Safe sedation of children for diagnostic and therapeutic procedures

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Abstract

There is an increasing use of sedation in children requiring imaging and other minor procedures. This article will discuss how sedation can be safely performed. The depth of sedation has been classified into minimal, moderate and deep according to the National Institute for Health and Care Excellence. Amongst others, benefits of sedation include increased parental and child satisfaction, increased cost benefits for the hospital and reduced adverse effects of general anaesthesia such as emergence delirium and postoperative nausea and vomiting. Safe sedation can be used for a wide range of procedures, most commonly for CT and MRI. Others include removing drains, changing burns dressings, simple plastic surgery procedures and endoscopy. Drugs can be used as sole agents or in combination to produce the desired level of sedation appropriate for the procedure. The children must be monitored according to the depth of sedation and personnel should be trained in the management of potential complications.

Keywords Complications; imaging; monitoring; paediatrics; premedication; procedures; sedation

Royal College of Anaesthetists CPD Matrix: 1A02, 2D06, 3D00, 3A07

Learning objectives

After reading this article, you should be able to:

- describe the different levels of sedation in children according to the NICE guidelines
- discuss the pharmacological properties of the commonly used drugs for sedation in children
- discuss the benefits and limitations of sedation in children
- contrast the levels of monitoring needed and explain the need for close monitoring during deep sedation

Definition of sedation

Sedation has been categorized by the American Society of Anaesthesiologists into minimal, moderate and deep sedation.[1] Minimal sedation implies a drug-induced state in which the patient will respond normally to verbal commands. The airway reflexes, ventilatory and cardiovascular functions are unaffected. Moderate sedation, with similar characteristics to conscious sedation, implies a drug-induced state in which the patient will respond purposefully to verbal commands alone or after light tactile stimulation (but not a reflex withdrawal from a painful stimulus). The airway remains patent. The ventilatory and cardiovascular functions remain largely unaffected. Deep sedation implies a drug-induced state in which the patient cannot be roused easily but will respond purposefully following repeated or painful stimulation. They may require airway support and spontaneous ventilation may be impaired, but usually no cardiovascular support is needed.

Light sedation is seldom used in the settings in which this article will describe as it requires child cooperation during the procedure. Those having an MRI for example, are either cooperative enough to lie still without sedation, or need moderate to deep sedation to achieve the images needed for diagnosis and therefore the majority of what will be discussed concerns these deeper levels of sedation. It is important to understand that the degree of sedation is realistically on a continuum and different children will respond differently to different drug doses.

As with all procedures, there are absolute and relative contraindications,[2] which depend on the severity of child's disease or issues. The level of expertise, support available during the procedure along with level of sedation required must be taken into account.

Drugs used

There are a number of different agents that have successfully been used for sedation in children. They can be used as sole agents or in combination to produce the desired level of sedation for that procedure. Combinations of agents can benefit from synergistic effects. However, caution must be observed when using polypharmacy to avoid undesired respiratory and cardiovascular effects, especially in the absence of anaesthetic support.

Propofol is a phenolic derivative non-barbiturate anaesthetic agent, which at lower doses can be used as a sedative drug. Although its exact mechanism of action is unknown, it is thought to potentiate inhibitory transmitters glycine and γ-aminobutyric acid (GABA).[3] An initial bolus dose can induce loss of consciousness in 30 seconds or less. Its short onset and offset time make it a popular choice for sedation. It can be difficult with some children to avoid going beyond deep sedation into general anaesthesia with subsequent loss of airway control.

Midazolam is a benzodiazepine (BDZ) whose structure depends on the surrounding pH. It is 89% un-ionized at physiological pH thus is very lipid soluble. It is thought to work by facilitating GABA receptors. Its elimination half-life is 1–4 hours and clearance of 6–10 ml/kg/minute which results in a relatively short duration of action compared to the other BDZs. Adequate sedation and anxiolysis can be achieved in 30 minutes after an IV or PO dose of up to 0.5 mg/kg and it is painless on injection. It can also be given PO, IM or intra-nasally. These characteristics make it a popular choice for sedation, especially

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for procedures where an anaesthetist is not required to be present. Compared to propofol though, top up doses mid procedure are rarely used due to the time taken to achieve the deeper level of sedation required.

Ketamine is a phencyclidine derivative and non-competitive antagonist of the N-methyl-D-aspartate receptor calcium channel. A PO dose of 5–10 mg/kg will give an adequate degree of sedation for some procedures after 30 minutes to 1 hour. Its analgesic effects make it useful for particularly painful procedures using a dose of 0.5–1 mg/kg. Although non-anaesthetists can safely use it, the child's depth of sedation must be carefully observed throughout its use as the dissociative form of general anaesthesia it produces can easily be mistaken by the untrained eye. The incidence of emergence phenomena, hallucinations and nightmares are reduced in children compared to adults.

Remifentanil is a synthetic phenylpiperidine derivative of fentanyl and pure μ-receptor agonist. Its pharmacokinetic actions make it unique from the other opioids. After administration, it has a rapid onset with peak effect from 1 to 3 minutes. It subsequently has a very short duration of action with an elimination half-life of 5 (range 3–10) minutes, clearance of 40 ml/minute/kg and a low volume of distribution of 0.3 litres/kg. The duration of action is determined by metabolism rather than distribution. These characteristics make it useful as a sedative agent but due to the very small margin of error between sedation and hypoventilation and subsequent hypercapnia, it must only be used by anaesthetists trained in its use. The other adverse effect of bradycardia can usually be reversed with a dose reduction or with glycopyrrolate at a dose of 0.1–0.4 μg/kg/minute.

Clonidine is an aniline derivative and an α-2 agonist acting at presynaptic adrenoceptors. Its sedating and analgesic effects are mediated by the α-2 adrenoceptors in the dorsal horn. The clear tasteless solution has a near 100% oral bioavailability making it a useful sedative drug for children. A dose of 4 μg/kg can be used but it must be given 1 hour prior to the procedure.

Dexmedatomidine, an imidazole derivative, is another α-2 agonist used for sedation.[4] It has a more unpredictable oral absorption rate. As an IV sedative, a bolus dose of 1–3 μg/kg and subsequent infusion of 0.5–2 μg/kg/hour can be used. It can be used in conjunction with other agents such as propofol or ketamine for invasive procedures.

Chloral hydrate, a synthetic sedative-hypnotic, is commonly used on paediatric intensive care units and on medical wards but not by anaesthetists as the sedation drug of choice due to its unpredictable onset and long duration of action. It can be used in doses up to 100 mg/kg. It has an unpleasant taste and can cause gastric irritation.

Nitrous oxide is a colourless inorganic gas which in a 50/50 combination with oxygen (trade name Entonox) is used as analgesic and aids in sedation for painful procedures (e.g. along with midazolam for burns dressing changes). Its exact mode of action is unknown but is thought to modulate enkephalins and endorphins in the CNS. It diffuses freely across the alveolar epithelium and uptake is increased by increased cardiac output, alveolar ventilation and concentration. Its rapid onset and offset along with relatively few side effects (15% nausea and vomiting) make it a useful adjunct to sedation in children.

NICE guidelines

NICE guidelines[5] written in 2010 and further updated in 2014 describe the management of sedation in children up to the age of 19 years. None of the drugs described have a marketing authorization for use in paediatric sedation and the burden of responsibility for their use lies on the responsible healthcare professional. Informed consent must be sought from the child and parents, where age appropriate and clearly communicated information is given. A pre-procedural assessment must be made of their medical health and suitability for sedation ascertained. Healthcare professionals should be suitably trained in drug pharmacology, in methods of administration, managing complications and recovery care. All involved must be trained in basic paediatric life support. For moderate sedation, at least one healthcare worker should be trained in intermediate paediatric life support and one in advanced paediatric life support during deep sedation procedures.

There is no need for the child to be fasted for minimal sedation and procedures involving nitrous oxide alone. For moderate and deep sedation, they should be fully fasted as per a general anaesthetic. Monitoring requirements depend on the level of sedation. Specific discharge criteria must be met. The guidelines give generic advice on drug choices but do not elaborate on routes of administration and dosing. Drugs used for common procedures are listed in Table 1.

Benefits of sedation

- Increased child and parent satisfaction
  - Reduced hospital admission time
  - Staggered admission process
  - Children can often remain in their normal clothes
- Increased cost benefits for the hospital
- No inpatient designated bed needed (e.g. for MRI)
  - Lists unaffected by bed allocation issues
- Avoidance of inhalational anaesthetic agents resulting in:
  - Reduced postoperative nausea and vomiting (PONV)
  - Reduced emergence delirium
- Less airway manipulation and associated complications
- To relieve anxiety and increase co-operation of an anxious child to undergo a procedure or investigation including undergoing an anaesthetic

Limitations of sedation

- Use limited to certain procedures
- Risk of over-sedation leading to airway compromise
- Unfamiliarity with its use in children
- Inability to meet requirements of certain procedures (e.g. breath hold during cardiac MRI)
- Movement artefact

Monitoring and positioning

Minimal requirements for continuous monitoring are given in Table 2. For deep sedation, the EtCO2 can be monitored by specifically designed nasal cannulae, which simultaneously deliver oxygen from a wall-mounted flowmeter. During an MRI, a mirror placed near the inner coil that surrounds the head can be

