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Sedation/anaesthesia in paediatric radiology

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Objectives: In this article we will give a comprehensive literature review on sedation/general anaesthesia (S/GA) and discuss the international variations in practice and options available for S/GA for imaging children.
Methods: The key articles were obtained primarily from PubMed, MEDLINE, ERIC, NHS Evidence and The Cochrane Library.
Results: Recently, paediatric radiology has seen a surge of diagnostic and therapeutic procedures, some of which require children to be still and compliant for up to 1 h. It is difficult and sometimes even impossible to obtain quick and high-quality images without employing sedating techniques in certain children. As with any medical procedure, S/GA in radiological practice is not without risks and can have potentially disastrous consequences if mismanaged. In order to reduce any complications and practice safety in radiological units, it is imperative to carry out pre-sedation assessments of children, obtain parental/guardian consent, monitor them closely before, during and after the procedure and have adequate equipment, a safe environment and a well-trained personnel.
Conclusion: Although the S/GA techniques, sedative drugs and personnel involved vary from country to country, the ultimate goal of S/GA in radiology remains the same; namely, to provide safety and comfort for the patients.
Advances in knowledge: Imaging children under general anaesthesia is becoming routine and preferred by operators because it ensures patient conformity and provides a more controlled environment.

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The main goals of paediatric sedation/general anaesthesia (S/GA) vary according to the specific imaging procedure, but generally encompass anxiety relief, pain control and control of excessive movement [1].

The American Academy of Pediatrics (AAP) defines the goals of sedation in the paediatric patient for diagnostic and therapeutic procedures as follows: to guard the patient's safety and welfare; to minimise physical discomfort and pain; to control anxiety, minimise psychological trauma and maximise the potential for amnesia; to control behaviour and/or movement to allow for the safe completion of the procedure; and to return the patient to a state in which safe discharge from medical supervision, as determined by recognised criteria, is possible [2].

The target level or depth of sedation will vary according to the imaging procedure (and modality), as well as the individual patient characteristics. For CT scanning, for instance, modern multislice scanners allow for rapid image acquisition; therefore, moderate sedation can be employed. However, some children need to be asleep in order to tolerate complex or prolonged investigations such as MRI and nuclear medicine imaging, which may involve the child keeping still for up to 1 h. MRI can be particularly frightening because it is noisy and involves lying still in an enclosed space [3]. Image acquisition after the administration of the radioactive tracer becomes essential in nuclear medicine techniques in order to avoid unnecessary repeat studies and the additional radiation burden. Careful planning of S/GA is particularly important for these modalities.

The rate of failure of adequate image acquisition has been reported by various investigators to be as rare as 1–3% [4], and by others to be as frequent as 10–20% [5, 6]. In one large prospective study of children who underwent sedation (n=922) or were given general anaesthesia (n=140) for an MRI or CT scan [7], the sedation was inadequate in 16% of children and failed in 7% of cases. However, the procedures were successful in all of the children who were imaged under general anaesthesia. Excessive motion was noted in 12% of scans of sedated children and in only 0.7% of those completed under general anaesthesia. Malviya et al [7] also reported a clear improvement in the quality of MRI scans performed using general anaesthesia compared with those using moderate sedation.

Rates of failure can be decreased dramatically when sedation is provided by a dedicated team, by implementing clear protocols [8] and when experienced anaesthesiologists themselves provide the S/GA [9].

Furthermore, when movement is excessive, procedures are often rescheduled until an expert sedation service provider is available. Obviously, this leads to significant increases in the cost of the procedure as well as patient stress. It is better to assess the patients prior to the procedure, decide if S/GA might be required

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and employ the appropriate technique the first time around.

General anaesthesia is often the best choice for children who are neurologically impaired, have global developmental delay or exhibit severe disturbances of behaviour, and also in cases where the procedure is likely to be prolonged [7].

Sedation has been the method of choice for image acquisition for many years, and is routinely provided by radiological staff within the imaging department. However, owing to identified risks and overall increased cost, there is a trend towards routinely using a dedicated anaesthetics team to provide this service in paediatric cases. Because this involves a change in established service provision in most imaging departments, the funding for the anaesthetic service is often debated. Provision must be made to divert some of the funding stream for a specific imaging procedure which involves S/GA to the anaesthetics department, which sometimes involves renegotiating imaging tariffs. Also, in busy departments where lists are booked to capacity, allocating sufficient time to image children and conforming to the allocated timeslot is the key to running an efficient department.

Another issue to address is the capacity and availability of anaesthetists (and their support staff, such as the operating department practitioners) who are trained in paediatric S/GA. Scheduling difficulty often arises if these personnel are required for short specified and sometimes unpredictable periods to fit around the imaging department's and patient's needs.

History

Owing to the expansion of procedural sedation outside operating rooms, which is often performed by a variety of specialists, the medical community has produced various sedation policies, procedures and guidelines. Although specialty societies may not agree on all aspects of sedation, they all are unified by their primary interest in providing safe care.

The first monitoring guideline for sedation was written as recently as 1983 (published in 1985) by Dr Charles Coté and Dr Theodore Striker, while working on behalf of the AAP Section on Anaesthesiology and Pain Medicine [10]. This guideline was written in response to reports of three deaths in a single dental office and other incidents primarily involving dental sedation [1]. The aim of the guideline was to establish uniform standards for sedation throughout all paediatric subspecialties. In 1992, the AAP Committee on Drugs revised the 1985 guideline [11]. This new iteration stated clearly that a patient could progress readily from one level of sedation to another and that the practitioner should be prepared to increase vigilance and monitoring as indicated. Pulse oximetry was recommended for all patients undergoing sedation [1]. The guidelines underwent subsequent revision by the AAP in 1998, 2002 and 2006. They have been adopted by many other scientific associations, including the American Dental Association, the American Academy of Pediatric Dentistry, the American College of Emergency Physicians, the American College of Radiologists and the Society of Nuclear Medicine [11].

Despite the existence of numerous studies on sedation, there is a lack of consistency in the terminology used, including the definition of adverse effects, use of a variety of techniques and representativeness across different specialties and countries. Standardisation of recommendations is required to safeguard against confusion and untoward events.

The first attempt to standardise the terminology in sedation provision was in 2008, when the Consensus Panel on Sedation Research of Paediatric Emergency Research Canada and the Paediatric Emergency Care Applied Research Network issued so-called ''Quebec Guidelines'', a set of definitions which could be adopted by all sedation providers [12].

In 2010, the World Society of Intravenous Anaesthesia established the International Sedation Task Force (ISTF), which comprises a group of internationally recognised sedation experts from different specialties. The members of this task force include sedation experts for both adults and children (in the areas of dental, hospital, emergency, gastroenterology and intensive care medicine, as well as anaesthesiology). The task force, led by chairman Keira Mason, MD, and co-chairman Steve Green, MD, aimed to establish globally accepted definitions of adverse events which were objective, reproducible and applicable to all settings worldwide, and which focused on events of clinical significance [13]. Furthermore, ISTF has completed a standardised sedation outcome reporting tool, and aims to establish an international consensus and produce a sedation monitoring record which could be used for all specialties around the globe to record patient history and documentation during sedation and recovery in a standardised format [13].

Definition of sedation

Sedation is defined as ''a technique in which the use of a drug or drugs produces a state of depression of the central nervous system enabling treatment to be carried out, but during which verbal contact with the patient is maintained throughout the period of sedation'' [14].

Several levels of sedation exist. The definitions of minimal, moderate, conscious and deep sedation used in this guideline are based on those of the American Society of Anesthesiologists (ASA).

- Minimal sedation: a drug-induced state during which patients are awake and calm, and respond normally to verbal commands. Although cognitive function and coordination may be impaired, ventilatory and cardiovascular functions are unaffected.
- Moderate sedation: drug-induced depression of consciousness during which patients are sleepy but respond purposefully to verbal commands (known as conscious sedation in dentistry) or light tactile stimulation (reflex withdrawal from a painful stimulus is not a purposeful response). No interventions are required to maintain a patent airway. Spontaneous ventilation is adequate. Cardiovascular function is usually maintained. Some healthcare practitioners regard conscious and moderate sedation as synonymous.

- Conscious sedation: drug-induced depression of consciousness, similar to moderate sedation, except that verbal contact is always maintained with the patient. The term is commonly used in dentistry.
- Deep sedation: drug-induced depression of consciousness during which patients are asleep and cannot easily be roused but do respond purposefully to repeated or painful stimulation. The ability to maintain ventilatory function independently may be impaired. Patients may require assistance to maintain a patent airway. Spontaneous ventilation may be inadequate. Cardiovascular function is usually maintained [3].

The word ''sedation'' carries a deceptive meaning [15] because it conveys the perception of a safe and pleasant state, even though sedation, particularly deep sedation (monitored anaesthesia care), can have potentially disastrous outcomes for patients as well for practitioners. Therefore, deep sedation requires the same level of competency and care as general anaesthesia.

The transition from moderate sedation to general anaesthesia progresses through a continuum; hence, without pre-defined steps, one can pass from the maintenance of protective reflexes and the ability to maintain a patent airway to the inability to breathe spontaneously [11].

Risks of sedation and general anaesthesia

S/GA itself poses risks to children undergoing radiological investigations owing to drug-induced depression of consciousness with a potential loss of protective reflexes. The most prevalent complication of S/GA is drug-induced cardiorespiratory depression, which includes upper-airway obstruction, hypoventilation, hypoxia and hypotension. Other adverse effects of S/GA which can occur in practice include post-sedation nausea, vomiting, disorientation, sleep disturbance and nightmares, but their incidence is much lower. Also, the use of three or more sedative drugs significantly increases the rate of adverse outcomes. The uncontrolled nature of sedation sometimes makes it difficult to continue with the procedures in uncooperative, agitated and unmanageable children, and elective or urgent procedures must be abandoned in favour of general anaesthesia. Table 1 summarises the principal problems associated with under- and oversedation.

Sedation providers

As would be expected, complications are more common in inexperienced hands and where there is a lack of attention to detail. There is a growing breed of paediatric anaesthesiologists to provide this specialist service. However, S/GA for radiological investigations worldwide is delivered by different specialists. Some examples are given below.

In the United Kingdom (UK), oral sedation requires the presence of two trained healthcare professionals and is usually carried out by sedation nurses who are skilled and competent in administrating sedation, and have knowledge of the pharmacology of the medications, airway management and advanced life support. Nevertheless, nurse-led sedation is not without limitations and is not provided to certain groups of patients, namely neonates, infants and children with anticipated sedation or airway difficulties, in which cases an anaesthetic team is contacted. Deep sedation or anaesthesia with the help of propofol, ketamine, thiopental or sevoflurane is provided only by an anaesthetic team [3, 6].

In Israel, there is a similar anaesthesia-directed sedation programme which involves specially trained nurses, all with intensive care backgrounds, and paediatric anaesthesiologists [13]. Nurse-administered sedation is limited to the oral route with midazolam or chloral hydrate. Nurses (who must be able to see the patient throughout the procedure) are allowed to sedate ASA Class 1 and 2 patients over the age of 1 month . However, anaesthesiologists are consulted for children in ASA Classes 3 and 4.

In the USA, there are several sedation models. In the paediatrician-delivered model, paediatricians who are allowed to deliver propofol sedation in hospital undergo vigorous training. Propofol credentialing requires a 3-h didactic session followed by 10 days of operating room training under the auspices of an anaesthesiologist, and the completion of 25 supervised propofol sedations. In order to maintain certification to deliver propofol, paediatricians must administer a minimum of 50 propofol sedations per year, always with the immediate availability of an anaesthesiologist if requested [13].

Another model is one in which sedation is delivered by an emergency medicine physician. One review of a paediatric emergency medicine-staffed sedation service for radiological imaging studies showed that of 923 sedations, there was an overall 10% incidence of adverse events. The majority of the sedations included

Table 1. Principal problems associated with under- and oversedation

Insufficient level of sedation
Inadequate imaging quality owing to motion effect
Repeat study and associated additional radiation burden
Psychological negative impact on children related to repeat investigations
Family burden forcing parents to take an additional day off or arranging childcare for repeat imaging
Increased cost of procedure
Oversedation
Respiratory insufficiency
Cardiocirculatory depression
Aspiration
Vomiting

pentobarbital, fentanyl, midazolam and/or chloral hydrate. 55 patients received propofol alone. There was a low (0.76%) incidence of major adverse events (significant hypoxamia, apnoea, laryngospasm and stridor) that required intervention, which may have included repositioning, brief positive-pressure ventilation, oral or nasal airway ventilation, supplemental oxygen or vigorous stimulation. Sedation failed to achieve adequate conditions in 17 (1.8%) cases. There was no incidence of endotracheal intubation or cardiopulmonary resuscitation with pharmacological intervention [16].

The intensive care medicine physicians-delivered model provides S/GA outside of critical care units by critical care physicians and advanced practice nurses, under the auspices of an anaesthesiologist. The outcomes of S/GA provided by this model are rivalled by those provided by doctors and nurses of different specialties.

Nurse-delivered paediatric sedation can be administered by specialised nurses under the direct supervision of sedation-designated anaesthesiologists. A review of 16,467 elective sedations delivered by radiology nurses at Boston Children's Hospital, MA, reported a total of 70 (0.4%) pulmonary adverse events. There was no cardiac arrest and no need for intubation [17].

Techniques

Good clinical care suggests that for efficient, safely expedient diagnostic and therapeutic procedures which fulfil the rights of the child, both pharmacological and non-pharmacological methods of sedation should be considered. Regardless of the method of sedation, the facilities for children should be safe, secure and child-friendly [6].

There is convincing evidence that the following types of non-pharmacological sedation may be successful for radiological imaging: sleep deprivation, hypnosis and distraction, melatonin, play therapy and parent involvement [18]. The reassuring presence of a parent is also beneficial and should be encouraged, and parents should be kept relaxed before and during procedures so that children will follow their example.

There is clear evidence that employment of hypnotic techniques and distraction diminish anxiety, sedation time and procedure-related post-operative pain [19].

Anxious children who do not respond to repeat reassurance may benefit from play therapist involvement. This is particularly useful for children who require repeat scans, and talking through with the child what they should expect to experience, using toy models and tape recording, significantly reduces the levels of anxiety. This is echoed by a UK study carried out in a Bristol hospital, where only 1 sedation was required in 169 children aged older than 4 years who were referred to the play department [18]. It is a safe but time-consuming method and is applied predominantly in cooperative children older than 4 years.

In addition, rehearsal with a mock scanner and use of photographs with parental involvement markedly increase child understanding and confidence.

It is interesting to note one randomised study performed by Ovayolu et al [20] in Turkey, in which it was shown that listening to Turkish classical music during colonoscopy aided in reducing the dose of sedative medications as well as patient anxiety and dissatisfaction during the procedure.

Newborn babies and infants younger than 4 months will tend to sleep naturally if warm and recently fed. Encouraging sleep deprivation with melatonin hormones before imaging may improve success, with or without sedation [6, 17]. The success rate of sleep induced by feeding in term children younger than 3 years may be up to 75% [21]. Windram et al [22] conducted a research study in Canada where all 20 infants underwent cardiovascular MRI with a 100% success rate using a feed-and-sleep technique.

Painless procedures may be performed on young babies without any sedation after they have received a feed and are provided with warmth, quiet, containment, topical local anaesthesia for single needling procedures, and sucrose [23].

In cases when the non-pharmacological methods of sedation fail or are not indicated (*e.g.* in uncooperative children weighing 5–30 kg), sedation agents are used. Although many clinical studies regarding sedative drugs are available in the literature, no single drug is recommended as a standard in paediatric sedation [11] and there is no ''ideal'' sedative agent for children [6]. The choice of the type and level of pharmacological sedation depend on the type of procedure, and age, weight, cooperativeness and co-morbidities of the child. For example, for an MRI study of children older than 3 years or with a body weight of >10 kg, sedation might be a safe alternative to anaesthesia if no specific airway abnormalities or co-morbidities are present. In infants younger than 3 years or in the presence of major comorbidities that may aggravate airway management or the clinical procedure, general anaesthesia is the preferred choice [24].

There is no good evidence that the combination of a sedative and an opioid provides a more effective moderate sedation than such agents administered alone. Because of the increased risk of respiratory depression and airway obstruction associated with drug combinations, and because fixed combinations do not allow for the titration of the individual agent, it is recommended that drug combinations are administered at doses lower than those used for single drugs and that respiratory function is monitored continuously [11].

The environment and facilities for children should be safe, secure and child-friendly [6].

Credentials required for administering deep sedation

There should be one person available whose sole responsibility is to constantly observe the patient's vital signs and airway patency as well as the adequacy of ventilation, and to either administer drugs or direct their administration.

At least one individual who is trained and competent in providing advanced paediatric life support, airway management and cardiopulmonary resuscitation should be present [13], per AAP guidelines.

In addition, any providers who deliver deep sedation should meet the following standards [1]:

- There should be defined competencies in terms of airway management (*i.e.* effective bag–mask ventilation), and these skills should be demonstrated in clinical practice or a simulation setting.
- Knowledge of disease entities that impact sedation and anaesthesia should be documented.
- Familiarity with sedation drugs (doses, side effects and contraindications), reversal drugs and rescue medications should be documented.
- Intraprocedural monitoring should mirror that for anaesthesia; this should include the optimal methods for monitoring ventilation (capnography) as well as oxygenation.
- All equipment required for emergency interventions, such as masks, airways, suction and ventilation bags, should be present for each sedation, and they must be regularly checked and accounted for.
- Sedation systems should have a quality improvement programme that examines its own outcomes on a continuing basis.

In addition, all practitioners of sedation must have the skills to rescue the patient from a deeper level of sedation than that intended for the procedure [2].

A protocol for access to back-up emergency services should be clearly identified, with an outline of the procedures necessary for immediate use. For non-hospital facilities, a protocol for ready access to the ambulance service and immediate activation of the emergency medical system for life-threatening complications should be established and maintained [2]. Two trained healthcare professionals should be available during sedation [3]. Venous access should be obtained before sedation except when using nitrous oxide alone or in cases where oral/transmucosal sedation is used in patients who do not cooperate with cannulation [23]. It is a prerequisite for deep sedation. In addition, intravenous (IV) access is required for radiological imaging with contract or radioisotope administration. Prior to venous cannulation, topical anaesthetics (*e.g.* amethocaine gel) should be applied to the site of venous access or inhalation of gaseous anaesthetics should be initiated.

Although the IV route increases the likelihood of having to adjust the sedation level, it lowers the risk of adverse events and allows resuscitation drugs to be given. Levati et al [11] reported that there were no sufficient data in the literature substantiating an advantage of the IV route over other routes in either moderate or deep sedation. If sedation is achieved by a non-IV route of administration, a person skilled in establishing IV access should be available.

An emergency cart or kit must be immediately accessible. This cart or kit must contain equipment to provide the necessary age- and size-appropriate drugs and equipment to resuscitate a non-breathing and unconscious child [2]. Reversal agents for opioids and benzodiazepine, and emergency equipment age–size-appropriate for aspiration, airway maintenance, positive-pressure ventilation with oxygen and cardiopulmonary resuscitation should be immediately available.

Overview of recommendations from global sedation guidelines

As stated, there are international variations in the practice of S/GA, but most providers of procedural sedation follow the principles outlined below.

Focused history and clinical examination

A good knowledge of patient history and sound clinical examination are essential in the stratification of patients and in safe planning of S/GA.

The health evaluation should include:

- obtaining age, height and weight
- obtaining a health history (Table 2)
- a review of systems with special focus on abnormalities of cardiac, pulmonary, renal or hepatic function that might alter the child's expected responses to sedation/analgesic medications
- determination of vital signs, including heart rate, blood pressure, respiratory rate and temperature (for some children who are very upset or non-cooperative, this may not be possible, and a note should be written to document this occurrence)
- physical examination, including a focused evaluation of the airway (*e.g.* for tonsillar hypertrophy or abnormal anatomy such as mandibular hypoplasia) to determine if there is an increased risk of airway obstruction; airway examination in cooperative children according to the Mallampati classification [11]
- physical status evaluation (ASA classification; Table 3)
- obtaining the name, address and telephone number of the child's medical home [2]
- review of the psychological and developmental status of the child [3].

If there is concern about a potential airway or breathing problem, the child or young person is ASA Class 3 or greater, or the patient is a neonate or infant, specialist advice needs to be sought before delivering sedation [3]. Table 4 outlines the contraindications for sedation [23].

Table 2. Main points which need to be addressed in history taking

Allergies and previous allergic or adverse drug reactions
Medication/drug history, including dosage, time, route and site of administration for prescription, over-the-counter, herbal, or illicit drugs
Relevant diseases, physical abnormalities and neurological impairments that might increase the potential for airway obstruction, such as a history of snoring or obstructive sleep apnoea
A summary of previous relevant hospitalisations
History of previous sedation or general anaesthesia and any complications or unexpected responses
Relevant family history, particularly that related to anaesthesia

Table 3. ASA physical status classification

ASA class	Description
1	Healthy patient (no physiological, physical or psychological abnormalities)
2	Patient with mild systemic disease without limitation of daily activities (*e.g.* controlled asthma, controlled essential hypertension)
3	Patient with severe systemic disease that limits activity but is not incapacitating (*e.g.* asthma, Type 1 diabetes mellitus, congenital heart valve defect)
4	Patient with an incapacitating systemic disease that is a constant threat to life (*e.g.* cranial trauma with intracranial hypertension)
5	Moribund patient not expected to survive
6	A declared brain-dead patient whose organs are being removed for donor purposes

ASA, American Society of Anesthesiologists.

Parental/guardian consent

Children may be able to give consent to medical procedures where they are either over a statutory age (14–16 years depending on the jurisdiction), or of sufficient maturity that they are able to understand the procedure and give informed consent (Gillick competency). If a child aged <16 years does not have the capacity to consent to a medical procedure (*e.g.* in the UK), a person with parental responsibility can consent for them.

Even if a child is deemed to be incompetent to make a decision about a procedure, it is vitally important to engage him or her in the discussion regarding it. First, by doing this we promote the principle of patient self-determination, or autonomy. Second, children's involvement in medical decision-making improves open communication among physicians, parents/guardians and children, which is fundamental to children's and parents'/guardians' satisfaction with medical care. Third, children's involvement promotes a sense of control and may facilitate compliance with future procedures.

It is essential that written and informed consent is given prior to the procedure and that the informed consent is documented [3]. In addition, appropriate information should be given to both the child and the parent/guardian to help ensure uneventful S/GA.

A physician who delivers sedation should offer the child or young person and their parents/guardians verbal and written information on all of the following:

- proposed sedation technique
- alternatives to sedation
- associated risks and benefits.

In emergency situations, if a child does not have the capacity to give consent, it is justifiable to treat him or her without obtaining written parental or guardian consent only if it is not possible to obtain consent in time or if the treatment is vital to the survival or health of the child [23]. In Scotland, consent should be obtained from a child when it is appropriate [23]. In addition, the adult with parental responsibility should be given information about care after discharge and contact numbers should be provided in case of problems [6].

Responsible person

The paediatric patient should be accompanied to and from the treatment facility by a parent, guardian or other responsible person. It is preferable for two or more adults to accompany children who are still in car safety seats if transportation to and from a treatment facility is provided by one of the adults [25].

Equipment

Part of the safety net of sedation is to use a systematic approach so as not to overlook having an important drug or a piece of equipment immediately available at the time of a developing emergency.

A commonly used acronym that is useful in planning and preparation for a procedure is SOAPME [2]:

- S (suction)—size-appropriate suction catheters and a functioning suction apparatus (*e.g.* Yankauer-type suction)

Table 4. Contraindications for sedation

Conditions in which airway management is likely to be difficult	Abnormal airway (including large tonsils and anatomical abnormalities of upper or lower airway)
Disorders with a high risk of respiratory failure	History of sleep apnoea Nasal blockage Neuromuscular disease Decreased consciousness level Respiratory failure Cardiac failure Lobar emphysema Pulmonary cysts of bullae Severe pulmonary hypertension
Abnormality with the increased likelihood of pulmonary aspiration	Raised intracranial pressure Bowel obstruction Pneumoperitoneum

- (oxygen)—adequate oxygen supply and functioning flow meters/other devices to allow its delivery
- A (airway)—size-appropriate airway equipment [nasopharyngeal and oropharyngeal airways, laryngoscope blades (checked and functioning), endotracheal tubes, stylets, face mask, bag–valve–mask or equivalent device (functioning)]
- P (pharmacy)—all the basic drugs needed to support life during an emergency, including antagonists as indicated
- M (monitors)—functioning pulse oximeter with size-appropriate oximeter probes and other monitors as appropriate for the procedure [*e.g.* non-invasive blood pressure and end-tidal carbon dioxide monitors, electrocardiography (ECG) machines, stethoscopes]
- E (equipment)—special equipment or drugs for a particular case (*e.g.* defibrillator).

Patients receiving deep sedation should have an IV line placed at the start of the procedure or a person skilled in establishing vascular access in paediatric patients immediately available. Monitoring devices, such as ECG machines, pulse oximeters (with size-appropriate oximeter probes), end-tidal carbon dioxide monitors and defibrillators (with size-appropriate defibrillator paddles), must have a safety and function check on a regular basis as required by local or state regulation [2]. The facilities required for the safe administration of anaesthesia and sedation are identical. A full range of paediatric equipment is necessary [6].

MRI-specific features

MRI is considered to be one of the safest of all the diagnostic radiological procedures employed in medicine. Despite the safety reassurances, MRI creates an extremely powerful static magnetic field, rapidly changing gradient magnetic fields, and radiofrequency electromagnetic impulses; these impose potential hazards. Indeed, MRI's magnet can attract objects containing ferrous materials, transforming them into dangerous projectiles. Moreover, strong radiomagnetic fields may bring about device malfunction/failure and burns. The most common magnetic field interactions are shown in Table 5.

Because of the magnetic field generated by MRI scanners, no ferromagnetic material is permitted inside the Faraday cage.

Several precautions must be observed. The monitors, infusion pumps and other equipment should be compatible with the magnetic field, so that a piece of equipment is safe to enter an MRI room and will operate normally without interference to the MR scanner. Non-MRI-safe equipment should be placed beyond the 5-gauss boundary line; respirator tubing should be longer than usual or located outside the field [6]. In order to produce an ECG, compatible electrodes and carbon fibre cables should be used, and the potential risk of burns and interference with image production should be verified. MR-compatible electrodes should be placed in a narrow triangle on the patient's chest, and leads should be braided and short (15 cm). Currents induced by blood flow through the transverse aorta will interfere with the ECG signal, inducing artefacts in the ST-T complexes which mimic hyperkalaemia [26]. There may be a delay of up to 20 s in obtaining the capnograph signal owing to the length of the sampling tubing. Monitoring screens should be present in the MR control room to allow for remote monitoring of the patient. Monitoring cables can be passed through the waveguide ports to facilitate this. All alarms should be visual rather than audible because of the noise made by the MR scanner.

In MRI, anaesthesia should be managed to maintain respiratory and cardiovascular stability, and intracranial pressure monitoring may be required [11].

Owing to the way that the MRI scanner builds up its images using radiofrequencies (RF), any additional electrical equipment introduced into the scan room will also produce RF and this can compromise the quality of the images. Likewise, RF produced by MRI scanners can corrupt the data received from the monitoring/anaesthetic systems and make monitoring during scanning challenging.

Fasting guidelines

Aspiration of gastric contents into the airways remains one of the major complications of drug-induced sedation. This complication is favoured by the head position in some imaging studies (CT, MRI and angiography), wherein the head is set in a perfectly axial position and extended [27]. Therefore, for all elective cases in paediatric radiology, fasting guidelines should be observed.

The presence of gastric solid or partially digested contents (>0.4–$0.8\,ml\,kg^{-1}$) may create a risk of aspiration. Complications following aspiration concern not only children undergoing deep sedation or general anaesthesia but all patients in whom the protective reflexes of the respiratory tract are diminished. For this

Table 5. Hazardous magnetic field interactions

Magnetic field type	Hazard	Potential adverse effects
Static magnetic field	Translational force: powerful attraction of ferromagnetic object to intense magnetic field. Rotational force/torque: rotation of object to align with the magnetic field	''Missile effect'': acceleration of object into the bore of the magnet
Radiofrequency electromagnetic fields	Heating owing to absorbed radiofrequency energy	Tearing of tissues, pain and dislodgement of some implants
	Electromagnetic interference	Overheating burns (thermal, electrical)
Gradient magnetic field	Induced currents in conductive tissues	Device malfunction; imaging artefact
	Induced currents in electrical devices	Nerve and muscle stimulation
		Device malfunction/failure

reason, the category of patients at high risk for aspiration should be identified [11].

Pathologies associated with risk of aspiration of gastric contents are shown in Table 6.

Before sedation, the practitioner should evaluate preceding food and fluid intake [2]. For elective procedures, the 2-4-6 fasting rule applies to children undergoing deep sedation and moderate sedation during which verbal contact may not be maintained [3]:

- no clear fluids for 2 h prior to the procedure
- no breast milk for 4 h prior to the procedure
- no solids for 6 h prior to the procedure.

When nitrous oxide is to be used, fasting is not required, provided the inspired concentration does not exceed 50% and no other drugs with sedative properties are used [23].

For an emergency procedure in a child or young person who has not fasted, the decision to proceed with sedation is based on the urgency of the procedure and the target depth of sedation [3]. Led by emergency physicians, the applicability of nil per os guidelines, which have been propagated for paediatric sedation as an extension of a practice, have been called into question [28]. According to Thorpe and Benger [29], there is high-level evidence demonstrating no link between pulmonary aspiration and non-fasted patients. To date, there are no reported cases of aspiration during sedation in an emergency department and aspiration is likely to happen during intubation or extubation, which is itself is not a common event in an emergency department. However, some selective patients may benefit from individualised risk–benefit assessment prior to sedation.

Psychological preparation

The child's mental state should be taken into account prior to sedation and a doctor delivering sedation should ensure that the child is prepared psychologically for sedation by offering information about:

- the procedure itself
- what the child should do and what the healthcare professional will do
- the sensations associated with the procedure (*e.g.* a sharp scratch or numbness)
- how to cope with the procedure.

In addition, physicians should ensure that the information is appropriate for the developmental stage of the child and check that they have understood. The parents or guardian should be offered the opportunity to be present during sedation if appropriate. For an elective procedure, consideration should be given to referring children who are severely anxious or who have a learning disability to a mental health specialist [3]. The classic ''tell-show-do'' method should be used to help reduced anxiety prior to procedures [23].

Sedation agents

The most prevalent sedative agents are shown in Table 7.

Hypnotics

Chloral hydrate, or its active metabolite trichlofos, is an example of a sedative drug that has been used for many years in infants and children weighing >15 kg or aged under 2 years. As early as 1894, chloral hydrate was being used in children [30]. Adverse effects are few when given in a single dose orally. The chloral hydrate adverse effects are desaturation, respiratory depression, airway obstruction, agitation, ataxia, vomiting and cardiac arrhythmia; no antagonist is available [11]. The main disadvantage is gastric irritation, which can lead to vomiting. Also, it has no intrinsic analgesic effect [31]. Chloral hydrate produces effective sedation in 80–90% of patients [32]. Repeated doses of choral hydrate may cause central nervous system depression, hyperbilirubinaemia in newborns and metabolic acidosis. It is controversial owing to its possible carcinogenic effect in humans, but this potential risk does not constitute a contraindication to the use [11]. Unfortunately, its unpredictable onset, long duration and the lack of a reversal agent make chloral hydrate less than an ideal

Table 6. Pathologies with increased risk of aspiration

Abnormalities producing inhibition of protective airway reflexes	Coma
	Psychomotor retardation
Conditions related to direct or indirect stimulation of a vomiting centre	Intracranial hypertension
	Space-occupying process in the posterior cranial fossa involving the lower cranial nerves
	Multiple trauma involving the cranium
	Acute abdominal pathology, also trauma (*e.g.* appendicitis, peritonitis)
	Peritoneal dialysis
	Acute pain requiring medication
Structural defects of airways	Tracheoesophageal pathology
Disorders causing a delay of gastric emptying	Uncontrolled diabetes
	Gastroesophageal dyskinesia
Abnormalities linked to incompetence of lower oesophageal sphincter or an increased intra-abdominal pressure	Hiatal hernia
	Ascites
	Obesity
	Neuromuscular disease

Table 7. Sedative drugs

Sedative group	Sedative agent	Route of administration	Loading dose	Maximum dose	Comments
Benzodia-zepines	Midazolam [34]	IV	0.025–0.05 mg kg^{-1}	6 mg kg^{-1} (children aged ≤6 years), 10 mg kg^{-1} (children aged 6–12 years), 7.5 mg kg^{-1} (children aged 12–18 years)	Over 2–3 min, 5–10 min before the procedure Reduce dose by 30–50% if combined with opioid analgesic (*e.g.* fentanyl); younger children (*i.e.* those aged <5 years) may require higher doses up to 0.6 mg kg^{-1} per dose
		Per os	0.5 mg kg^{-1}	20 mg kg^{-1}	30–60 min before procedure
		Rectal	0.3–0.5 mg kg^{-1}		15–30 min before procedure
		Buccal	0.2–0.3 mg kg^{-1}	5 mg kg^{-1}	Children aged 6 months to 10 years
			6–7 mg	8 mg kg^{-1} if the child weighs ≥70 kg	
Hypnotics	Chloral hydrate [34]	Per os or rectal	30–50 mg kg^{-1} (neonates) 30–50 mg kg^{-1} (children aged 1 month to 12 years) 1–2 g (children aged 12–18 years)	100 mg kg^{-1} 1 g kg^{-1}	45–60 min before procedure Higher doses up to 100 mg kg (a maximum of 2 g may be used)
Barbiturates	Pentobarbital [35]	IV	1–2 mg kg^{-1}	6 mg kg^{-1}	
		IM	1–6 mg kg^{-1}	100 mg kg^{-1}	
		Per os	4–6 mg kg^{-1}	100 mg kg^{-1}	
	Methohexital [35]	Rectal	25 mg kg^{-1}	500 mg kg^{-1}	15 min before procedure
Opioid analgesics	Fentanyl [34]	IV	0.001–0.003 mg kg^{-1} (children aged 1 month–12 years)	200 μg on specialist advice	Over at least 30 s
			0.05–0.1 mg kg^{-1} (maximum 0.2 mg on specialist advice, for children aged over 12 years)		Then 0.025–0.05 ms as required
Anaesthetics	Ketamine [34]	IV [55]	1–2 mg kg^{-1} (neonates to children aged 12 years) 1.0–4.5 mg kg^{-1} (for children aged over 12 years)	2 mg kg^{-1} (children aged 1 month to 12 years), 4.5 mg kg^{-1} (children aged 12–18 years)	Adjusted according to response
		IM [56]	2–5 mg kg^{-1}	13 mg kg^{-1}	
		Per os [56]	6–10 mg kg^{-1}		Mixed in cola or other beverage 30 min before procedure
	Etomidate [34]	IV	0.15–0.3 mg kg^{-1}	400 μg kg^{-1} (children aged <10 years)	Children aged under 10 years may require up to 0.4 mg kg^{-1}
	Propofol 0.5% [34]	IV	1–2 mg kg^{-1} (children aged 1 month to 17 years); 0.5–1 mg kg^{-1} (children aged 17–18 years)	4 mg kg^{-1} by IV injection	Over 1–5 min
	Thiopental [34]	IV	Up to 2 mg kg (neonates) Up to 4 mg kg^{-1} (children aged 1 month to 18 years)	4 mg kg^{-1} 7 mg kg^{-1}	Then 1 mg kg^{-1} repeated as necessary Then 1 mg kg^{-1} repeated as necessary
Inhalational anaesthetics	Nitrous oxide [34]	Inhalation	50–60% in oxygen	Concentration 66% in oxygen	
	Sevoflurane [34]	Inhalation	Up to 4% in oxygen (neonates); 0.5–1% initially then increased gradually to 8% in oxygen (children aged 1 month to 18 years)	Concentration 4% in oxygen (neonates), 8% in oxygen (children aged up to 18 years)	
Miscellaneous agents	Dexmedetomidine (a selective alpha-2 agonist)	100 μg ml^{-1} (adult dose)	2–3 mg kg^{-1} over 10 min	IV 3 μg kg^{-1}	1–2 mg kg^{-1} h^{-1} as an infusion for sedation maintenance; the drug is not suitable for patients with cardiac compromise

IM, intramuscular; IV, intravenous.

sedative [30]. Owing to its long duration (60–150 min) [35], the question of whether it is appropriate to use it for a 5-min study arises. Even more important are the delayed adverse effects described by Malviya et al [36]. These investigators found restlessness and agitation lasting more than 6 h in one-third of children undergoing neuroimaging with chloral hydrate sedation, 5% of whom did not return to their baseline activity for 2 days after their procedure. The financial implications of lost workdays for parents and return visits to emergency departments have never been fully considered in studies of long-acting sedatives used for brief procedures [1].

Benzodiazepines

Midazolam is a more potent agent with a more rapid onset and offset of effect. The quality of anxiolysis is good, although the degree of sedation is less predictable. It is bitter tasting, but this can be disguised in syrup or juice. It is suitable for children aged over 1 year undergoing brief procedures where anxiolysis or sleep is the main requirement. There is some degree of retrograde amnesia in children. Although the intranasal route of administration is quick and convenient for sedation, midazolam stings greatly and the experience is unpleasant [6, 37].

Diazepam is 4–5 times less potent than midazolam. Despite a longer elimination half-life, recovery profiles are similar (usually by 2 h).

Temazepam is more palatable and preferred, and can cause some anxiolysis and sleep: combined with droperidol, it induces sleep in 70% of children (weighing 10–20 kg) undergoing MRI; a top-up with diazepam improves success rates to 95%.

Barbiturates

Barbiturates are used in the induction and maintenance of deep sedation. In Italy, thiopental is administered because other agents, such as pentobarbital and methohexital, are not available [11]. Because of their long duration of action, barbiturates can cause a prolonged deep sedation with the potential risk of respiratory depression and airway obstruction [11].

Pentobarbital IV or 4–6 mg kg^{-1} per os has a long history of effective use in radiology imaging with a low incidence of respiratory depression and remains a very common sedative agent in the USA [38]. It used predominantly by nurses for CT studies.

Methohexital is an effective sedative in IV form. The rectal route is not recommended owing to the high frequency of apnoea/desaturation events [39].

Intravenous anaesthetics

Ketamine is often used in radiological procedures, but not routinely in the UK. Ketamine is effective for sedation and analgesia for painful procedures. It has adverse effects, such as nausea and vomiting after the procedure, and laryngospasm [40]. It is often combined with an anticholinergic for control of secretions. Combination with midazolam is common, although the effectiveness of this in treating emergence dysphoria is debated. It is useful to remember that ketamine is contraindicated in patients with intracranial hypertension. Moreover, subjects sedated with ketamine may keep their eyes open while a level of general anaesthesia is achieved [11].

Propofol is close to an ideal sedating agent for non-painful procedures such as MRI scans or nuclear scans, but it can induce profound respiratory depression and loss of protective airway reflexes, making it suitable for use only by persons trained in the administration of general anaesthesia or by expert airway managers with good back-up systems [41]. The data from one study [42] suggest a greater variability with a loading dose in children younger than 1 year and with a maintenance dose in children older than 7 years. The effectiveness and smooth recovery characteristics of this drug have caused non-anaesthesiologists to gravitate towards its use, despite concerns about monitoring and airway management [1]. Propofol and fentanyl are the most effective drugs for deep S/GA, but the risk of requiring advanced airway management is high [43]. Kiringoda et al [44] confirmed in a retrospective study a low incidence of adverse events and no long-term complications in high-risk children (ASA Class 3) who received propofol S/GA (PSA) by an anaesthesiologist for research-related imaging studies.

Although nurse-administered propofol sedation (NAPS) is common around the world for adult sedation, NAPS is not practised for child sedation because most paediatric sedations are deep, and children's airways are narrower and their time to react to an adverse event is shorter [13].

The administration of propofol to children undergoing S/GA for diagnostic and therapeutic procedures remains controversial. For example, the ASA recommends that only professionals trained in the delivery of general anaesthesia should deliver deep S/GA. Despite the ASA guideline, PSA is delivered to children for procedures in emergency departments, intensive care units and S/GA units all over the USA (and around the world) by paediatric generalists and subspecialists every day. Furthermore, other professional organisations have written guidelines and recommendations for propofol use by their constituents. Unfortunately, all of the positions taken by professional societies are based on collective opinion and analysis of relatively small, observational single-centre studies, because there simply have not been any large multicentre reports on the safety of propofol anaesthesia or on the complications that may occur during propofol anaesthesia. A study by Cravero et al [45] presented the largest experience with PSA for children outside of the operating room that had been published until 2009. In this study, 49 836 PSA events were analysed, submitted from 37 locations. The data clearly showed that serious adverse events were quite rare in the practice of PSA for procedures within their consortium; no deaths occurred and two cardiac arrests were reported (both responded almost immediately to treatment and suffered no long-term injury). The observed (low) incidence of mortality was not unexpected and was consistent with the low incidence of mortality currently associated with the provision of general anaesthesia. Four aspiration episodes were reported, yielding a rate consistent with previously

reported incidences for PSA and S/GA practice. However, more minor, but potentially serious, adverse events clearly are not as rare. Approximately 1 in 65 PSA was associated with stridor, laryngospasm, airway obstruction, wheezing or central apnoea, any of which could progress to poor outcomes if not managed well. Indeed, 1 in 70 PSA administrations required airway and ventilation interventions, including oral/nasal airway placement, bag–mask ventilation and emergency tracheal intubation. The ability of the S/GA systems involved in this study to deliver these types of interventions was critical in preventing more serious adverse events [45].

Inhalational anaesthetics

Nitrous oxide is a potent analgesic used in paediatric sedation for radiological procedures. The use of nitrous oxide mixed with 50% oxygen or less to induce moderate sedation is acceptable only in ASA Class 1 or 2 patients. It has been shown to significantly reduce pain and anxiety and subsequently increase the compliance and satisfaction of patients [46].

Nitrous oxide should not be used in specific situations such as pneumothorax, pneumocephalus, pneumopericardium, otitis media or bowel obstruction (apple peel atresia). Care must be taken when used in addition to other sedatives (local anaesthetics), as deep sedation can easily result [47].

Sevoflurane, or fluorinated methyl isopropyl ether, has been used frequently for inhalation induction of anaesthesia. Owing to its non-pungency, rapid induction and quick elimination, sevoflurane may be useful for sedation only by professionals who are skilled in general anaesthesia.

Miscellaneous sedative agents

Dexmedetomidine is a potent α-2 agonist with sedative and analgesic properties. It is popular in the USA for sedation in mechanically ventilated adult patients and there has been an increasing interest in the clinical application of dexmedetomidine in the paediatric population. High-dose dexmedetomidine ($3\,\mu g\,kg^{-1}$ IV load over 10 min with an infusion of $1\,\mu g\,kg^{-1}\,h^{-1}$) has been used successfully for the sedation of children undergoing MRI. Using this dose, Mason et al [48] noted bradycardia and a 20% drop in blood pressure with minimal change in respiratory parameters. A small study on 40 children undergoing magnetic resonance imaging (MRI) under general anaesthesia showed that dexmedetomidine–midazolam provides adequate anaesthesia for MRI although recovery is prolonged when compared with propofol. Heart rate was slower and systolic blood pressure was greater with dexmedetomidine when compared with propofol [49]. Moreover, Mason et al [50] concluded in their study that dexmedetomidine is a safe and effective alternative to pentobarbital for paediatric CT, being associated with a much shorter recovery time and less need for adjuvant sedatives. Despite the fact that IV dexmedetomidine in the paediatric population is associated with modest fluctuations in heart rate and blood pressure and should be used in those patients who may not tolerate such fluctuations, dexmedetomidine is an appropriate sedative for children undergoing CT imaging [51].

Chlorpromazine is a typical antipsychotic drug which used to be part of ''DPT'' (demerol, phenergan, thorazine), an intramuscular cocktail of meperidine, promethazine and chlorpromazine, but is now common only in France for IV sedation.

Opioids

Opioids are used in painful procedures. For example, remifentanil is currently used exclusively by anaesthesiologists for significant risk of apnoea [52]. In neuroradiological studies, the respiratory depressant effect of opioids should be carefully evaluated in patients with altered levels of consciousness and intracranial pressure. To reduce the requirement for systemic narcotics analgesics during arterial catheterisation, the application of local anaesthesia at the puncture site is advisable [11].

Reversals

The most prevalent reversals are shown in Table 8. Naloxone and flumazenil can antagonise the respiratory depression caused respectively by opioids and benzodiazepines. Antagonists should always be available in sedation/analgesia procedures. Supplementary oxygen and positive-pressure ventilation should also be readily available. Considering that the antagonist half-life is shorter than the benzodiazepine and opioid half-life, the patient should be observed in a protected area as long as the risk of rebound effect persists [11].

Although there is an overall trend to using short-acting sedatives, opioid and anaesthetic drugs, sedation protocols differ from country to country. A few examples of sedative practice are described below.

Interventional procedures under radiological control should be performed under general anaesthesia with

Table 8. Reversal agents

Drug	Indication	Dose	Comments
Naloxone	Reverses opioid agonists	0.005–0.01 mg kg IV/IM; may repeat q2–3 min *pro re nata*	Onset of action for IV administration is 1–3 min *vs* 10–15 min for IM; rebound sedation may occur
Flumazenil	Reverses BZPs	0.1–0.2 mg IV infused over 15 s; may repeat after 45 s and then every 1 min; total cumulative dose of 1 mg is not to be exceeded	Rebound sedation may occur; may precipitate seizures unresponsive to BZPs

BZP, benzodiazepine; IM, intramuscular; IV, intravenous.

topical and infiltration local anaesthesia for puncture sites [23]. For example, the most frequently used sedative drugs in the USA during interventional radiological procedures are midazolam (92%), morphine (42%) and diazepam (33%), according to Haslam et al [53]. They also have reported a European frequency of midazolam (58%), diazepam (45%), fentanyl (33%) and morphine (20%) in interventional radiology. In Turkey, Derbent et al [54] found that fentanyl (89%) was the most popular agent for interventional radiological procedures, followed by sevoflurane (77%), thiopental (47%), midazolam (24%), ketamine (9.6%) and propofol (8%).

In Canada, the most popular drugs for conscious sedation are lorazepam, midazolam, diazepam and fentanyl. By contrast, in the USA, pentobarbital is the drug of choice in nurse-led sedations for CT studies, whereas propofol is preferred by anaesthetists.

In the UK, chloral hydrate, temazepam, droperidol, midazolam, sevoflurane and propofol are widely used for painless procedures. Painful procedures require the use of nitrous oxide, midazolam, ketamine, propofol, fentanyl or other general anaesthetics. Bracken et al [55] showed a high effectiveness of use of chloral hydrate with a reduced dose in Ireland and a successful rate at 96.7%.

In France, IV chlorpromazine is used extensively for procedural sedation in young children undergoing MRI and CT; Heng Vong et al [56] reported a 96% rate of adequate sedation.

In Pakistan, low-dose ketamine and propofol administered by a qualified person appears to be highly effective and safe to facilitate the performance of painful procedures in children with cancer.

Monitoring during procedures

As highlighted by Krauss and Green [57], the most precarious periods in S/GA are the 5–10 min after IV administration of medication and during the period immediately after the end of the procedure when procedural stimuli are ceased. Therefore, during S/GA, the following parameters should be continuously monitored [58]:

- level of consciousness every 15 min (when possible) using the Glasgow Coma scale, the paediatric coma scale and the Ramsey scale (Table 9)
- ventilation (respiratory rate every 5 min, chest auscultation, capnography). In deeply sedated patients and when direct observation is not possible, capnography is currently the most valuable method for ventilation monitoring [11]
- oxygenation (pulse oximetry with appropriate alarms)
- vital signs (blood pressure, pulse, ECG)
- record of monitored values (every 5 min).

Deep sedation and general anaesthesia are equivalent and require the same level of monitoring. The operator should not be the same person responsible for monitoring the child during the procedure [23]. The designated person must continuously observe the child's face and mouth and the motion of the chest wall.

Discharge criteria

In view of the aforementioned adverse outcomes of S/GA, particularly the delayed outcomes, it is imperative to ensure that all the following criteria are met before the child is discharged:

- Vital signs (usually body temperature, heart rate, blood pressure and respiratory rate) have returned to normal levels. Haemodynamic and respiratory stability maintained over a sufficiently long observation period (*e.g.* 30 min) [11].
- Motion and walking capability (appropriate for age).
- The child is awake (or returned to a baseline level of consciousness) and there is no risk of a further reduced level of consciousness.
- Nausea, vomiting and pain have been adequately managed [3].
- Hydration status is adequate [11].

On discharge, parents should be given verbal and written instructions on what to expect and how to manage their children after S/GA. Children's behaviour, activity and food intake should return to normal within 24 h after administering a sedative. Children should remain under the responsible adult's supervision and they should not participate in any activity that requires motor skills over that time. Contact details and a clear contingency plan should be given to parents in case of any queries or if an emergency arises.

Summary

The incidence of S/GA in paediatric imaging has grown considerably over the past decade, favouring anaesthetist-led procedures. Although it is a relatively safe procedure, to practise safe care one needs to observe appropriate guidelines in the pre-sedation assessment, choice of sedation delivered, provider of sedation and sedative agents used. Provision of a safe environment with appropriate monitoring, meeting discharge criteria,

Table 9. Ramsey score

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

improving resuscitation skills and S/GA management to pertinent standards are essential. All healthcare providers who sedate children, regardless of their practice venue, should be competent in advanced airway assessment and management and skilled in the resuscitation of infants and children [59]. Moreover, as sedation has spun across specialties and countries with different definitions and guidelines, in order to advance safe sedation one should use universal terminology, report all sedative practices using a standardised sedation outcome reporting tool suggested by the International Sedation Task Force and, through reflection on adverse events and large-scale studies, make improvements in the practice of S/GA.

Safe practice is the key to successful and uneventful S/GA, and aids in high image quality, image interpretation and an efficient paediatric imaging service.

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