Sedation and General Anesthesia in Diagnostic Pediatric Imaging

Prakash Choudhary[1] Neha Boski[1]

[1] Department of CT and MRI, Dr. Gulati Imaging Institute, Delhi, India

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Address for correspondence Prakash Choudhary, MD, Dr. Gulati Imaging Institute, Delhi 110016, India (e-mail: pkdch01@gmail.com).

Abstract

Objective In this article we will try and provide a comprehensive literature review on the use of sedation and general anesthesia (SAGA) in pediatric population for diagnostic studies and the salient differences in practices worldwide particularly with regards to the practice differences in developed versus developing countries.

Methods The key articles we obtained were primarily from *Indian Journal of Anesthesia*, Local NHS Trust protocols, PubMed, MEDLINE, NICE Evidence, UptoDate (Wolters Kluwer), and The Cochrane Library.

Results In the last two decades pediatric radiology has seen a huge increase in volume of procedures with a proportional increase in SAGA. The duration being dependent on the modality (for example, few minutes for computed tomography scan and up to an hour for magnetic resonance imaging particularly if there are multiple studies). SAGA has an extensive list of adverse effects that could be due to the underlying drug or due to wrong patient selection. The principles for safe use of the drugs remain the same just like any other medical or surgical procedure and include meticulous assessments of children and ruling out the contraindications, obtaining parental consent, deciding the drugs which can be given, ascertain the duration of procedure after communication with the radiologist, monitor closely before, during, and after the procedure, discharge, and after the discharge criteria are met. All the above criteria depend on the local guidelines and therefore vary from not only one country to the other but also from one institution to the other within the same country.

Conclusion As expected, the SAGA techniques, drugs, and personnel involved in delivering the care vary from country to country. However, the final and desired outcome remains the same that is to deliver safe care with acquisition of optimal images that serve the purpose of arriving at the correct diagnosis.

Keywords
- sedation
- general anesthesia
- pediatric imaging

Introduction

The two main aims of sedation and general anesthesia (SAGA) are control of anxiety and prevention of movement to acquire optimal images with no motion artifacts. Another reason for sedation/GA could also be wishes of the parents if they do not want the child to remember the experience. The American Academy of Pediatrics (AAP) defines the goals of sedation in the pediatric patient for diagnostic and therapeutic procedures as follows: to guard the patient's safety and welfare; to minimize physical discomfort and pain; to

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control anxiety, minimize psychological trauma, and maximize the potential for amnesia; to control behavior and/or movement to allow for the safe completion of the diagnostic/interventional procedure; and to return the patient to a state from which safe discharge is possible.[1] The drugs used for SAGA will depend on the imaging modality, number of studies involved, and the patient characteristics. Therefore, a short procedure like computed tomography (CT) might not require GA but on the other hand magnetic resonance imaging (MRI) that can take anywhere between 10 minutes to an hour depending on the study usually requires deep sedation or GA. MRI can be particularly frightening because it is noisy, has relatively long scan time, and involves lying still in an enclosed space, therefore waking up in the middle of the procedure can be a disturbing experience.

The rate of failure of adequate image acquisition has been reported to be as low as 1 to 3% in some studies,[2] and even frequent as 10 to 20% in others.[3,4] Worldwide there has been a shift toward administering drugs according to predefined protocol and studies have suggested that this decreases the failure rate.[5] Studies have shown that the procedures were more likely to be successful in children who were imaged under GA like the ones by Malviya et al[6] which reported a clear improvement in the quality of MRI scans performed using GA compared with those using moderate sedation. It is essential to minimize the risk of procedure failure due to patient movement and rescheduling as it is a major burden on patient and family who must come again as well as for the radiology team in terms of time loss and arranging a new appointment in busy department. It is better to assess the patients prior to the procedure, decide the strategy (sedation vs. GA), and employ the appropriate technique only. Sedation has long been used for clear image acquisition and was provided by the radiological staff only, particularly in developing countries. However, in recent years especially due to rising legal issues there has been a trend toward employing and using dedicated services of individuals or personnel who have the expertise in delivering SAGA in pediatric population. The monitoring and the qualification of the individual/team depends on the local hospital/prevalent guidelines and may include dedicated trained nurses, pediatricians, emergency physicians, and/or anesthesiologists.

History and Literature

Until 1985 there were no guidelines for pediatric sedation. Unfortunate adverse events in dental offices heightened awareness of the hazards of pediatric sedation. This led the AAP to develop guidelines for the elective use of SAGA by Dr. Charles Coté and Dr. Theodore Striker.[7] In 1992, the AAP Committee on Drugs revised the 1985 guidelines. It was acknowledged that a deeper unintended level of sedation could be easily reached. Pulse oximetry was recommended for all patients undergoing sedation.[8] "The guidelines underwent subsequent revision by the AAP in 1998, 2002, and 2006" ("BIR Publications"). During the following years, the American Association of Anesthesiologists (ASA) became involved with the sedation safety, in part because the Joint Commission on Accreditation of HealthCare Organizations (JCAHO) modified their regulations in such a way that made departments of anesthesiology responsible for developing "within-institution" sedation guidelines. The first ASA iteration succeeded in changing the terminology from the oxymoron "conscious sedation" to the more appropriate term "sedation/analgesia." In 2002, the ASA published revised sedation guidelines that address all depths of sedation.[5] The ASA, working closely with JCAHO, also developed new language to describe the sedation's process, which was later incorporated by the JCAHO.

Now, besides GA, three stages of sedation are described—minimal sedation, moderate sedation, and deep sedation. Recently, the AAP adopted the ASA definitions for their sedation guidelines ("Discharge Criteria for Children Sedated by …"). The Neuroanesthesia and Neurointensive Study Group of the Italian Society of Anesthesia, Analgesia, Resuscitation, and Intensive Care (SIAARTI) with the Italian Society of Neonatal and Pediatric Anesthesia and Resuscitation (SARNePI) have been published in 2004—the SIAARTI-SARNePI Guidelines—for sedation in pediatric neuroradiology.[9]

However, all these studies and guidelines failed to ensure a standard set of terminology to define the relevant procedures involved in sedation and the adverse effects due to SAGA. Standardization of recommendations was required to safeguard against confusion and untoward events ("BIR Publications"). The first attempt to standardize the terminology in sedation provision was in 2008, when the Consensus Panel on Sedation Research of Pediatric Emergency Research Canada and the Pediatric Emergency Care Applied Research Network issued so-called "Quebec Guidelines," a set of definitions which could be adopted by all sedation providers.[10] In 2010, the World Society of Intravenous Anesthesia established the International Sedation Task Force (ISTF), which comprised of members from different countries and backgrounds 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 ("Sedation/anesthesia in pediatric radiology"). ISTF has also produced a standardized sedation outcome reporting tool and aims to establish an international consensus and produce a sedation monitoring record to perform and document preprocedure assessment, monitoring, and discharge in any sedation procedure.[11]

Definition of Sedation

Initially, there were three levels of sedation that were recognized, conscious sedation, deep sedation, and GA. However, soon it was acknowledged that the terminology of conscious sedation could not be used for pediatric population especially the young children.[12]

Sedation in general 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

performed."[13] Three levels of sedation are defined in addition to GA.

Minimal sedation: A 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: A state 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.

Deep sedation: In this plane of sedation 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.

GA: This is a drug-induced loss of consciousness during which patients are not arousable, even by painful stimulation. "The ability to maintain independent ventilatory function is often impaired." They need assistance with maintaining their airway and positive pressure ventilation is often required to maintain adequate gas exchange. Cardiovascular function may also be impaired.

Dissociative sedation, another category has been added by the European pediatricians. This is defined as a trance-like cataleptic state induced by the dissociative agent ketamine or s-ketamine and characterized by profound analgesia and amnesia with retention of protective airway reflexes, spontaneous respiration, and cardiopulmonary stability.[14]

Although sedation and anesthesia have well-defined definitions, it can be quite dangerous to adhere to a state strictly during a procedure. The dose of drugs required for moderate sedation in one child can lead to deep sedation in the other or even apnea and airway obstruction that might necessitate same level of care and supervision/intervention as GA[9] (►**Table 1**).

Adverse Effects and Complications to Sedation and General Anesthesia

SAGA can lead to adverse effects and complications because of the drugs on ventilatory and cardiovascular systems that are usually dose-dependent but lower dosages can lead to significant side effects in patients with underlying comorbidities or congenital problems. The individual side effects characteristic of a particular drug will be discussed later; however, the most prevalent side effects are usually respiratory in nature which includes apnea, upper airway obstruction due to tongue fall, and hypoventilation, all of which can lead to hypoxemia. Cardiovascular side effects can also occur and include fluctuations in heart rate and blood pressure depending on the drug used. Other adverse effects of SAGA which can occur in practice include postsedation nausea, vomiting, and allergic reaction to the underlying drugs.

After studying 95 sedation-related adverse events with 51 deaths and 9 permanent neurological injuries, Cote et al concluded that most of the events were preventable and due to human errors rather than the side effects of the drugs. Certain conclusions that can be drawn from numerous studies are[15–17]:

1. All classes of drugs have been associated with problems even when administered in recommended doses and therefore there is no one category that can be recommended or is entirely safe.
2. Adverse events more frequently involved use of more than one drug (three or more being particularly dangerous).
3. Respiratory complications are the usual initial adverse events and cardiac arrests and neurological damage occurred as secondary adverse events secondary to hypoxemia.

Therefore, it seems that most of the mortalities and morbidities that take place are avoidable.

Sedation and General Anesthesia—Personnel

There is a large variation in the expertise of personnel and background training that perform SAGA for radiological

Table 1 Levels of sedation

	Responsiveness	Cardiovascular system	Airway	Respiration
Minimal sedation	Normal response to voice	No changes	Maintained	Unaffected
Moderate sedation	Purposeful response to light touch or verbal commands	Usually, no changes	No intervention required	Adequate
Deep sedation	Purposeful response to repeated commands or painful stimuli	Usually, no changes	Intervention may be required	Usually, adequate
General anesthesia	Unarousable	Might be adversely affected	Intervention usually required to maintain airway	Intervention usually required to maintain ventilation

investigations with uniformity and guidelines followed throughout the country on one hand to different people administering different drugs according to their preference on the other in the absence of strict protocols.

In India there are no strict uniform guidelines that dictate the personnel who would be performing SAGA. The individual hospitals and standalone dedicated imaging centers generally use services of an anesthesiologist for GA with some using the same level of expertise and care for administering sedation and some on the other hand using the services of a general practitioner or an in-house radiologist having some experience in sedation. However, with increasing medico-legal problems many busy standalone centers have started employing full-time anesthesiologist.

In the United Kingdom, oral sedation is usually performed by sedation nurses who have had a structured training to deliver this service with knowledge of the procedure, the adverse effects of the drugs, and the skills to resuscitate the patients if required. However, the patients who need GA or are high risk depending on the underlying problems are taken care of by the anesthesia team.[18]

In Israel, there is a similar sedation program which involves specially trained nurses, all with intensive care backgrounds with pediatric anesthesiologists at the next level who deliver GA or deep sedation to those who fail a trial of nurse-administered sedation or are high-risk category.[11]

In the United States, there are several sedation models ranging from pediatricians to anesthesiologists who deliver SAGA. In the pediatrician-delivered model, pediatricians who can deliver propofol in hospital undergo a well-defined structured training program before they are allowed to deliver propofol-based SAGA independently with the immediate availability of an anesthesiologist for backup if needed.[11] Another model uses the services of emergency medicine physicians. The intensive care medicine physicians-delivered model provides SAGA by critical care physicians and practice nurses, with overall support and backup from anesthesiologist.

Equipment and Monitoring

Although the pediatric diagnostic radiological procedures are usually short and do not involve any surgical stimulation, this should never diminish the level of care and monitoring. Most of the complications that take place during a surgery can happen during these procedures as well. Also, the level of monitoring should be the same for sedation and anesthesia.

The acronym that is used for the equipment and monitoring that should be available and is widely followed is the one recommended by AAP-SOAPME.[1]

S – Suction—Suction catheters and/or Yankauer's suction with a functioning suction apparatus.
O – Oxygen—Adequate oxygen supply with optimal backup and functioning flow meters/other devices to allow its delivery.
A – Airway—Nasopharyngeal and oropharyngeal airways, laryngoscope blades, endotracheal (ET) tubes, supraglottic airway devices, stylets, bougie, face mask, bag–valve––mask/AMBU, or equivalent device.
P – Pharmacy—All the basic drugs needed to support life during an emergency, including antagonists as indicated.
M – Monitor—Functioning pulse oximeter with size-appropriate probes and other monitors (noninvasive blood pressure, end-tidal carbon dioxide monitors, electrocardiogram [ECG], stethoscopes) ("Procedural Sedation Learning Module - MNCYN").
E – Equipment—Special equipment or drugs for both anesthesia and resuscitation (e.g., defibrillator).

It is essential that all the above are checked on a daily/weekly/monthly basis as appropriate before the start of the first case in the morning as per the established protocols.

Special Problems due to Imaging Modality for Sedation/GA

MRI

Although MRI involves the use of powerful magnetic fields and therefore is free from all the radiation exposure traditionally associated with diagnostic radiology, it has its own unique set of hazards. The powerful magnetic pull that can transform any ferrous containing article into a projectile object capable of causing severe physical injuries necessitates the use of MR-compatible equipment for delivering SAGA while all the noncompatible ones must be placed beyond the recommended boundaries.[19] The MR-compatible pulse oximeter, ECG electrodes, and capnograph tracing are not always available particularly in small diagnostic imaging institutes in developing countries and can impose a big challenge to the SAGA provider. This makes it essential to monitor the respiratory movements continuously to detect any early compromise.

Remote monitoring based on visual monitoring and observation of the patient during scanning is available at some places.[20] For the anesthetist, the main challenge is the inability to access the head end for positive pressure ventilation and/or insertion of an airway in case of respiratory complications and requires interruption of the procedure and the patient needs to be pulled out.

CT Imaging

The risk of exposure to radiation generally prevents the caregiver from being physically present inside the room during the procedure and all that can be accessed is the readings on the monitor that are attached to the patient. Therefore, it is essential that immediately after administration of the drug the patient is monitored closely for vitals, adequate respiration, and it is ensured that there are no movements that can prevent acquisition of optimal images before the CT is started and it is only then that the SAGA provider leaves the room.

Pre-SAGA Assessment

Focused History and Clinical Examination

A thorough patient history, clinical examination, and investigations as indicated[9] are essential in the stratification of patients and ensuring that SAGA is delivered safely. Height, weight, and body mass index must be measured and ideally the drug dosages should be calculated beforehand.

The history taking and clinical examination should be performed as sincerely as for any other major procedure bearing in mind that all complications are possible. Particular attention should be given to the possibility of congenital problems, underlying comorbid diseases, allergies, and history of adverse reaction to anesthesia previously or in the family. If there is an underlying problem related to a system, then relevant investigations must be accessed or performed before taking up SAGA if required.

Airway assessment is equally important; however, it may not be possible to do it thoroughly in neonates, infants, and young children. A history of sleep apnea and obesity might indicate a higher risk of airway obstruction during SAGA.

The main purpose of doing the above is to arrive at the ASA status of the patient and assess whether the procedure can be safely performed or not. For instance, ASA 1 and 2 patients might be taken up for sedation by trained nurses in congruence with the local protocols and higher risk patients or those with difficult airways often require pediatric anesthetists/emergency physicians trained in sedation. Also, standalone imaging centers without adequate backup from other specialties might not want to do ASA 3 or greater risk patients.

ASA Class Description

Below are the ASA class descriptions:

1. Healthy patient (no physiological, physical, or psychological abnormalities).
2. Patient with systemic disease without limitation of daily activities (e.g., controlled asthma, controlled diabetes).
3. Patient with severe systemic disease that limits daily activities.
4. Patient with an incapacitating disease that is a constant threat to life (head injury with risk of brain herniation).
5. Moribund patient not expected to survive with or without surgery.
6. A declared brain-dead patient whose organs are being removed for donor purposes.

Fasting Guidelines

The same fasting guidelines should be followed that are used for surgical cases as aspiration of the gastric contents and the consequent complications can be life threatening.

The category of patients at high risk for aspiration should be identified as this may decide the method of securing the airway during GA (supraglottic device vs. ET tube). Also, the same might indicate the need for a peri-procedure antireflux/antacid/proton-pump inhibitor prophylaxis (►**Table 2**).

Fasting Guidelines—Elective[18] Rule of 2–4-6

-No clear fluids for 2 hours prior to the procedure.
-No breast milk for 4 hours prior to the procedure.
-No solids or formula feeds for 6 hours prior to the procedure.
-Emergency procedures: Decision to proceed with sedation is based on the urgency of the procedure, depth of sedation required, and the available personnel.

Parental/Guardian Consent

The person who can give the consent varies depending on the age of the child and the national guidelines.

In India, parental/guardian consent is required for children under the age of 18 years and the consent is written and informed. The guidelines given by the Indian Council of Medical Research should be followed.

In the United Kingdom, children may be able to give consent to SAGA where they are either over 16 years (competency assumed) or of sufficient maturity that they are able to understand the procedure and give informed consent (Gillick competency). If a child aged 16 or more years does not have the capacity to consent, a person with parental responsibility can consent for them. It is essential that written and informed or verbal and informed consent is taken before the procedure is done. The mode of anesthesia, risk, and side effects should be discussed and documented in case of a verbal consent.[18]

In emergency situations, where the child is incompetent, and parents are not available the procedure and SAGA can be performed in the best interests of the patient.[21]

Sedation and General Anesthesia Drugs

The drugs used for SAGA depend on the underlying procedure, the duration, patient factors, and the local guidelines. There are numerous agents employed for this purpose

Table 2 Clinical situations predisposing to aspiration

Pathophysiology	Clinical conditions
Impaired airway reflexes	Coma, intoxications
Increased reflux	Gastroesophageal reflux disease (GERD), hiatus hernia
Acute abdomen	Appendicitis, peritonitis
Miscellaneous	Obesity, pregnancy

ranging from oral syrups, intramuscular/intravenous injections to volatile inhalational gases. A particular drug can be employed as the sole agent or in combination with drugs from other groups.

No data exist on whether a specific anesthetic technique is superior to others for MRI. Usher and Kearney[22] reported based on surveys in 11 Canadian medical institutes more than 50% use of total intravenous anesthesia with propofol for MRI. Another study conducted by Usher et al[23] demonstrated excellent airway preservation and rapid recovery using GA doses of propofol in children. Other studies have shown the safety and use of sevoflurane in infants.[24,25] Recently, dexmedetomidine has been reported to be useful even in difficult airways.[26]

The main drawback of mild to moderate sedation is its high failure rate as compared with GA which increases the number of attempts required by the radiographers and considerably adds to the scan time.

Most Used Medications

Oral

Chloral Hydrate and Triclofos

They are arguably the most frequently used sedative in infants and children under 2 years and continue to be used as the main agent for sedation in diagnostic pediatric radiology in developing countries. In recent years it has been employed even in children more than 2 years with considerable success. Parents feel more comfortable with an oral syrup for sedation for their child rather than a painful intravenous injection. As early as 1894, chloral hydrate has been used in children.[27]

Choral hydrate and triclofos are effective oral sedatives and metabolized to trichloroethanol. "Chloral hydrate has an unpleasant taste and causes gastric irritation; triclofos is more palatable but is slower and less potent (1 g triclofos = 600 mg chloral hydrate)." In a large study, approximately 2,000 children aged < 18 months received chloral hydrate (up to 100 mg/kg) without respiratory complications, but in another study, out of 854 children, 4 had airway obstruction, 11 vomited, and 6 had paradoxical reactions.[28] Chloral hydrate produces effective sedation in 80 to 90% of patients.[29] However, its unpredictable onset, long duration, lack of a reversal agent, and the possibility of the child waking up in the middle of the procedure requiring further dosages and attempts for scanning make it less than an ideal agent for sedation. Because of the abovementioned reasons, it is no longer used in some countries.

Midazolam

It is available in oral form in some countries and can be given in the dose of 0.25 to 0.5 mg/kg (max: 20 mg). It takes approximately 20 minutes to act, and the duration can last up to 60 minutes. Side effects are mentioned in ►**Tables 3** and **4**.

Monitoring

During Procedure

The operator should not be the same person responsible for monitoring the child during the procedure.[21] There should be dedicated personnel responsible for observing and recording the vitals and should be able to assist in resuscitation if required.

The vitals must be recorded continuously every 5 minutes with documentation of heart rate auscultation, oxygen saturation, capnography as appropriate, respiratory rate, and blood pressure.[30] The drugs administered with additional dosages to maintain anesthesia must also be recorded at the same time with record of adverse events if any. If contrast is given the same must be documented with exact time and dose to differentiate the allergic reaction due to contrast versus the side effects due to the anesthetic agent.

After Procedure (Recovery Area)

The vitals should be recorded every 15 minutes and documented. The child can be discharged once the desired criteria are met. The discharge advice should be given in a document that mentions the relevant phone numbers and the nearest emergency facility to contact in case of a problem.

Responsible Person

The child should be discharged from the treatment facility only when the parent, guardian, or other responsible person can stay with the patient continuously for a period of 24 hours or a greater duration till the child becomes completely normal and returns to his baseline.

Discharge Criteria

The discharge criteria to be followed depends on the local guidelines and hospital policy but all involve the mandatory requirement of stable vital signs, consciousness, and absence of adverse effects like nausea and vomiting and optimal hydration.[9,18] However, the commonly used criteria cannot be used to discharge children who have been given long-acting agents like chloral hydrate and triclofos. Malviya et al suggested that ensuring that the child can stay awake for 20 minutes when undisturbed should be a safe discharge criterion in such instances.[31]

On discharge, the responsible adult/parent should be given instructions on what to expect and how to manage the child after discharge. Children should remain under the responsible adult's supervision, and they should not participate in any activity that requires motor skills over that time. The potential problems that can arise, contact details of physicians, and the nearest available emergency services must be communicated on discharge (►**Table 5**).

Summary

With the advancements in imaging equipment and technology, availability of stronger magnets in MRI, shortened procedure time, and low threshold for imaging studies

Table 3 Intravenous and intramuscular agents

Drug	Induction dose	Maintenance dose	Onset of action	Duration	Common side effects	Comments
Propofol	6 mo to 2 y: 1 to 2 mg/kg IV > 2 y of age: 0.5 to 1 mg/kg IV bolus dose	Additional IV bolus dose 0.5 mg/kg every 3 to 5 min, up to 3 mg/kg	Within a minute	5 to 15 min after a single dose	Pain on injection, respiratory depression, apnea, airway obstruction hypotension, and/or rapid transition to deeper levels of sedation	One of the most used agents, excellent recovery profile
Ketamine	1–2 mg/kg IV 4–5 mg/kg IM	0.5 to 1 mg/kg, repeated every 5 to 10 min with IV induction	1 to 2 min (IV) 5 to 10 min (IM)	15 to 30 min (IV) 30 to 60 min (IM)	Emergence reactions, vomiting	Lesser respiratory adverse effects than propofol Produces dissociative anesthesia
Fentanyl	1 to 2 mcg/kg	0.5 to 1 mcg per kg	5 to 10 min	30 to 60 min	Vomiting, respiratory depression, chest wall rigidity	Usually given in combination with propofol
Midazolam	6 mo to 5 y: 0.05 to 0.1 mg/kg IV, > 5 y: 0.025 to 0.05 mg/kg IV, (Max dose – 2 mg in any age group)	Repeat 0.2 mg/kg per dose every 2 to 5 min up to max of 6 mg in total	1–3 min	15–60 min depending upon the total dose	Respiratory depression, apnea, paradoxical reactions like aggressiveness and crying	Provides amnesia and anxiolysis
Thiopental sodium	1 to 2 mg /kg IV	1 to 2 mg/kg every 3 to 5 min up to maximum of 6 mg/kg	Less than 1 min	15–60 min depending upon the total dose	Respiratory depression, apnea, bradycardia, hypotension	Rarely used now due to availability of better drugs
Dexmedetomidine	1 to 3 mcg/kg IV (over 10 min)	0.5 to 1 mcg/kg/h continuous infusion	5 to 10 min	30 to 70 min	Bradycardia, hypertension Hypotension with loading dose	No respiratory depression

Abbreviations: IM, intramuscular; IV, intravenous.

Table 4 Inhalational agents

Drug	Induction dose	Maintenance dose	Onset of action	Common side effects	Comments
Nitrous oxide	50 to 70% N_2O administered with oxygen through a demand valve system with scavenging capability ("Agents for pediatric sedation (not intravenous route ...") ("Agents for pediatric sedation (not intravenous route ...")	Continuous use in the same concentration	Within a minute	Nausea, vomiting, dysphoria	Provides anxiolysis, amnesia
Sevoflurane	0.5% increased slowly to up to 8% in oxygen	Requires continuous administration	Depends on the concentration used within 2 to 3 min	Respiratory depression might occur with higher concentrations	Smooth induction

Table 5 Objective discharge criteria that are commonly followed is the Modified Aldrete scoring system

Score	Activity	Circulation	Respiration	Oxygen saturation	Consciousness
2	Able to move all four limbs spontaneously or on command	BP within 20 mm Hg of preanesthesia level	Normal, can breathe deeply and cough normally	> 92% on air	Fully awake
1	Able to move two limbs spontaneously or on command	BP within 20 to 49 mm Hg of preanesthesia level	Shallow breathing, dyspnea	Needs oxygen to maintain > 90% saturation	Arousable on calling
0	No movement	BP >/< 50 mm Hg of preanesthesia level	Apnea	< 90% on oxygen	Not arousable

Abbreviation: BP, blood pressure.
Note: A score of 9 or more is required for discharge.

due to medico-legal concerns, volume of pediatric imaging studies has grown considerably over the last two decades and consequently has increased the procedures being done under sedation and GA. Every procedure that involves the use of SAGA can lead to adverse effects and complications. Therefore, to practice safe care one needs to establish and follow the local protocols[32] for preprocedure assessment, choice of drug, maintain an effective and continuous communication with the radiologist and radiographer, use appropriate monitoring, and adhere strictly to the discharge criteria. All health care providers who deliver SAGA for pediatric diagnostic imaging should be competent in airway assessment and skilled in the resuscitation of this subset of patients. There are wide variations in the techniques and personnel employed for this purpose across the world; however, the desired outcome in all countries is the same that is to deliver safe, effective SAGA with acquisition of optimal images for the correct diagnosis.

Conflict of Interest
None declared.

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