The management of infants and children for painless imaging


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The ability of a child to remain sufficiently immobile for painless imaging depends upon their behaviour and the imaging itself. Anaesthesia allows imaging to be optimised but it is expensive, scarce and inappropriate for many situations. Fortunately, sedation and behavioural techniques are sufficiently successful for the majority of scanning, and success rates are high provided that suitable children are selected. Sedation, however, administered by non-anaesthetists, may have catastrophic complications such as airway obstruction. Current UK recommendations demand that any sedation technique has a ‘wide margin of safety’, but in addition to this, safety is dependent on trained, skilful and experienced staff. Magnetic resonance imaging frightens many children and special planning is necessary for sedation and anaesthesia. When planning an imaging service for children, all the management techniques should be considered in order to achieve maximum efficiency, quality and safety.

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Introduction

Children vary in their behaviour. Some will lie still or fall asleep naturally, yet many others are too irritable or frightened to cooperate. Fortunately, provided the procedure is painless, the majority of children will keep still without recourse to anaesthesia by using behavioural or sedation techniques (see Table 1 for definitions). In contrast, painful procedures are managed more effectively by anaesthetists who can use potent short acting drugs safely.1–3 We wish to emphasise this distinction and confine this review to painless imaging.

We begin with a brief overview of the ‘problems’ of painless imaging and the types of children who need them, and follow with a review of the possible management techniques. Finally we discuss some general and strategic issues.

‘Problems’ of painless imaging

Ultrasound and echocardiography

Virtually all children cooperate with most ultrasound examinations but sedation is sometimes needed. Irritable small children, who may be cyanotic or in heart failure, need sedation for echocardiography. Trans-oesophageal echocardiography is too uncomfortable and always requires anaesthesia.

Computed tomography (CT)

Helical CT scanners are fast, quiet, not frightening and allow easy access. In comparison with multislice scanners, success rates for scanning without any sedation or anaesthesia are now very high.
Usually, only children with behavioural problems or small ill children need special attention. Oral contrast, needed for some abdominal imaging, may be aspirated during sedation, but the risk is small and each case should be assessed carefully.4

Nuclear medicine imaging

A child-friendly approach and patient preparation is all that is required to succeed for approximately 95% of all nuclear imaging. A 12-month unpublished audit of our experience showed that of a total of 2700 procedures only 1% needed anaesthesia and 3.7% had sedation (7% unsuccessfully). Only a handful of 1880 renal isotope scans required any sedation because complete immobility is unnecessary. Bone scans, mainly for malignant disease, may need urethral catheters and out of 69, 32 needed sedation and 10 needed anaesthesia. Most brain scans are in children with severe epilepsy who may not cooperate, especially for post-ictal imaging; of 147, 51 were sedated and 8 anaesthetised. MIBG scans take 2 h and most children needed a drug induced sleep. Finally 80% of 140 children were persuaded to breathe from a plastic facemask for a lung scan without sedation.

Positron emission tomography (PET)

PET is an emerging functional imaging technique in paediatrics. Malignant disease can be detected using the isotope fluorodeoxyglucose (FDG) that is absorbed into metabolically active cells.5 8 To prevent FDG being absorbed by muscle cells, and thereby giving inaccurate images the patient must be still for around one hour after the injection. The scan itself lasts for up to an hour and the child must be very still for this time especially for PET/CT scanning. Fasting is also important as blood glucose competitively inhibits FDG uptake and any sedation drugs containing sugar should be avoided. The isotope is absorbed onto plastic central venous catheters and therefore should be given peripherally.

Magnetic resonance imaging (MRI)

Of all painless imaging, MRI is the most troublesome.9 It takes 20-60 min of immobility in a noisy tunnel and most children under 8 years of age will not lie still for long enough, if at all, without special care or preparation. Furthermore, special equipment (especially monitoring) and planning is necessary to delivery a safe and efficient service.10

Special equipment

In the UK, there are minimum monitoring standards and a comprehensive equipment list has been published by the Association of Anaesthetists specifically for MRI.10 Ideally both induction and recovery of anaesthesia and sedation should take place outside the scanner where there are no restrictions. Resuscitation equipment should not be taken into the scanner—the patient should be taken out to the equipment. A small child is easy to carry but otherwise a special aluminium trolley is necessary. Equipment used within the magnetic field must be MR compatible and made safe by adequate fixation. Safe and compatible anaesthetic machines are available. Sophisticated and compatible ventilators, capable of delivering high frequencies or end expiratory pressures are currently not available.11 Safe syringe drivers are also not available and must be tested for radio-frequency interference. The view of a child within the scanner is restricted and it is therefore reasonable for staff to remain in the control room. There are two possible monitoring systems.

Table 1

A summary of the definitions used and described in more detail in the text.

| Sleep: a quiet and immobile state, induced without drugs or occurring spontaneously, from which the individual can be roused. |
| Sedation: a “sleep-like” state induced by drugs, from which the individual may be roused. |
| Conscious sedation: can be roused by gentle stimulation |
| Unconscious sedation: difficult to rouse even with vigorous stimulation. Appreciable depression of vital reflexes must be expected. |
| Anaesthesia: an unrousable “sleep-like” state induced by drugs. Appreciable depression of vital reflexes is commonplace. |
| Conventional anaesthesia: intervention is often necessary to support the airway, breathing and circulation. |
| Minimal anaesthesia: “Anaesthetic” doses are used to induce an unrousable sleep lasting a few minutes. Thereafter the doses used are so low or “sub-anaesthetic” that although the individual remains asleep |
| — they may be rousable |
| — appreciable effects upon vital reflexes are unlikely, and |
| — recovery is rapid |

Mechanical connections

Both conventional blood pressure (invasive and non-invasive) and gas analysis monitors are not MR
compatible but can be sited in the control room and connected to the patient via long, non-conducting, plastic cables passed through a hole in the copper screen. A long fiberoptic cable also connects the patient, via the same route, to a pulse oximeter monitor in the control room. A filtered ECG should already be available. This solution is not suitable for small infants or sick patients because the blood pressure signals may be damped—indeed non-invasive pressure recording may not be possible.

Telemetry
Electrical signals from a compatible 'main' monitor in the scanning room can be transferred to a 'slave' monitor in the control room using ultra-high frequencies. This system is more sensitive and convenient, particularly for blood pressure monitoring, but is expensive.

Planning
Because onset of sedation is variable, it is best delivered near to the scanner to prevent delays. We have found that parents and children need a reception area where they can wait, a room for the administration of sedation (this can also be used as an interview room), a quiet room with dimmed lighting to allow the onset of sleep and finally an area for recovery. These areas could serve several scanners.

Patient management techniques
- Behavioural techniques
- Natural sleep
- Sedation
- Anaesthesia

Behavioural techniques
Behavioural techniques are effective, inherently safe and require modest facilities.

Reassurance, communication and environment
People who are "good with children" have the ability to gain trust through confidence, kindness and communication and much can be done in a short time by experienced radiographers and nurses to persuade children to lie still. Decoration, lighting, temperature and noise level can also allay anxiety, and waiting rooms need to be comfortable for parents and have sufficient distractions to help to pass the time. Prior to scanning, children and parents should be prepared for the practicalities of the procedure, and informative booklets, pictures, videos or visits to the radiology department may be helpful. An internet website could allow a virtual visit with instructions and answers readily available to common questions.

Play specialists
Rehearsing scans through play can help children to gain confidence12 and play specialists are especially useful in anxious children who do not respond to routine reassurance.13 Success may require hours of preparation but is a worthwhile time investment particularly if further imaging or treatment is planned.

Play specialists must be knowledgeable about the demands of the scan, and may need to accompany the child through the procedure. Success rates vary according to skills and circumstances; at an MR imaging unit in Bristol out of 169 children over the age of 4 years referred to the Play department only 1 needed sedation.14 This impressive record was due to skilful specialists who gained trust by using toy models and tape recordings to show the children what to expect. Play specialists are less likely to be effective for urgent situations.

Natural sleep

'Feed and wrap'
Natural sleep in infants can be induced by food, comfort and warmth15,16 and, in our experience, depending upon the length of the scan, approximately 75% of infants aged under 3 months can be scanned successfully for 45 min. Movement artefact is often a nuisance during noisy MR imaging sequences. Success is less likely in ex-preterm infants who are often too irritable; incidental apnoea or bradycardia or convulsions can occur and all infants should be monitored, at least with pulse oximetry. If sleep fails, anaesthesia or sedation must wait for 6 h because of the risk of pulmonary aspiration.17

Sleep deprivation
Tiredness may be a crucial factor in the efficacy of any sedation regimen16,18 although a recent report found no evidence to support this.19 Sleep deprivation can be impractical for parents and occasionally children become too irritable.

Melatonin
Natural sleep agents could be ideal, however, some patients have sleep apnoea and even natural agents have side effects. Melatonin is promising because it is absorbed by mouth and has been used with limited success to make children sleep for
imaging\textsuperscript{20,21} and for EEG\textsuperscript{22} and to treat abnormal sleep itself.\textsuperscript{23} Nevertheless, the dose response is unclear and any interaction with sedatives is unknown. Melatonin has been reported to provoke convulsions in epileptics\textsuperscript{24} although in another study it was found to be beneficial.\textsuperscript{25} An intravenous derivative has been tested in volunteers but it causes significant hypotension.\textsuperscript{26} Natural sleep agents could revolutionise paediatric imaging, but until enough data are available they should be regarded as drugs.

**Sedation**

**Hazardous practice—related to judgement and skills**

Sedation that is 'too deep' causes airway obstruction and, if unrecognised or untreated, it leads to death or cerebral damage. Anaesthetists are specifically trained to control conscious level, while maintaining vital functions and have a culture of safety and of working to defined standards. In contrast, non-anaesthetist 'sedationists' have limited training and expertise and, in the UK at present, there are no qualifications for sedation practice. Ideally, anaesthetists should manage all sedation, but this is unattainable because the availability of paediatric anaesthetists can never be sufficient to meet the very large demand. Non-anaesthetists therefore must use sedation—but safely. The risk of death related to sedation of children for painless imaging is unknown but is considered to be very low.

**Definition**

Sedation is a decrease in conscious level, usually combined with anxiolysis and amnesia. As conscious level progressively falls, there is a reduction of muscle tone of the oropharynx and the tongue occludes the airway. At deeper levels, the glottic reflexes may fail allowing potential obstruction due to secretions or gastric contents. All hypnotic agents, used in both anaesthesia and sedation, cause these events to a variable extent. Opiates are famous for causing respiratory depression but this is almost always associated with a reduction in conscious level. Cardiovascular reflexes may also eventually fail manifesting as bradycardia and hypotension (this is a particular hazard with severe heart disease).

Knowing that airway obstruction is linked to conscious level has helped the Royal Colleges of Radiologists and Anaesthetists\textsuperscript{1} to define safe sedation as "a technique...during which verbal contact with the patient is maintained". This was termed conscious sedation, and sedation deeper than this is considered to have the potential to be too deep and should be managed by anaesthetists. In the UK, this principle has been recommended by all medical, surgical and dental specialties.

In the USA the concept of "deep sedation" was accepted as a state deeper than conscious sedation but not anaesthesia.\textsuperscript{27} It was "...a state of depressed consciousness from which the patient is not easily roused. It may be accompanied by a partial or complete loss of protective reflexes and includes the inability to maintain a patent airway independently and respond purposefully to physical stimuli". In 2001\textsuperscript{28} American hospital insurance organisations recommended that deep sedation should be managed with the same standards of care as for anaesthesia and with this development, at least in practical terms, the UK and US recommendations for safe practice have become similar.

Conscious sedation in uncooperative children is not possible. Sedation does not gain assent unless it is by the reduction of distress—it does not change a 'no' to a 'yes'.\textsuperscript{29,30} If a child responds to verbal contact, sedation is usually too light, and it may be reasonable to use gentle physical stimulation instead. Nevertheless sedation for imaging is designed to cause immobility through sleep and any stimulus that causes arousal will be counter-productive. The Royal College of Radiologists has acknowledged "a deeper level of sedation (than conscious sedation) is generally necessary such that the child remains asleep during the entire procedure and in these circumstances the child is not expected to be able to respond to verbal stimuli".\textsuperscript{1} Nevertheless it should be possible to rouse the child from sleep at the end of scanning.

A more useful safety principle is that "techniques should have a safety margin wide enough" and means that a safe dose should be much smaller than a dangerous dose.\textsuperscript{1} It was originally applied to make 'the loss of consciousness unlikely' but we have suggested that it should make 'the loss of airway and breathing reflexes unlikely'.\textsuperscript{16}

**Assessment of conscious level**

Once a child is asleep and comfortable they will often lie still unless they are disturbed and it would be useful to know whether they could be roused or whether they could become too deep. Several observational scoring systems have been developed but they describe the response to a stimulus and are only useful before and after scanning.\textsuperscript{32,33} Monitors of conscious level, based upon the processed EEG in adults and used to prevent awareness during anaesthesia, could be useful during sedation\textsuperscript{34,35}. 
but they are difficult to apply in uncooperative children and cannot be used in an MR scanner. It is important to accept that conscious level can change quickly and that continuous monitoring of breathing and airway patency must take priority over any other observation.

Recovery or discharge readiness is important because long acting sedation drugs can cause re-sedation; it has been proposed that children should be able to stay awake for at least 20 min if left undisturbed.36

**Drugs suitable for sedation**
The ideal drug, which does not exist, should cause predictable depression of conscious level, be free of cardio-respiratory depression and allow rapid awakening. Anaesthetic drugs are more predictable but can cause accidental airway obstruction and do not have a safety margin wide enough for use by non-anaesthetists.1,2,37 Conversely, sedation drugs are safer provided that doses are limited yet as a consequence a failure rate has to be accepted that varies from 5% to 15%.16,38,39 Also, sedation drugs are slower, less predictable in onset and offset, and are occasionally unsuccessful because of paradoxical excitement due perhaps to dizziness, anxiety or hallucinations.

A drug can only be considered safe after experience in thousands of cases and few drugs have been studied to this extent. The main sedation drugs and techniques are outlined below and reviewed in more detail elsewhere.3,40–42

**Guidelines/recommendations**
Guidelines for children have been published by the Scottish Intercollegiate Guidelines Network (SIGN).2 This publication is helpful but, although it has been accepted by the Association of Paediatric Anaesthetists it has not, at the time of writing, been endorsed by the Royal College of Paediatrics and Child Health because it does not meet their standard of evidence base. In fairness, the guideline is largely a document of opinion, but is essential reading for those who wish to develop a sedation service in the UK.

In 2001, the Academy of Medical Colleges responded to reports of unacceptable mortality in adult patients having sedation for endoscopic procedures and made recommendations which, by 2002 were endorsed by the Royal College of Radiologists.43 In our view 3 principles are most important and are equally appropriate for paediatric patients:

- Safe sedation techniques should be defined for each specialty
- Organisations should ensure that staff receive sedation training
- Hospitals should appoint 2 lead consultants (an anaesthetist and non-anaesthetist) to lead and support sedation services.

**Protocols**
Sedation that achieves 100% success will almost certainly cause occasional airway obstruction and therefore, with safety in mind, a small failure has to be accepted. Principles of safety include patient assessment to enforce contraindications, not exceeding maximum drug doses, good facilities and equipment, and rules for fasting and recovery. Principles of success include having the sedation area next to the scanner, minimal imaging, effective drugs, and experienced skilled staff who can deselect children resistant to sedation. We believe that having staff with sufficient judgment and seniority is more important than any other factor in avoiding sedation complications.16,44 The common groups of children in whom sedation is often contraindicated is presented in Table 2 and they need to be managed by anaesthetists.

Sedation drugs can have a delayed effect and, being long acting, can lead to excessive sleepiness after scanning.45 Children should stay for at least 2 h after scanning until they can respond appropriately and be able to drink or feed; a few children will need to stay overnight until their conscious level has returned to baseline. Sedation disasters’ have been reported when this level of basic care has been ignored.46

**Sedation techniques**
*Chloral hydrate or triclofos.* Small oral doses calm small children and are suitable for echocardiography or CT scanning.47 Larger doses of chloral 50–100 mg kg−1 can cause sleep lasting 30–60 min in 95% of children between 5 and 15 kg.16,48–52 It may be less predictable in small infants.53 It has an unpleasant taste and is a gastric irritant but vomiting is probably related to the volume, making it less valuable for use in larger children—triclofos is better tolerated but has a slower onset. Several large series demonstrate that there are hazards of unpredictable and prolonged sedation.48,49,54–59 From our own audit, sleep onset is between 20–40 min and 80% children are awake by 90 min. Oral chloral and triclofos contain glucose to make them palatable and are therefore unsuitable when using FDG for PET scanning.

*Benzodiazepines.* Midazolam is short acting and when administered by mouth, via the nose or per
rectum, will calm children within a few minutes. This may be enough for echocardiography or CT scanning, but to induce sleep benzodiazepines alone have a poor success rate. Sedation can be reversed with flumazenil but because of its short action, re-sedation can occur. Temazepam combined with droperidol has a 70% success rate in children between 15 and 25 kg and the success rate can be increased to 95% with intravenous diazepam. Children with severe epilepsy or major behavioural problems can be ‘resistant’.

**Opiates.** In combination with other sedatives, intramuscular opiates such as morphine and pethidine cause 40 min of sleep successfully in 80% for MRI. We have used this technique for nuclear medicine scans that last over 60 min. Pethidine Compound, containing pethidine, chlorpromazine and promethazine, is a powerful and effective combination; occasionally it causes apnoea. Respiratory depression can be reversed with naloxone, which has a short action but can be repeated as necessary.

**Barbiturates.** Pentobarbital, which is not available in the UK, is regarded as a safe intravenous sedative in North America however 1-3% of children have airway obstruction or paradoxical excitement reactions. Oral pentobarbitone is slightly safer and more effective than chloral but more "rage reactions” occur during recovery. Quinalbarbitone, given orally, makes 90% of children (<5 years) sleep but older children have more paradoxical reactions.

**Melatonin.** Sleep may be induced successfully in 55% of children for MRI but the correct dose is uncertain. Recently we have started to use melatonin for PET/CT scanning and found that children become drowsy by 20 min and, with either chloral suppositories or oral temazepam, fall asleep by 30 min, and remain asleep for 2 h. So far in 10 children, we have succeeded in 9, 3 of whom needed to void their bladders just before imaging and fell asleep again afterwards.

**Dexmedetomidine.** This sedative has recently been shown to cause a light, rousable sleep that may have a wide safety margin; it acts by adrenergic depression and hypotension is possible.

**Anaesthesia**

**Definition**

Anaesthesia is an unrousable state associated with loss of airway reflexes and respiratory depression.

**Mortality risk**

The causes of death or brain damage due to anaesthesia may be divided into the unavoidable and avoidable. Unavoidable causes include malignant hyperthermia and anaphylaxis, or life threatening organ failure. Avoidable causes range from error, equipment or technical problems, to clinical misjudgement or incompetence. Deaths after surgery have been assessed by the Confidential Report into Patient Outcome and Death (CEPOD) and it has been estimated that the mortality rate from anaesthesia factors alone is approximately 10 per million and this risk is possibly higher in children. CEPOD has recommended that anaesthesia is safer in well equipped hospitals, with experienced staff working in routine hours.

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**Table 2** Common contraindications to sedation

<table>
<thead>
<tr>
<th>1. Airway problems</th>
<th>*any actual or potential airway obstruction e.g. snoring or stridor, blocked nose, small mandible, large tongue</th>
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<tbody>
<tr>
<td>2. Apnoic spells</td>
<td>*related to brain damage or previous drug treatment</td>
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<tr>
<td>3. Respiratory disease</td>
<td>*SpO₂ less than 94% in air *respiratory failure (high respiratory rate, oxygen treatment) inability to cough or cry</td>
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<tr>
<td>4. High intracranial pressure</td>
<td>*drowsiness *headache *vomiting</td>
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<td>5. Epilepsy</td>
<td>*generalised convulsions requiring rectal diazepam within the last 24 h OR rectal diazepam used more frequently than once in two weeks</td>
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<td></td>
<td>*previous adverse reaction to sedation—i.e. exacerbation of seizures.</td>
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<td></td>
<td>*children requiring resuscitation during a convulsion within the last month.</td>
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<td></td>
<td>*children who not only have convulsions but also have other major neurological or neuromuscular disease: such as apnoic spells or hypotonia as part of global neurological disease; intracranial hypertension due to cerebral tumour or encephalitis.</td>
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<td></td>
<td>*generalised convulsions with cyanosis more frequent than once per day</td>
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<td></td>
<td>*children who have had a convulsion less than 4 h before sedation</td>
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<td></td>
<td>*failure to regain full consciousness and mobility after a recent convulsion</td>
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<tr>
<td>6. Risk of pulmonary aspiration of gastric contents</td>
<td>*abdominal distension *appreciable volumes draining from NG tube</td>
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<td></td>
<td>*vomiting</td>
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<tr>
<td>7. Severe metabolic, liver or renal disease</td>
<td>*requiring IV fluids or dextrose *jaundice or abdominal distension</td>
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<td></td>
<td>*requiring peritoneal or haemodialysis</td>
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Anaesthesia techniques
For painless imaging, anaesthesia can be divided into two common techniques depending upon the need to provide airway or breathing support.

Minimal anaesthesia—no airway or breathing support
Commonly, after a sleep dose of an anaesthetic agent, a sub-anaesthetic maintenance dose will ensure that sleep continues until the child is stimulated. This principle allows the use of ‘minimal’ anaesthetic techniques that have been described by some as deep sedation rather than anaesthesia. Minimal techniques require administration of oxygen, and recovery is rapid but, as with sedation, a few will rouse during scanning and more formal anaesthesia may then be necessary. The majority of uncooperative children can be managed effectively by the use of either propofol or sevoflurane—ketamine is an alternative but is a poor quality experience by comparison.

Propofol. Propofol is the best of all the intravenous sleep drugs because recovery takes just a few minutes and is almost always pleasant. After the induction dose, which can be painful, it should be administered by infusion. Brief apnoea and desaturation are common at induction and therefore propofol is not recommended for non-anaesthetists. Occasionally there are odd, unexplained, purposeless movements that are not overcome by increasing the dose. Thiopentone is an effective alternative but recovery is not so rapid because it is metabolised slowly and infusions cause accumulation.

Inhalational agents. The inhalation of an anaesthetic vapour such as sevoflurane is possible in infants and small children without the need for airway support. Once asleep anaesthetic vapour carried in oxygen can be administered, by a facemask or by nasal cannulae, and low concentrations are enough to maintain sleep provided the child is not stimulated.

Ketamine. This drug causes a trance-like state in which cardio-respiratory function is maintained. Unfortunately airway secretions may cause swallowing movements, laryngospasm and apnoea. In a series of 1022 children in an emergency department setting, 4 had laryngospasm and 2 had apnoea. Nausea and vomiting can occur in 15-33% and distressing hallucinations in 3% even when combined with midazolam. For needle phobic children, an oral or rectal dose causes variable sedation after 10-20 min and recovery can be prolonged. A small intravenous dose causes approximately 10-20 min of immobility and may be useful for brief scans.

Formal anaesthesia—airway and breathing support
Children with a multitude of medical and surgical conditions cannot reliably maintain their airway when sedated and usually require either an oropharyngeal airway or a laryngeal mask airway (LMA) to enable unobstructed breathing. The LMA is inserted via the mouth and is a tube with spoon shaped cuff that surrounds the laryngeal inlet. Both these devices require sufficient anaesthesia to prevent coughing, gagging or laryngospasm and neither will protect against aspiration. Tracheal intubation is necessary whenever there is the potential for aspiration or when respiratory reserve is poor or when there is cardiovascular instability. Mechanical ventilation may be delivered through an LMA though a tracheal tube is more commonly used.

In comparison with minimal anaesthesia, the insertion of an artificial airway requires higher doses that may prolong induction and recovery, and the side effects such as sore throat and laryngospasm are likely to be more common. Nevertheless, conventional anaesthesia is extremely safe and virtually guarantees optimum imaging. Whatever the anaesthetic technique, children should remain in hospital for at least 2 h after scanning.

During recovery, some children have a short period of delirium for which the cause is unknown. The incidence varies but seems to be highest after sevoflurane; it has also been described after sedation techniques.

General and strategic issues

Multidisciplinary team
A successful service needs radiographers, nurses, play therapists, radiologists and anaesthetists. Each team member has discrete responsibilities such as safety or patient care but ideally someone should take a lead role in the prioritisation and planning of the workload and this could be the radiographer with help from the radiologist.

Responsibility and consent
For surgery, a surgeon takes consent and bears responsibility for advising a patient to undergo a procedure that has benefit and risk. For imaging however, both the referring clinician and radiologist understand the benefit of the scan but believe that it is almost risk-free, and they may be unaware of the
hazards the sedation or anaesthesia techniques. Likewise, the sedationist or anaesthetist understands the risks but will not be sure of the benefits. We prefer that the referring clinician should obtain prior written consent and that the sedationist or anaesthetist should explain the recommended technique subsequently. In the unlikely event that the clinician has not appreciated that the risks out-weigh the benefits, timely communication and reassessment is required. Whatever the practice, it is important that parents and children are fully informed of the intended procedures and that someone takes responsibility.

The management of uncooperative children should take into account their individual needs and fears, within the context of the illness, and in partnership with the parents or guardians. Ideally, the wishes of the child should be respected and, if a competent child is resistant to the persuasive powers of parents and professionals, the investigation must be delayed and reassessed.

**Patient assessment and selection**

Children vary from premature neonates weighing less than 1 kg to 100 kg teenagers and there is huge diversity in physiology, pathology and psychology. Sufficient time is needed to allow individual assessment, discussion and consent issues and any special preparation such as play therapy. Serial imaging may be necessary over weeks or years so it is important to try to optimise the child’s first experience and to be aware of previous experiences. Some children are resistant to sedation and should be anaesthetised instead. Contraindications to sedation are usually predictable (Table 2), yet there may be illnesses such as an upper respiratory tract infection or gastroenteritis that will cause delay until the child has recovered. For MRI, clinicians may not appreciate the hazards of metallic implants and radiographers must use a checking protocol to prevent accidents.

**Choosing a technique**

Local resources should guide the scanning team to choose strategies that maximise the use of the scanner. This in turn will influence the choice of technique for the individual child. In many hospitals, anaesthetists can meet the demand for sedation or anaesthesia but in large centres, the demand is too great and there are sufficient skilled non-anaesthetists available. Fig. 1 is an example of a strategy summarising the characteristics of the techniques.

**Intensive care**

Transporting an intubated child from an intensive care environment is potentially hazardous; transport ventilators are not sophisticated and there is potential for the displacement of endotracheal tubes and interruption of vaso-active infusions. Unstable patients are particularly at risk and more so for MRI where equipment attached to the patient will need changing. The risk can be justified if the image, such as a head CT scan, is considered essential for decisions about emergency therapy. Non-essential scans should wait until the child is stable. Intensivists may not be familiar with MRI and consequently anaesthetists are usually required to supervise scanning and advise on the magnitude of risk.

**Personnel for anaesthesia and sedation**

In the UK, only specialist doctors can deliver anaesthesia. Currently, this is being challenged and pilot training schemes are underway to develop non-medically qualified anaesthetists who will be supervised within a team. Such a system is already established in other countries but is controversial in the UK because of concerns over safety. Anaesthesia in children is more technically demanding than in adults especially during surgery. During painless imaging however, once anaesthesia has been established, it may be reasonable for suitably trained (and qualified) nurses to monitor the patients and make basic interventions; anaesthetists would still need to be immediately available to...
provide prompt help if necessary. A qualified anaesthesia assistant is also mandatory in the UK.

For sedation, someone with appropriate training must give undivided care to the child and record observations. The necessary level of ‘training’ has not been widely agreed or established. Assistance should be available. Radiographers could be trained to help in resuscitation but further nursing and medical staff must be nearby; sedation out of routine service hours is not advisable for this reason. In some hospitals sedation is delivered by medical staff but where there are experienced nurses, a nurse-led service is possible\(^\text{16,37,96-98}\) and is preferable to inexperienced doctors.

Successful efficient imaging of children needs a cohesive multi-disciplinary team. Skills and knowledge may be taught within a few weeks, but judgement is learnt through much longer experience. Leaders in the team must be able to understand the ‘patient journey’ and to appreciate the relative importance of a scan.

**Training non-anaesthetists for sedation**

Currently, training is the “missing factor” in sedation. Two recent reports, from the Academy of Medical Royal Colleges\(^9\) and the latest NCEPOD,\(^10\) emphasise the need but have not defined the ‘what’ or ‘how’. This is a difficult step because ideally any training scheme should be standardised after widespread agreement. In our own sedation unit we train experienced nurses who have a background of anaesthesia, intensive care or accident and emergency. They undergo tutorial style teaching training in resuscitation and then practice airway and intravenous skills in theatre on anaesthetised children. These skills are revalidated every 3 months, and safety is increased further because sedation is delivered by a team. Simulation is a training tool that could be developed.

Training non-anaesthetists to use sedation drugs safely is crucial to effective imaging and we believe that both certification and revalidation should be established.

**References**

27. American Society of Anesthesiologists Task Force on Sedation.


