suitable or sufficient, either an advanced sedation technique or anaesthesia should be considered. The specialist techniques themselves involve the use of combinations of potent drugs, and there may be a risk of unintended deep sedation, depending on the drugs and their doses. Specialist techniques should only be used by specially trained teams and are only safe in fully equipped facilities.

Endoscopy

Whilst many adults can swallow an endoscope or tolerate the discomfort of colonoscopy without sedation, children almost always require sedation or anaesthesia.

Endoscopy is possible under *moderate sedation* in older children using intravenous midazolam; an opioid is sometimes necessary. Both drugs should be titrated carefully. Two techniques are recommended:

- Upper gastrointestinal endoscopy. Intravenous midazolam, starting dose 25–50 mcg kg^{-1} IV.
- Lower gastrointestinal endoscopy. Intravenous midazolam combined with fentanyl (or equivalent opioid), starting dose of fentanyl 0.25–0.5 mcg kg^{-1} IV.

Propofol sedation or minimal anaesthesia without tracheal intubation is widely used for endoscopy for younger children or where *deeper sedation* is required. Older children can be positioned on their side and monitoring attached prior to drug administration. Nasal speculae are used to deliver oxygen and monitor capnography. Intubation is advised for children less than one year.

For gastroscopy:

- Use propofol to induce sedation/anaesthesia with 1–2 mg kg^{-1} IV, or if using propofol TCI titrate up to effect aiming for a target concentration of 6 $mcg.ml^{-1}$.
- A dose of 0.5 mcg kg^{-1} IV fentanyl is a useful adjunct if the child is breathing well and not having colonic manometry.
- Insert a mouth gag to protect the endoscope.
- The depth of anaesthesia can be tested by inserting a suction catheter into the pharynx.

- Give 1–2 mg kg^{-1} IV increments of propofol or increase TCI concentration if there is too much movement.
- Some gag reflex should be preserved but not enough to make the procedure difficult, and this can be attenuated with a dose of 1 mg kg^{-1} lidocaine IV.
- Insert the gastroscope.
- A soft suction catheter can be used to remove pharyngeal secretions and to help prevent laryngospasm.
- It may be necessary to perform a jaw thrust to maintain the airway.
- Inject further boluses of propofol as required (1 mg kg^{-1} IV). A total dose of 3–4 mg kg^{-1} IV is usually required for a 10-minute procedure.
- Duodenoscopy may cause retching.

Colonoscopy is uncomfortable but not usually painful, except when the colon is stretched, often during biopsy of the terminal ileum. For colonoscopy:

- Maintain anaesthesia with propofol 10 mg kg^{-1} h^{-1} IV infusion, or if using propofol TCI reduce the target concentration to 3 mcg $kg^{-1.}$
- Entering the terminal ileum is usually the most stimulating part of the procedure. Colonic distension is painful, and further boluses or analgesia may be necessary. Opioids affect colonic motility and should be avoided for colonic manometry.
- Propofol 8–9 mg kg^{-1} IV is commonly required for colonoscopy of 45 minutes duration.

Discharge Criteria after Sedation

After sedation, children should be recovered and monitored in a fully equipped recovery area until they have regained control of their airway and breathing reflexes, are haemodynamically stable and are easily roused. Written 'safety netting' advice with contact numbers is useful for families to take home. Before being discharged, children must meet the following criteria:

- Vital signs have returned to normal.
- They are awake or have returned to their baseline level of consciousness and are not at risk of further reduced level of consciousness (the ability to eat, socially interact, ambulate and pass urine are useful signs).
- Any nausea, vomiting, pain or other complications of the sedation or procedure have been adequately managed.

Key Points

- Sedation is one of many useful and effective tools to help children cope with medical procedures.
- Fasting protocols should be guided by the depth of sedation required, patient comorbidities and procedural requirements.
- Practitioners should be trained and ready to prevent or manage complications of potent sedative drugs.

Further Reading

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