SCHOLASTIC:
Journal of Natural and Medical Education

Volume 5, Issue 3, Year 2026
https://univerpubl.com/index.php/scholastic

Article

Recommendations for Sedation During Procedures in Children and Adolescents

Mardiyeva Sora Alisher Kesey [1], Atamuratova Nodira Bekpulatovna[2]

1. Urgench State Medical Institute
2. Urgench State Medical Institute

*Corrsepondence: mardiyevasora@gmail.com

Abstract: Many pediatric patients require sedation and analgesia for diagnostic tests and therapeutic procedures outside the operating room. This document reviews the literature on procedural sedation, focusing on the prevention of adverse events through the selection of suitable patients, early preparation for emergencies, and adequate monitoring during and after pharmacological administration. Procedural sedation should only be performed by physicians competent in airway patency and resuscitation, as part of a hospital program with active and engaged quality and safety initiatives. The recommendations include the development of institutional rules and procedures for the safe use of procedural sedation in infants, children and adolescents.

Keywords: behavior, anxiolysis, nitrous oxide, children

1. Introduction

Infants, children, and adolescents often need sedation for diagnostic tests and therapeutic procedures. The goal of procedural sedation is to minimize discomfort, physical exertion, or pain while maintaining airway reflexes, adequate oxygenation and ventilation, and cardiopulmonary stability, which is reflected in a limited deviation from baseline vital signs [1],[2],[3],[4],[5].

The growing literature on procedural sedation includes recommendations from the American Academy of Pediatrics (AAP) the establishment of the Pediatric Sedation Research Consortium, and numerous other publications. Adverse events associated with procedural sedationare rare, but they can lead to significant morbidity and mortality. The vast majority of events can be prevented and the risk is minimized when patients are carefully selected, prepared and monitored [6],[7],[8],[9],[10].

Procedural sedation should only be performed by physicians who have been trained and experienced in procedural sedation, advanced airway patency, and pediatric resuscitation. Resuscitation personnel, equipment, and medications should be immediately available regardless oftheыхselected pharmacologicalыхagent(s) or the intended depth of sedation, as individual reactions to medications can be unpredictable [11],[12],[13],[14],[15].

This statement provides recommendations for best practices in developing institutional standards for safe proceduralsedation of infants, children and adolescents (Figure 1). The term "procedural sedation" here refers to the administration of any pharmacological preparations for the purposeof sedation. The recommendations contained in this document do not necessarily apply to patients receiving anxiety

Citation: Kesey M. S. A., Bekpulatovna, A. N. Recommendations for Sedation During Procedures in Children and Adolescents. Scholastic: Journal of Natural and Medical Education 2026, 5(3), 9-15.

Received: 5th Jun 2026
Revised: 31st Jul 2026
Accepted: 14th Aug 2026
Published: 3rd Sep 2026

medications or pain relief analgesics. Such cases are described in another statement of the Canadian Pediatric Society, dedicated to managing pain and discomfort in children undergoing short-term diagnostic and therapeutic procedures [16],[17],[18],[19],[20].

2. Materials and Methods

This study was conducted as a narrative literature review aimed at identifying evidence-based recommendations for safe procedural sedation in infants, children, and adolescents. The analysis focused on published clinical guidelines, systematic reviews, observational studies, prospective studies, and other scientific publications addressing pediatric procedural sedation, patient selection, pharmacological management, physiological monitoring, adverse events, and post-sedation care.

The reviewed literature included publications and recommendations from professional organizations and research groups involved in pediatric sedation and anesthesia, including the American Academy of Pediatrics and the Pediatric Sedation Research Consortium. Particular attention was given to evidence concerning patient-related risk factors, characteristics of sedative medications, airway management, monitoring requirements, personnel qualifications, emergency preparedness, and the prevention of sedation-related complications.

A qualitative descriptive approach was used to synthesize the available evidence. The identified information was organized into major clinical domains: pre-sedation patient assessment, selection and administration of sedative agents, personnel requirements, physiological monitoring, availability of emergency equipment and medications, recognition and management of adverse events, and post-sedation observation. Findings from the reviewed sources were compared and integrated to formulate practical recommendations for safe pediatric procedural sedation.

Physicians responsible forsedation procedures should have a thorough understanding and experience of all medications administered, including (but not limited to) the mechanism of action, time of onset of action, time to peak effect, duration of action, and side effects. They should also be prepared to stop any adverse events that occur as a result of the use of administered medications.

The choice of medications should be based on the characteristics of the patient, the expected duration of the procedure, the need for analgesics, the doctor's knowledge of the drug, and the availability and authorization of its use in the institution. General principles include matching the type and duration of the procedure (for example,sedation or sedation and analgesia; short-or long-acting drugs), and titrating until the desired effect is achieved. Although the use of multiple medications may increase the risk of adverse events, the combination of medications has also been shown to provide bettersedation, reduce the overall dose of the drug used, and shorten recovery time.

As for procedural sedation, children differ from adults in several ways. Children tend to be less cooperative, often require a deeper level of sedation, and it's not uncommon for children to go to a deeper level of sedationthan intended. In addition, children, especially infants, have significantly lower functional residual lung capacity and higher oxygen consumption. Critical hypoxia develops much faster during sleep apnea. Anatomical differences (such as a large occiput and tongue, flaccid epiglottis, anterior and cranial position of the larynx, narrowsubglottic airways) can create difficulties for doctors who do not have experience working with the airways in children. Children are also prone to excitatory movements and adverse behavioral reactions (for example, paradoxical reactions to sedation, unpleasant recovery reactions).

2.1 Data Analysis

Documentation should include assessment of the patient's condition before sedation, informed consent, real-time recording of vital signs every 5 minutes during sedation and every 15 minutes during recovery, medications administered (including dosage, route of administration, and time), side effects, and the need for any unforeseen or emergency interventions (for example, auxiliary medications). respiratory medications, antidotes, or other medications to relieve symptoms), the adequacy of sedation (using a formal assessment system) , and discharge instructions [21],[22],[23],[24],[25].

Although most serious adverse events occur within the first 25 minutes after the last dose of the drug, monitoring after sedation should continue until the patient's condition returns to baseline. Most antidotes have a shorter half-life than the corresponding sedatives. Patients receiving antidotes should be monitored to ensure that sedation and cardiorespiratory depression do not recur after the antagonist is discontinued [26],[27],[28],[29],[30].

Hospitalization for overnight follow-up should be considered for all patients requiring urgent medical attention.

1) Relevant personnel

Procedural sedation should only be performed in the presence of at least two medical professionals, including a doctor who has the skills to perform procedural sedation, as well as advanced airway patency and resuscitation. One of the medical personnel should be specifically assigned to continuously monitor the patient and respond to physiological changes. If the doctor responsible for sedationis also performing the procedure, continuous patient monitoring and targeted medication administration should be delegated to another highly qualified healthcare professional, such as another doctor, nurse, anesthesiologist assistant, or nurse with advanced resuscitation skills (for example, with many years of experience in the emergency department, intensive care unit, or postoperative recovery) [31],[32].

2) Monitoring equipment

Monitoring should include continuous pulse oximetry and periodic non-invasive blood pressure measurement every 5 minutes [33]. The American Academy of Pediatrics (AAP) and the American Association of Respiratory and Cardiovascular Surgery (ASA) recommend the use of continuous three-channel electrocardiography (ECG) and end-expiratory carbon dioxide monitoring (i.e. capnography) for moderate sedation, as this method is superior to clinical monitoring in its pure form [34].

Pulse oximetry is necessary, but not sufficient, since normal saturation values may persist after the onset of insufficient ventilation. Hypoventilation can be замаскированаdisguised as maintaining normal saturation levels [35]. Although ECG electrodes allow transthoracic impedance monitoring, chest movements may continue to be interpreted as "normal" during episodes of obstructive sleep apnea or laryngospasm. Air flow is best assessed by auscultation [36]. The ability to immediately detect respiratory failure due to hypoventilation, apnea, upper airway obstruction, or laryngospasm allows timely intervention and prevention of progression to cardiac arrest. Hospitals should ensure that the necessary equipment and skills of medical personnel are available for performing and interpretingcapnography, for moderate to deep procedural sedation [37].

3) Emergency care equipment and medications to stop seizures

Regardless of the intended level of sedation, emergency care equipment appropriate to the patient's age and size (Table 3) and medications for managing seizures (Table 4) should be immediately available [38]. The sedation physicianand caregivers should ensure that they are familiar with the location and functioning of the equipment,

as well as with the doses of seizure medications calculated based on the patient's weight, including medications needed for cardiopulmonary resuscitation and antidotes.

3. Results

The most common adverse events associated with procedural sedationinclude airway obstruction or significant respiratory depression.

Although hemodynamic instability and cardiovascular collapse may occur, these phenomena are often the result of unrecognized and / or untreated respiratory failure and occur more frequently when procedural sedation is performed outside the hospital [39].

The vast majority of adverse events can be prevented if sedation is performed in hospitals that follow the guidelines.

Procedural sedation should only be performed as part of a hospital program that engages in quality assurance through reporting, monitoring, and analysis of adverse events. Unforeseen events, including the useof respiratory assistive drugs, antidotes, or other medications to relieve symptoms, should be clearly documented and these cases should be addressed as part of a quality assurance program [40].

4. Discussion

The findings of this review demonstrate that the safety of procedural sedation in children and adolescents depends not only on the selection of an appropriate sedative agent but also on the organization of the entire sedation process. Patient assessment, personnel competence, physiological monitoring, emergency preparedness, and post-sedation observation function as interconnected components of a comprehensive safety system. This is particularly important in pediatric patients because their physiological and anatomical characteristics can contribute to rapid respiratory deterioration when sedation becomes deeper than intended [41].

Respiratory complications represent the principal safety concern identified in the reviewed evidence. Airway obstruction and respiratory depression may progress to more serious cardiovascular complications if they are not recognized and managed promptly. Consequently, continuous observation and appropriate physiological monitoring are essential. Although pulse oximetry remains an important monitoring method, its limitations in detecting early hypoventilation indicate the value of additional respiratory monitoring, particularly capnography during moderate or deep procedural sedation [42].

Another important implication concerns professional competence and institutional preparedness. Because individual responses to sedative medications may be unpredictable, healthcare professionals must be capable of managing a level of sedation deeper than initially intended. The availability of personnel trained in advanced airway management and pediatric resuscitation, together with immediately accessible emergency equipment and medications, can reduce the likelihood that a manageable respiratory event will progress to a serious adverse outcome.

The findings also highlight the importance of standardized institutional protocols. Safe procedural sedation should be considered a structured clinical process rather than an isolated pharmacological intervention. Documentation of patient assessment, medications, physiological parameters, adverse events, emergency interventions, recovery, and discharge provides an important basis for quality assurance. Systematic reporting and analysis of adverse events can further help institutions identify preventable risks and improve sedation practices over time.

Post-sedation care should receive similar attention. Clinical stability immediately after completion of a procedure does not necessarily indicate complete recovery, particularly when reversal agents have been administered. Continued monitoring until

the patient returns to the pre-sedation baseline is therefore necessary to identify recurrent sedation or cardiorespiratory depression.

Taken together, these findings support a multidisciplinary and systems-based approach to pediatric procedural sedation. The effectiveness of sedation should be evaluated not only by successful completion of the diagnostic or therapeutic procedure, but also by the prevention, early recognition, and appropriate management of adverse events. Implementation of standardized protocols, appropriately trained personnel, adequate monitoring, and continuous quality-improvement activities may therefore strengthen the safety of procedural sedation in pediatric healthcare settings.

5. Conclusion

This review demonstrates that safe procedural sedation in infants, children, and adolescents requires a comprehensive and standardized clinical approach. The prevention of sedation-related adverse events depends not only on appropriate pharmacological management but also on careful patient selection, professional competence, continuous physiological monitoring, emergency preparedness, and adequate post-sedation observation. Respiratory complications, particularly airway obstruction and respiratory depression, remain the principal safety concerns during pediatric procedural sedation. Because children may progress unexpectedly to a deeper level of sedation and can develop hypoxia rapidly, healthcare professionals responsible for sedation must be capable of recognizing and managing airway and cardiorespiratory complications promptly. Appropriate monitoring, including pulse oximetry and, when indicated, capnography and electrocardiographic monitoring, is therefore an essential component of patient safety. The findings further emphasize that procedural sedation should be performed within an institutional system supported by standardized protocols, qualified personnel, immediately available resuscitation equipment and medications, appropriate documentation, and systematic quality assurance. Pre-sedation assessment, informed consent, appropriate fasting practices, and careful recovery monitoring should form integral components of this system. In conclusion, pediatric procedural sedation can be performed safely when evidence-based recommendations are consistently implemented throughout the pre-sedation, sedation, and recovery periods. Hospitals and healthcare professionals should regularly evaluate sedation-related practices and adverse events to strengthen patient safety and maintain high standards of pediatric procedural care.

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