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PERSPECTIVE

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Procedural sedation and analgesia in pediatric diagnostic and interventional radiology: An expert DELPHI consensus document developed by the ITALIAN scientific society of anesthesia, analgesia, resuscitation and intensive care (SIAARTI)

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Abstract

Background: Children undergoing diagnostic and interventional radiology procedures often require sedation to achieve immobility and analgesia if the procedure is painful. In the past decades, leading scientific organizations have developed evidence-based guidelines for procedural sedation and analgesia in children outside of the operating room. Their recommendations are being applied to procedural sedation in radiology. However, some questions remain open regarding specific aspects contextualized to the radiology setting, such as elective prone sedation, the urgency of the procedure, when venous access or airway protection is required, and others.

Aims: To address the unresolved issues of procedural sedation and analgesia in pediatric diagnostic and interventional radiology.

Methods: An expert panel of pediatricians, pediatric anesthesiologists, intensivists, and neuroradiologists selected topics representative of current controversies and formulated research questions. Statements were developed by reviewing the literature for new evidence, comparing expertise and experience, and expressing opinions. Panelists' agreement with the statements was collected anonymously using the DELPHI method.

Results: Twelve evidence-based or expert opinion incorporate are presented, considering risks, benefits, and applicability.

Conclusions: This consensus document, developed by a multidisciplinary panel of experts involved in the field, provides statements to improve the quality of decision-making practice in procedural sedation and analgesia in pediatric radiology.

KEYWORDS

analgesia, diagnostic imaging, interventional, pediatric, radiology, sedation

1 | INTRODUCTION

Children undergoing diagnostic and interventional radiology procedures often require sedation to achieve immobility and analgesia if the procedure is painful. Sedatives aim to improve comfort, cooperation and limit movement. Drugs and depth of sedation depend on the radiology and individual needs, motor control is more common in younger patients or in cases of cognitive impairment, and some radiology procedure require absolute immobility. The need for analgesia is less affected to the developmental status, and sometimes pain control may allow children to remain immobile. In recent decades, several leading scientific organizations have developed guidelines for pediatric procedural sedation and analgesia outside of the operating room based on available evidence.[1–4] According to their principles, treatment efficacy and patient safety should always be ensured; the competence and experience of the team, available equipment, and correct assessment of patient risk all contribute to achieving this. When considering efficacy, nonpharmacologic techniques should be considered first, with sedatives and opioids selected based on pharmacokinetics, side effects, invasiveness, duration and urgency of the procedure. Whenever possible, the least invasive route of drug administration should be preferred.[1–3,5] Patient risk assessment should include medical history, potential difficult airway, current condition, pain, upper respiratory tract infection, and fasting status.[6] It is critical to ensure appropriate monitoring to allow early detection of any clinical changes to continue during post-procedure until completely recovery.[7] Adverse events (AEs) may occur for several reasons, sometimes as a result of an unexpected deepening of sedation; the use of opioids or multiple drugs may increase the risk.[8] All recommendations of the aforementioned guidelines are being applied to procedural sedation and analgesia in pediatric diagnostic and interventional radiology. However, there are still open questions regarding specific aspects contextualized to the radiology setting (Figure 1). In this document, a panel of experts has

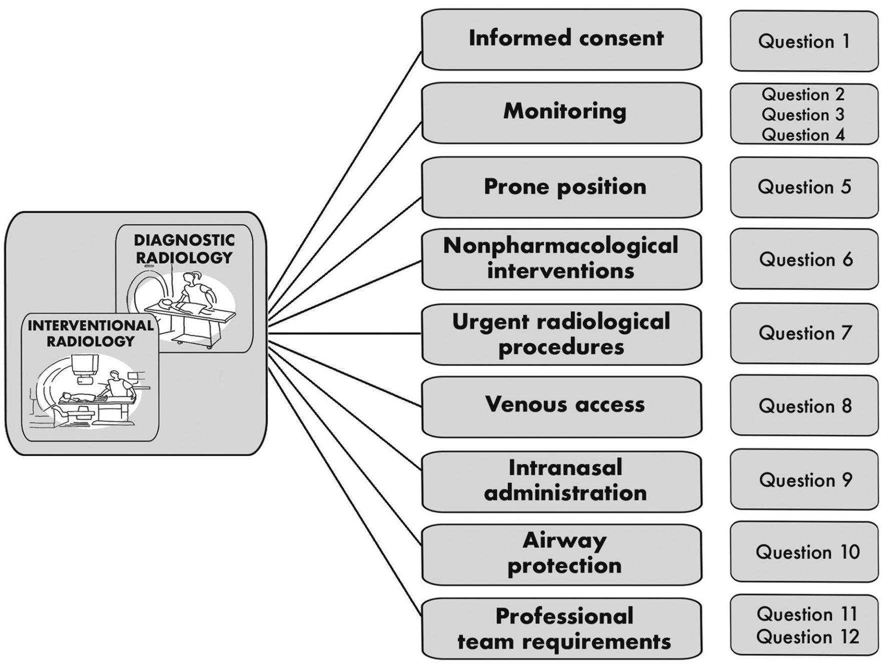

FIGURE 1 Issues addressed in the consensus document.

addressed these issues from an international perspective by reviewing the most recent literature, comparing expertise and experience, and expressing consensus opinions according to a validated methodology. The statements reported in this paper should be considered in accordance with the regulations and resources of the country and institutions.

2 | METHODS

2.1 | Selection of the expert panel

In September 2021, the Italian Scientific Society of Anesthesia, Analgesia, Resuscitation and Intensive Care (SIAARTI) appointed two coordinators with clinical and scientific experience to lead a project on procedural analgesia and sedation in diagnostic and interventional pediatric radiology. The main national societies related to this topic were invited to ensure an appropriate multidisciplinary approach. The National Scientific Societies of Anesthesia, Neonatal and Pediatric Resuscitation (SARNePI), Pediatrics (SIP), and Neuroradiology (AINR), agreed to participate and proposed their representatives based on their expertise in the field. The panel consisted of two anesthetists, five pediatric intensivists, one pediatrician, and two neuroradiologists.

2.2 | Development of research questions

The expert panel convened via videoconference in October to discuss the project and select the topics that were representative of the current controversies and open questions, which resulted in safety issues, management issues, and competence issues. Subsequently, the panel formulated the main research questions. In December 2021, consensus on the research questions was anonymously assessed via the SurveyMonkey platform, using a Likert rating scale divided into three sections: 1–3 'disagree' or 'strongly disagree', 4–6 'unsure', and 7–9 'agree'. Agreement (≥75% consensus IQR 7–9) was achieved for 12 research questions.

2.3 | Search strategy and evidence synthesis

In February 2022, literature searches were initiated using search strings identified by two external reviewers. The search terms included keywords related to the context such as 'pediatrics', 'radiology', and 'interventional radiology' as well as areas of interest such as 'intranasal', and 'vascular access', were combined with 'AND' or 'OR' (Table S1). The search was conducted using MEDLINE database in accordance with the methodology required by SIAARTI. Filters applied included article type (clinical trial, RCT, systematic review, meta-analysis, and review), publication date (within the last 10 years), age (birth-18 years), and language (English). Publications before 2012 were included for some questions. Excluded were editorials, letters, case series, case reports, and studies that included only neonates. The reviewers selected 3124 articles by title, assessed 349 for eligibility, and included 70. Subsequent searches identified 16 new relevant studies, bringing the total number of included studies to 86. A detailed description is provided in the PRISMA diagrams (Table S2).

2.4 | Formulation of the statements

The panelists were divided into three working groups in March 2022, with each group assigned four research questions to develop. Twelve statements were formulated between April 2022 and April 2023 using an evidence-based approach or expert opinion, taking into account risks, benefits, and applicability (Table 1). The coordinators collated the contributions and reformulated the overlapping content. In September 2023, DELPHI rounds were conducted to evaluate statements and receive comments. Anonymous voting was conducted via the SurveyMonkey platform, again using the Likert scale. In the first round, no agreement was reached on statement four. The coordinators reviewed the comments and proposed a new wording, which was approved in a second round of voting. Finally, the draft document was submitted to two external reviewers. The coordinators edited and added to the text as requested.

3 | RESULTS

3.1 | Question 1

What are the minimum elements required for informed consent (IC)?

3.1.1 | Statement

IC for sedation and analgesia, verbal or written, should be obtained from both or one of the child's parents/guardians in accordance with specific institutional requirement, along with a communication time appropriate to establish a therapeutic alliance and eventually involving the patient, considering their age and maturity.

3.1.2 | Rationale

Effective communication and adequate information are essential to ensure that patients fully comprehend proposed healthcare treatments. IC is the cornerstone of the care relationship and trust between patients and physicians, aligning the patient's decision-making autonomy with the physician's competence and responsibility. In the context of a therapeutic alliance, the time spent communicating and sharing between a physician and patient is considered a time of care. The IC must be conscious, truly informed, customized, understandable, specific, current and preventive, revocable, and renewable at any time.[9] Literature guidance on IC for procedural sedation and

TABLE 1 Statements.

QUESTION 1 *What are the minimum elements required for informed consent?*
Informed consent for sedation and analgesia, verbal or written, should be obtained from both or one of the child's parents/guardians in accordance with specific institutional requirement, along with a communication time appropriate to establish a therapeutic alliance and eventually involving the patient, considering their age and maturity
QUESTION 2 *What monitoring should be used to assess the presence of respiratory depression?*
Respiratory function should be assessed through pulse oximetry, and depending on the level of sedation and radiology modality, clinical observation and capnography should also be deployed for detection of respiratory depression
QUESTION 3 *What monitoring should be used to assess the level of sedation?*
To assess the level of sedation, a validated tool should be used
QUESTION 4 *What monitoring should be used to assess the presence of hemodynamic instability?*
To assess the presence of hemodynamic instability, combined pulse oximetry, electrocardiography, and blood pressure monitoring should be used.
QUESTION 5 *Which strategies and monitoring should be considered for patients in the prone position?*
To ensure safety, it is important to examine the expected functional changes in the prone position and pre-procedural conditions. A high-flow nasal cannula with a low inspired oxygen fraction should be used during the procedure and/or recovery phase. Sedation and analgesia should be performed by experienced clinicians
QUESTION 6 *Which non-pharmacological interventions should be proposed for pediatric radiology?*
Non-pharmacological interventions optimize patient care before and during radiology procedures. Active involvement of parents and team is essential. In diagnostic and interventional radiology, professionals should select interventions that are age-appropriate and evidence-supported
QUESTION 7 *Which pharmacological interventions should be used in urgent radiology procedures?*
When selecting pharmacologic interventions for urgent radiology procedures, it is important to consider the patient's perioperative risk as assessed by the ASA physical status classification, along with other patient- and procedure-related factors
QUESTION 8 *In which cases is venous access required for radiology procedures without contrast media?*
Venous access should be guaranteed for interventional radiology, diagnostic examinations with contrast media, or procedures of long duration. For patients with an ASA class >2 or other risk conditions, venous access should be planned. Otherwise, the less invasive route should be adopted on a case-by-case basis
QUESTION 9 *When is it possible to use only intranasal drug administration for diagnostic radiology?*
Intranasal administration can be successfully used for sedation during diagnostic radiology procedures. Midazolam, Ketamine, and Dexmedetomidine have been shown to effectively improve patient compliance. Evidence is stronger for short-term imaging
QUESTION 10 *In which cases is airway protection necessary during radiology?*
The decision to use airway protection devices is at the discretion of the clinician. The choice may depend on the patient, the radiology investigation, and the duration of the procedure. If a device is planned, adequate depth and monitoring are required until the device is removed and the patient has recovered from pre-sedation conditions
QUESTION 11 *What skills are necessary to ensure safe and effective outcomes during sedation in pediatric diagnostic radiology?*
The team providing sedation should have skills and experience regarding the patient medical diseases, procedure duration, and planned level of sedation. These skills should include airway management and cardiopulmonary resuscitation, maintained as part of a shared pathway among specialties within the institution
QUESTION 12 *What skills are necessary to ensure safe and effective outcomes during sedation in pediatric interventional radiology?*
To ensure effective and safe analgosedation in pediatric interventional radiology, the presence of an anesthesiologist or intensivist with pediatric experience is always necessary

analgesia in specific settings, such as pediatric radiology is lacking. However, parents should be informed of the procedural sedation purpose, benefits, and available approaches to optimize the radiology investigation, as well as the risks of AEs, sedation failure, and alternative options. If required by the national regulation, a written version of the IC should be used to obtain signatures from parents and clinicians involved. Consent for minors must be expressed or refused by the parental authority. However, their wishes should be considered proportionally to their age and maturity. It should be a right for minors to enhance their ability to understand and make decisions, as well as to receive health-related information appropriately.[10,11]

3.2 | Question 2

What monitoring should be used to assess the presence of respiratory depression?

3.2.1 | Statement

Respiratory function should be assessed through pulse oximetry, and depending on the level of sedation and radiology modality, clinical observation and capnography should also be deployed for detection of respiratory depression.

3.2.2 | Rationale

Sedatives and opioids can cause respiratory depression, especially in children due to their unique respiratory system characteristics. Children have a smaller and more collapsible upper airway, reduced lung functional residual capacity (FRC), higher oxygen consumption, and immature central respiratory drive. During sedation, patients may experience a loss of airway patency and protective airway reflexes, as well as bradypnea or apnea, and desaturation.[5,12] To monitor these events, clinicians should observe chest movements and count breath rate if the radiology modality permits it. For example, it impossible to observe patients in MRI, CT, and certain interventional procedures.[13] Therefore, a pulse oximeter should be used in all patients to noninvasively measure the oxygen saturation of hemoglobin in peripheral blood via infrared and provide information on heart rate and plethysmographic curves. In situations of low perfusion or patient movement, a 'conventional' pulse oximeter may be unreliable, and event detection may be delayed by 20–30s. The use of pulse oximetry alone to detect respiratory depression is inaccurate and significantly delayed, particularly in patients receiving supplemental oxygen.[14] Therefore, capnography should be deployed to detect early changes in ventilation, although the device may not be tolerated in minimally sedated children. Both capnometry, which measures the maximum partial pressure of carbon dioxide on expiration (end-tidal CO_2), and capnography, which tracks the graphical curve trend, should always be considered and are recommended in moderate sedation.[2,15] When measuring smaller age groups, it is important to acknowledge limitations in accuracy. Transcutaneous measurement of CO_2 may also be helpful, but it requires an equilibration time of 10min to obtain a reliable measure, making it unsuitable for routine monitoring. Furthermore, the reliability of transcutaneous measurements can be influenced by microcirculation perfusion.[16]

3.3 | Question 3

What monitoring should be used to assess the level of sedation?

3.3.1 | Statement

To assess the level of sedation, a validated tool should be used.

3.3.2 | Rationale

Sedation level monitoring is important to determine the level of sedation achieved by the patient to reach the desired goal appropriate to the needs of the radiology procedure. Several validated pediatric scales exist most of which are observational, including the Pediatric Sedation State Scale (PSSS),[17] the University of Michigan Sedation Scale (UMSS),[18,19] the Overt Agitation Sedation Scale (OASS),[20] and the Modified Observer's of Alertness/Sedation Scale (MOAA/S).[21] Instruments such as processed electroencephalography,[20,22–24] which measures the effects of GABAergic drugs through cortical electrophysiological signals, should be considered in monitoring procedures that require deep and prolonged sedation using benzodiazepines, barbiturates and propofol. However, processed EEG may not be readily available and/or not always feasible. In addition, there is currently no data on the benefits of such monitoring in improving patient outcomes.[25–27]

3.4 | Question 4

What monitoring should be used to assess the presence of hemodynamic instability?

3.4.1 | Statement

To assess the presence of hemodynamic instability, combined pulse oximetry, electrocardiography, and blood pressure monitoring should be used.

3.4.2 | Rationale

To ensure patient safety during analgosedation, it is important to maintain hemodynamic stability and proper cardiovascular function. Hemodynamic stability is indicated by minimal deviations from baseline values of parameters assessed by cardiovascular monitoring.[28] Cardiovascular function is typically preserved during moderate to deep sedation, but respiratory depression may lead to hemodynamic instability. Pulse oximetry, continuous 3-lead electrocardiography, and noninvasive interval blood pressure monitoring should be used to detect instability. If there is concern that cuff inflation to measure blood pressure is an excessive stimulus, measurement intervals should be lengthened.[1,12] The plethysmographic wave by pulse oximeter and peripheral perfusion index can contribute to hemodynamic monitoring by providing information on the peripheral vasomotor tone and peripheral flow.[29] In the case of normoventilation, a decreased EtCO2 wave value is a warning of possible cardiovascular events.[30]

3.5 | Question 5

Which strategies and monitoring should be considered for patients in the prone position?

3.5.1 | Statement

To ensure safety, it is important to examine the expected functional changes in the prone position and pre-procedural conditions. A high-flow nasal cannula with a low inspired oxygen fraction should be used during the procedure and/or recovery phase. Sedation and analgesia should be performed by experienced clinicians.

3.5.2 | Rationale

The prone position may be required by the radiologist under specific conditions to optimize visualization of organs and tissues. This position may be useful in magnetic resonance imaging (MRI) to diagnose spinal cord tethering,[31] lesions of the back wall, or computed tomography (CT) of the lungs, or even to simulate the position of structures in scoliosis in preparation for corrective surgery. In sedated patients, the prone position is associated with predictable functional changes and the risk of several complications. The prone position increases lung volume and promotes uniform distribution of lung perfusion, resulting in better ventilation/perfusion matching, oxygenation, and compliance. However, it also reduces the elasticity of the rib cage and airflow in the airway. Infants and toddlers have an increased risk of hypoventilation due to their reduced FRC and greater susceptibility to hypoventilation during sedation while spontaneously breathing.[32] Risks and benefits should be considered; obese patients or those with known critical airway may be at risk. Therefore, some authors suggest intubating the patient and applying positive end-expiratory pressure or alveolar recruitment maneuvers during sedation in the prone position.[33] High-flow nasal cannula oxygen therapy (HFNO) is suggested as an alternative to endotracheal intubation or supraglottic devices for children with healthy cardiorespiratory function.[34] HFNO provides a continuous positive pressure to prevent airway collapse, increase functional residual lung capacity, and improve CO_2 washout.[34] However, it is worth mentioning that at high fractions of inspired oxygen, lung volume decreases.[35] The use of HFNOs during MR is precluded by magnetic fields, but it could be proposed in the recovery period with a recruitment function. Regarding cardiovascular function, the prone position may reduce systolic output due to reduced preload caused by increased intra-abdominal pressure and compression of the inferior vena cava. It is crucial to ensure freedom of movement of the abdomen. Venous return and organ perfusion may be locally compromised.[36] Care should be taken to avoid rotation injury, stretching or crushing during pronation of the sedated patient.

3.6 | Question 6

Which non-pharmacological interventions should be proposed for pediatric radiology?

3.6.1 | Statement

Non-pharmacological interventions optimize patient care before and during radiology procedures. Active involvement of parents and team is essential. In diagnostic and interventional radiology, professionals should select interventions that are age-appropriate and evidence-supported.

3.6.2 | Rationale

Non-pharmacological interventions can optimize patient care by relieving anxiety, promoting coping strategies, and developing trust between patients and providers.[3,37] However, achieving a standardized approach across different settings remains a challenge. Most evidence-supported non-pharmacological interventions focus on controlling anxiety through techniques that involve active or passive patient participation.[38,39] Play therapy, such as role-playing, is a cornerstone in preparing patients for the procedure.[40–42] The easy availability of distracting programs on smartphones is widespread. Immersive exposure to virtual reality can serve as a distraction tool or as an application of cognitive-behavioral methods. Virtual exposure can provide a safe and gradual way to experience feared or unfamiliar environments. Promising study results support this approach; however, virtual exposure is expensive and not always accessible.[43,44] Research has confirmed the importance of preparation, which can be achieved through traditional methods such as booklets, videos, or information technology to inform both children and parents about the procedure. This preparation has been shown to effectively reduce the need for pharmacological intervention.[45,46] A systematic review reported that cognitive-behavioral approaches, play therapy, and preparation are associated with reduced patient distress during radiotherapy.[47] Research in infants has shown that breastfeeding and swaddling before MR allows for good-quality images without sedation.[48] In addition, infant songs accompanied by the sound of the heartbeat appear to reduce agitation during CT scans.[49]

3.7 | Question 7

Which pharmacological interventions should be used in urgent radiology procedures?

3.7.1 | Statement

When selecting pharmacologic interventions for urgent radiology procedures, it is important to consider the patient's perioperative risk as assessed by the ASA physical status classification, along with other patient- and procedure-related factors.

3.7.2 | Rationale

The approach to urgent radiology for children begins with a perioperative risk assessment, using the American Society of Anesthesiologists (ASA) physical status classification along with other patient- and procedure-related factors.[1,50] However, to evaluate complex pediatric conditions, it is necessary to improve the accuracy of definitions for pediatric-adapted ASA classes.[51,52]

ASA >2

For patients classified as ASA >2, it is also important to evaluate the presence of organ failure and consider the respiratory, cardiovascular, and neurological AEs of individual medications to maximize safety. In prolonged painless procedures, continuous infusion of drugs such as dexmedetomidine, propofol, or inhaled sevoflurane should be administered. Otherwise, a single bolus of midazolam, propofol, or ketamine should be used. If the procedure is painful or if pain is already present, opioids or ketamine should be added.[53]

ASA ≤2

For patients with ASA≤2, drug choice is mainly based on procedure-related variables such as type, duration, and invasiveness.[53]

Ketamine is effective and safe in combination with propofol. In a randomized, double-blind, controlled trial, esketamine-propofol was shown to reduce the dose of propofol and provide faster recovery compared to dexmedetomidine-propofol.[54] However, esketamine is not available/approved in all countries.[54] Propofol and thiopental increase the risk of respiratory and hemodynamic depression. Inhaled sedation requires specific equipment, vaporizers and a scavenging system. Dexmedetomidine may be a suitable alternative, due to its minimal respiratory depression and low risk of severe adverse effects (<1%).[55] However, its delayed onset and prolonged offset may pose problems in urgent settings.[56] In some cases, proper analgesic coverage may make the use of sedatives unnecessary.[57] Sedation performed in urgent conditions does not increase the risk of AEs by itself. However, the use of multiple drugs may increase the incidence of AEs.[58] It is not necessary to postpone the urgent procedure due to the fasting state. The benefits should be weighed against the risk of possible vomiting, passive regurgitation, and pulmonary aspiration; if the child is at risk due to gastrointestinal obstruction, esophageal disease, insufficient fasting duration, combined with long sedation duration, the patient should be intubated to protect the airway and lungs.[59]

3.8 | Question 8

In which cases is venous access required for radiology procedures without contrast media?

3.8.1 | Statement

Venous access should be guaranteed for interventional radiology, diagnostic examinations with contrast media, or procedures of long duration. For patients with an ASA class >2 or other risk conditions, venous access should be planned. Otherwise, the less invasive route should be adopted on a case-by-case basis.

3.8.2 | Rationale

Venous access may not be necessary if both of the following conditions are met:

1. The radiology is diagnostic, brief, and does not involve contrast media.
2. The patient has an ASA class ≤2.

The presumed difficulty of peripheral venous catheter placement, established through history or clinical objectivity (no visible, no palpable vein), should not be considered an indication to place the venous catheter. Similarly, the operator's experience should not be a factor. It should be considered whether venous access provides an advantage, taking into account the risk of emergency or other complications. If catheter placement is required, in most cases it can be accomplished quickly and easily on the first attempts in patients without comorbidities.[60] The infrared visualizer has shown little benefit in reducing the number of attempts in small patients with poor vein visibility.[61] Conversely, ultrasound can assist in ensuring vascular access.[62] Topical anesthetic applications may increase the likelihood of successful placement.[63] Alternatives to the intravenous route may include the intranasal or inhaled route. For intranasal administration, refer to the next section (question 9). Nitrous oxide and sevoflurane are frequently used to facilitate venous access placement by ensuring patient immobility.

3.9 | Question 9

When is it possible to use only intranasal drug administration for diagnostic radiology?

3.9.1 | Statement

Intranasal administration can be successfully used for sedation during diagnostic radiology procedures. midazolam, ketamine, and dexmedetomidine have been shown to effectively improve patient compliance. Evidence is stronger for short-term imaging.

3.9.2 | Rationale

Intranasal drug administration is becoming increasingly popular as an alternative to traditional routes such as intravenous, oral, inhaled, or intramuscular.[64,65] This method is preferred for elective procedural sedation and not just as a rescue technique when venous access is difficult to obtain[66,67] or when delivering anesthetic vapor through a face mask.[68] To increase efficacy, it is suggested to administer the concentrated drug via mucosal atomization device, taking into consideration the dead space and the volume not to exceed the absorption capacity per nostril. Dexmedetomidine has good intranasal bioavailability but its onset of action is slow, taking 15–20 min for doses of 2.5–3 μg/kg (with a dose range of 1–4 μg/kg).[69,70] Intranasal midazolam may cause a burning sensation, so it may be helpful to administer lidocaine beforehand.[71] The intranasal dose range for midazolam is 0.4–0.5 mg/kg, although some studies have reported efficacy at 0.2 mg/kg.[71,72] The use of ketamine via intranasal route is controversial due to its low bioavailability (8–45%) compared to intravenous (100%) and intramuscular routes (93%). The intranasal dose range for ketamine is 3–9 mg/kg, and the optimal dose is still debated.[73,74]

3.10 | Question 10

In which cases is airway protection required during radiology?

3.10.1 | Statement

The decision to use airway protection devices is at the discretion of the clinician. The choice may depend on the patient, the radiology investigation, and the duration of the procedure. If a device is planned, adequate depth and monitoring are required until the device is removed and the patient has recovered from pre-sedation conditions.

3.10.2 | Rationale

Airway patency can be compromised during procedural sedation in spontaneous breathing. Airway obstruction may result from the hypotonic effect of drugs and position during the procedure. Risk factors for airway obstruction include obesity and obstructive sleep apnea. The Mallampati score III/IV, which predicts a difficult airway, does not correlate with a higher risk of AEs during sedation.[75] To maintain upper airway patency during mild to moderate sedation, it is essential to ensure the correct position of the patient's head, and jaw advancement. Soft collars can ensure adequate retroglossal and retropalatal area size in infants.[76] Additionally, chest CT in sedated children can detect atelectasis induced by hypoventilation, which can affect diagnostic sensitivity. When sedation is necessary to perform CT without respiratory movement, lung recruitment by ventilation has been suggested.[77] To ensure recruitment maneuvers without gastric gas distension, it is suggested to use a tracheal tube rather than a laryngeal mask.[77,78] Additionally, controlling the oxygen concentration is necessary to avoid adsorption atelectasis.[78] HFNO produces minimal continuous positive pressure stabilizes the airway, promotes nasopharyngeal dead space wash-out, improves gas exchange, and reduces respiratory effort. However, the use of high-flow nasal cannula precludes the use of capnography. Additionally, there is a lack of evidence for its use in pediatric radiology. A comparison study found no differences between low and high flow rates at the same oxygen concentration during gastroscopy, although mouthpiece leakage may have interfered.[79] Conversely, a reduction in desaturations was recorded during fibro-bronchoscopy.[80] Similarly, there is insufficient evidence to support the use of nasal-CPAP or noninvasive ventilation with nasal or face mask in pediatric radiology.[81] Airway devices may increase the risk of spasms, obstruction, or cough, especially in children with recent upper respiratory tract infections or asthma.[82] The laryngeal mask has been associated with a lower incidence of respiratory AEs.[83,84] A recent study analyzing the incidence of unplanned intubation during MR found a 2% incidence and identified ASA class ≥3, prematurity, gastroesophageal reflux, and congenital heart disease as risk factors.[12]

3.11 | Question 11

What skills are necessary to ensure safe and effective outcomes during sedation in pediatric diagnostic radiology?

3.11.1 | Statement

The team providing sedation should have skills and experience regarding the patient medical diseases, procedure duration, and planned level of sedation. These skills should include airway management and cardiopulmonary resuscitation, maintained as part of a shared pathway among specialties within the institution.

3.11.2 | Rationale

In accordance with international guidelines, the team responsible for administering procedural sedation should have knowledge and expertise in the pharmacology of the drugs used, patient assessment, anesthetic risk, monitoring, management of complications, and the proposed procedure and requirements. Furthermore, it is necessary to have practical experience in the sedation approach for each level of sedation.[3] As different levels of sedation encompass a continuum, the team responsible for procedural sedation possess a comprehensive understanding and the necessary skills to manage subsequent deeper levels of sedation. When providing minimal sedation to patients with ASA class 1 or 2, it is necessary to have at least two BLS-certified providers present. For moderate sedation, one provider with PALS certification and advanced airway management expertise is required to manage the risk of deep sedation. For deep sedation or general anesthesia, it is essential to have an anesthetist or intensivist with pediatric experience present.[1] For patients with ASA class >2, regardless of the planned level of sedation, an anesthetist or intensivist with pediatric experience is always necessary. This is because such patients may show unpredictable responses to the pharmacological strategy used.[85] Additionally, the duration of sedation is an additional risk factor since the dose and number of drugs required may deepen the sedation level. To maintain team competency, the institutional organization should promote appropriate training and regular re-training by establishing educational programs shared within the hospital setting and,

TABLE 2 Strengths and weaknesses.

STRENGTHS
• All relevant specialists who deal with this issue are involved in a comprehensive approach to discuss radiological and sedation indications, possible alternative care options, and timing
• The consensus development process strictly adhered to a validated methodology. The statements are informed by the review of the latest new evidence
• The implementation of procedural sedation program is the purpose of the consensus document always pursued in terms of safety, effectiveness, in the best interest of the child
WEAKNESSES
• The research questions selected by the group do not encompass all potential issues related to this topic
• Panel specialists with proven experience in the field are from the same nation
• Only pediatric neuroradiologists, not pediatric radiologists were included in the panel
• Patients and parents/caregivers are not involved in the consensus document development process

ideally, homogeneous nationwide.[3] The simulation technique can improve the training in this setting.[86]

3.12 | Question 12

What skills are necessary to ensure safe and effective outcomes during sedation in pediatric interventional radiology?

3.12.1 | Statement

To ensure effective and safe analgosedation in pediatric interventional radiology, the presence of an anesthesiologist or intensivist with pediatric experience is always necessary.

3.12.2 | Rationale

Analgosedation appropriate for interventional radiology requires at least a moderate level of sedation to ensure comfort, immobility, and analgesia for pain management. It is important to note that due to the increased risk of respiratory and hemodynamic complications,[58] the presence of an anesthesiologist or intensivist with pediatric experience is always necessary. The institutional organization should establish educational programs for proper training and regular retraining to maintain pediatric competence. These programs should be shared within the hospital setting and, ideally, nationwide.[3,86]

4 | STRENGTHS AND WEAKNESSES

Strengths and weaknesses are given in Table 2.

CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

ETHICS STATEMENT

No ethical approval is required.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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