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## Original Research

### Efficacy and Safety of Midazolam Versus Ketamine for Paediatric Imaging: A Comparative Study

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#### ABSTRACT

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**Background:** Paediatric imaging often requires sedation to minimize movement and obtain diagnostic-quality images. Midazolam and ketamine are commonly used agents, but their comparative efficacy, recovery characteristics, and safety profiles may differ.

**Methods:** A prospective comparative observational study was conducted from August 2025 to April 2026 among 240 paediatric patients requiring sedation for diagnostic imaging. Participants were equally allocated to a midazolam group (n = 120) and a ketamine group (n = 120). The primary outcome was successful completion of imaging without significant movement or rescue sedation. Secondary outcomes included time to adequate sedation, recovery time, physiological stability, and sedation-related adverse events.

**Results:** Successful imaging completion was achieved in 105 (87.5%) patients in the midazolam group and 113 (94.2%) in the ketamine group, although the difference was not statistically significant ( $p = .071$ ). Ketamine produced a significantly faster onset of adequate sedation than midazolam ( $6.9 \pm 2.1$  vs.  $8.6 \pm 2.4$  minutes;  $p < .001$ ). Recovery was significantly shorter with midazolam ( $38.4 \pm 9.7$  vs.  $43.7 \pm 10.8$  minutes;  $p < .001$ ). Oxygen desaturation occurred in 4.2% and 2.5% of patients, respectively ( $p = .475$ ).

**Conclusion:** Both midazolam and ketamine provided effective and clinically acceptable sedation for paediatric imaging. Ketamine offered faster sedation onset, whereas midazolam provided faster recovery, supporting individualized sedative selection based on patient and procedural requirements.

**Keywords:** Paediatric Imaging, Midazolam, Ketamine, Sedation

## INTRODUCTION

Pediatric diagnostic imaging often requires the child to remain still for a sufficient period to obtain diagnostically acceptable images. Movement, anxiety, fear of unfamiliar equipment, and difficulty understanding instructions may lead to motion artefacts, repeated examinations, prolonged imaging time, or incomplete studies. These challenges are particularly relevant during magnetic resonance imaging (MRI), computed tomography (CT), and other prolonged or technically demanding radiological procedures. Although non-pharmacological approaches such as parental presence, behavioural preparation, distraction, and sleep-based techniques may reduce the need for medication in selected children, sedation remains necessary for some patients who cannot cooperate adequately.<sup>[1-3]</sup> The primary objectives of paediatric procedural sedation are to maintain patient safety, minimize anxiety and discomfort, facilitate immobility, and allow completion of the diagnostic examination while ensuring an appropriate and timely recovery. Sedation in radiology requires particular attention because the child may be physically separated from the clinical team during imaging, while access to the patient can be restricted, especially in the MRI environment. Consequently, appropriate patient selection, pre-sedation assessment, continuous monitoring, airway preparedness, and trained personnel are essential components of safe pediatric sedation.<sup>[4]</sup> Current American Academy of Pediatrics recommendations emphasize systematic pre-procedure assessment, appropriate monitoring, airway-rescue capability, and dedicated recovery facilities for children receiving sedation. Midazolam is a short-acting benzodiazepine widely used in pediatric practice because of its anxiolytic, sedative, amnestic, and

anticonvulsant properties. It can be administered through several routes, including oral, intranasal, and intravenous routes, which makes it practical in children who may be distressed or unwilling to accept intravenous access. However, midazolam has limited analgesic properties and may provide inadequate or inconsistent sedation when used as a sole agent for procedures requiring prolonged immobility. Studies involving children undergoing imaging have reported variable

sedation success with midazolam, highlighting the importance of selecting an appropriate regimen according to the procedure and characteristics of the child.<sup>5,6</sup> Ketamine differs pharmacologically from midazolam and produces dissociative sedation with analgesic and amnestic effects while generally maintaining spontaneous respiration and protective airway reflexes. These properties have made ketamine an important option for pediatric procedural sedation, particularly when cooperation is limited or analgesia may be beneficial. Ketamine has also been investigated specifically in radiological procedures, with studies demonstrating high rates of successful completion of short interventional imaging procedures.<sup>7</sup> Nevertheless, ketamine may be associated with increased secretions, nausea, vomiting, emergence reactions, and changes in cardiovascular parameters, necessitating appropriate monitoring and trained personnel.<sup>[8,9]</sup>

Evidence comparing these agents in pediatric imaging is not entirely consistent. A randomized clinical trial involving children undergoing CT reported that a combination of oral midazolam and ketamine produced a higher rate of adequate sedation than oral midazolam alone, although neither regimen achieved an optimal success rate for all patients.<sup>[10]</sup> Similarly, studies evaluating midazolam–ketamine combinations have reported improved behavioral cooperation and ease of separation from parents compared with midazolam alone.<sup>[11]</sup> However, the use of combination regimens may introduce additional pharmacological considerations, and current guidance recommends careful matching of sedative selection to the intended depth and purpose of sedation. The choice between midazolam and ketamine should therefore consider not only sedation success but also onset of sedation, hemodynamic and respiratory stability, duration of the imaging examination, recovery characteristics, adverse events, and overall procedural efficiency. Previous investigations in pediatric MRI have demonstrated that different sedative approaches can achieve satisfactory imaging conditions, but differences in recovery and adverse-effect profiles remain clinically important.<sup>[12,13]</sup> Moreover, contemporary reviews emphasize that sedation for pediatric MRI should be individualized according to patient characteristics, imaging

requirements, institutional resources, and the availability of appropriately trained personnel. Despite the widespread use of both midazolam and ketamine, comparative evidence specifically addressing their efficacy and safety during pediatric radiological imaging remains limited, particularly across different imaging settings. Therefore, the present study was undertaken to compare the efficacy and safety of midazolam versus ketamine for pediatric imaging procedures, with particular emphasis on sedation success, hemodynamic and respiratory stability, adverse events, recovery time, and successful completion of the scheduled imaging examination. Such evidence may assist radiology and sedation teams in selecting an appropriate pharmacological strategy while maintaining patient safety and diagnostic image quality.

## MATERIALS AND METHODS

**Study Design and Setting:** A prospective comparative observational study was conducted to evaluate the efficacy and safety of midazolam versus ketamine for sedation during pediatric imaging procedures in a radiology department. The study was conducted over a period of 9 months, from August 2025 to April 2026, at the participating hospital's radiology department.

**Study Population and Sample Size:** The study included 240 pediatric patients who required pharmacological sedation to complete a scheduled diagnostic imaging examination. Participants were allocated into two groups: Group A (midazolam, n = 120) and Group B (ketamine, n = 120). Children were included based on the need for sedation to achieve adequate immobilization and successful completion of the planned imaging procedure.

**Eligibility Criteria:** Children requiring sedation for diagnostic imaging were eligible for inclusion. Patients were excluded if they had a known allergy or contraindication to either study medication, significant uncontrolled cardiorespiratory disease, severe systemic illness requiring intensive care, or incomplete clinical or monitoring records.

**Sedation Procedure:** After pre-sedation assessment, including relevant medical history, physical examination, and baseline vital signs, the selected sedative was administered according to the institutional pediatric sedation protocol and the child's clinical requirements. Group A received midazolam, whereas Group B received ketamine. Drug administration and dosing were determined by the responsible physician according to age, body weight, clinical condition, imaging modality, and institutional protocol. Continuous monitoring was maintained throughout the sedation and imaging procedure.

**Outcome Measures:** The primary outcome was sedation efficacy, assessed by successful completion of the

planned imaging examination without significant movement or the need for rescue sedation. Secondary outcomes included time to adequate sedation, duration of the procedure, recovery time, hemodynamic and respiratory stability, and sedation-related adverse events, including oxygen desaturation, nausea/vomiting, excessive secretions, agitation, or other clinically significant events.

**Patient Monitoring and Recovery:** Heart rate, respiratory rate, oxygen saturation, and blood pressure were monitored before, during, and after sedation. Appropriate airway equipment, oxygen supplementation, and emergency medications were kept immediately available. Following completion of imaging, children were observed in a designated recovery area until they achieved clinically acceptable recovery criteria and were considered suitable for discharge from the sedation unit.

**Statistical Analysis:** Data were entered into a statistical software package and analyzed using descriptive and inferential statistics. Continuous variables were expressed as mean  $\pm$  standard deviation, while categorical variables were presented as frequencies and percentages. The efficacy and safety outcomes of the midazolam and ketamine groups were compared using appropriate statistical tests, including the independent-samples *t* test or Mann–Whitney *U* test for continuous variables and the chi-square or Fisher's exact test for categorical variables. A two-sided *p* value  $< .05$  was considered statistically significant.

## RESULTS

A total of 240 paediatric patients requiring pharmacological sedation for diagnostic imaging were enrolled between August 2025 and April 2026. As shown in Figure 1, participants were equally divided into two groups: 120 (50.0%) received midazolam (Group A), while 120 (50.0%) received ketamine (Group B). The two groups were subsequently compared in terms of sedation efficacy, time to achieve adequate sedation, recovery characteristics, physiological stability, and sedation-related adverse events.

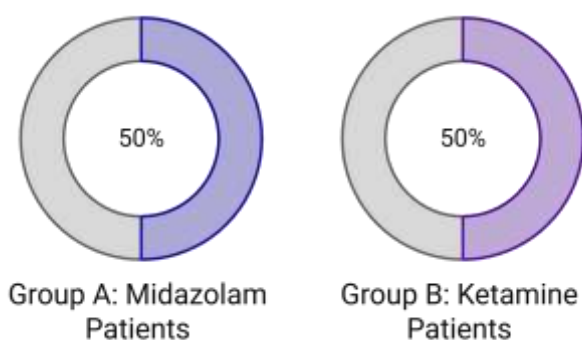


**Figure 1. Paediatric Sedation Study Enrolment**

**Sedation Efficacy:** As presented in Figure 2, successful completion of the scheduled imaging examination without significant patient movement or the need for rescue sedation was achieved in 105 (87.5%) children in the midazolam group and 113 (94.2%) in the ketamine group. Although ketamine demonstrated a higher numerical rate of procedural success, the difference between the groups was not statistically significant ( $p = .071$ ). These findings indicate that both sedative agents provided adequate conditions for successful paediatric imaging, with a modest numerical advantage for ketamine.

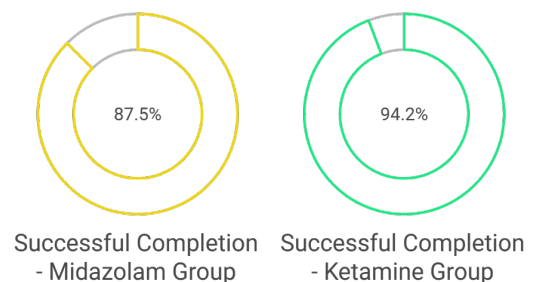


**Figure 2. Sedation Efficacy in Paediatric Imaging**

**Onset of Adequate Sedation:** As shown in Figure 3, the mean time required to achieve adequate sedation was shorter in the ketamine group than in the midazolam group. Children receiving midazolam achieved adequate sedation in  $8.6 \pm 2.4$  minutes, compared with  $6.9 \pm 2.1$  minutes among those receiving ketamine. This difference was statistically significant ( $p < .001$ ), demonstrating a significantly faster onset of adequate sedation with ketamine. The relatively narrow variability observed in both groups suggests a consistent sedation response across participants.

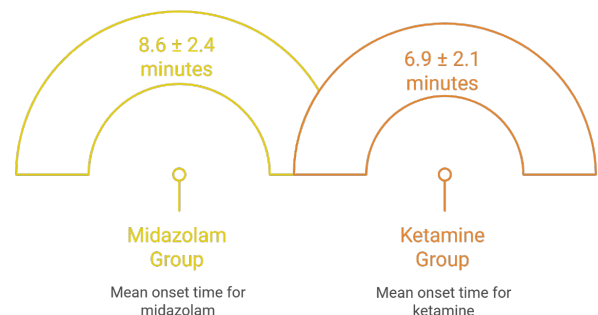


**Figure 3. Onset of Adequate Sedation**

**Recovery Characteristics:** A clear difference in recovery duration was observed between the two treatment groups (Figure 4). The mean recovery time was  $38.4 \pm 9.7$  minutes among children who received midazolam, compared with  $43.7 \pm 10.8$  minutes among those who received ketamine. The difference was statistically

significant ( $p < .001$ ), indicating that recovery was approximately 5.3 minutes longer following ketamine administration. Nevertheless, both groups achieved satisfactory recovery, and no child required prolonged ventilatory support or intensive-care intervention.

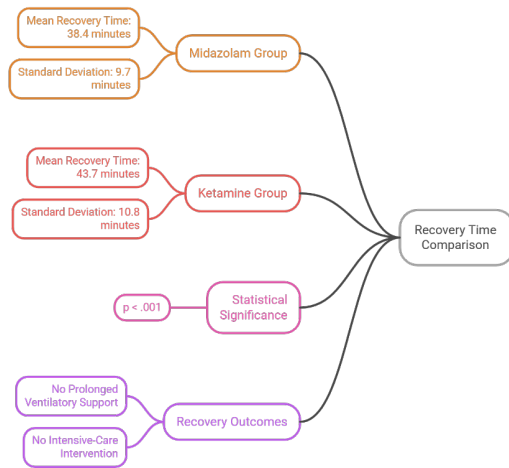


**Figure 4. Recovery Time Comparison: Midazolam vs. Ketamine**

**Physiological Stability:** As presented in Figure 5, cardiorespiratory parameters remained generally stable throughout sedation and recovery in both groups. Transient increases in heart rate and blood pressure were observed more frequently among children receiving ketamine, while clinically significant respiratory events were uncommon. Oxygen desaturation occurred in 5 (4.2%) children in the midazolam group and 3 (2.5%) in the ketamine group. Although desaturation was numerically more frequent with midazolam, the difference was not statistically significant ( $p = .475$ ). Overall, both sedative groups demonstrated an acceptable physiological safety profile under continuous monitoring.

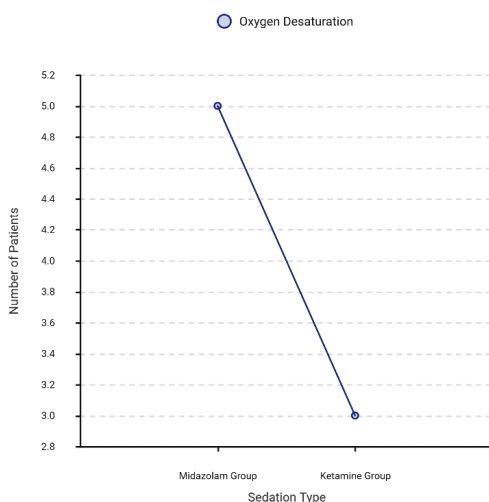


**Figure 5. Oxygen Desaturation Events During Sedation.**

Oxygen desaturation events were slightly more frequent in the midazolam group compared to the ketamine group, though the difference was not statistically significant.

**Sedation-Related Adverse Events:** Adverse events were documented in 18 (15.0%) patients receiving midazolam and 22 (18.3%) patients receiving ketamine (Figure 6). The overall difference in adverse-event frequency was not statistically significant ( $p = .482$ ). The pattern of adverse events differed between the groups. Nausea and vomiting were observed more frequently among patients receiving ketamine, whereas inadequate sedation and paradoxical agitation were relatively more prominent among patients receiving midazolam. No serious adverse event requiring endotracheal intubation or prolonged ventilatory support was reported.

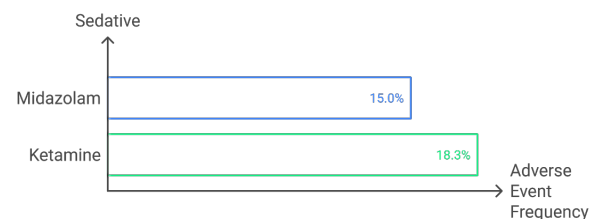


**Figure 6. Sedation Related Adverse Events**

As summarized in Table 1, both midazolam and ketamine provided effective sedation for paediatric imaging, but each demonstrated different advantages. Ketamine achieved adequate sedation more quickly and showed a higher numerical rate of successful imaging completion, whereas midazolam resulted in a shorter recovery time. The overall frequency of adverse events was similar between the groups and was not statistically significant. These findings suggest that the choice of sedative should consider the child's condition, imaging requirements, expected recovery time, and available monitoring facilities.

**Table 1. Comparison of Sedation Outcomes Between the Midazolam and Ketamine Groups**

| Outcome                                        | Midazolam (n=120) | Ketamine (n=120) | p-value |
|------------------------------------------------|-------------------|------------------|---------|
| Successful imaging completion, n (%)           | 105 (87.5)        | 113 (94.2)       | .071    |
| Time to adequate sedation, mean $\pm$ SD (min) | 8.6 $\pm$ 2.4     | 6.9 $\pm$ 2.1    | <.001   |
| Recovery time, mean $\pm$ SD (min)             | 38.4 $\pm$ 9.7    | 43.7 $\pm$ 10.8  | <.001   |

|                            |           |           |      |
|----------------------------|-----------|-----------|------|
| Oxygen desaturation, n (%) | 5 (4.2)   | 3 (2.5)   | .475 |
| Any adverse event, n (%)   | 18 (15.0) | 22 (18.3) | .482 |

The findings show that ketamine had a faster onset of sedation, while midazolam allowed faster recovery. The two groups had comparable rates of adverse events, indicating that both medications can be used for pediatric imaging when appropriate sedation protocols, continuous monitoring, and emergency facilities are available.

## DISCUSSION

The present comparative study of 240 children demonstrated that both midazolam and ketamine provided clinically acceptable sedation for diagnostic imaging. Ketamine achieved adequate sedation significantly faster than midazolam ( $6.9 \pm 2.1$  vs.  $8.6 \pm 2.4$  minutes) and showed a numerically higher imaging completion rate (94.2% vs. 87.5%), although the latter difference was not statistically significant. These findings suggest that ketamine may be advantageous when rapid onset and reliable immobilization are important. Previous paediatric imaging studies similarly indicate that sedation efficacy is influenced by the drug, route of administration, and procedural requirements. Midazolam was associated with significantly shorter recovery time than ketamine ( $38.4 \pm 9.7$  vs.  $43.7 \pm 10.8$  minutes). This may be clinically relevant because recovery duration affects patient turnover, staffing, and recovery-area utilization. Thus, the longer recovery associated with ketamine should be balanced against its faster onset and potentially more reliable procedural conditions.

The cardiorespiratory safety profiles of both agents were acceptable. Oxygen desaturation occurred in 4.2% of children receiving midazolam and 2.5% receiving ketamine, with no significant difference. Overall adverse events were also comparable (15.0% vs. 18.3%). Ketamine was associated with relatively more nausea and vomiting, whereas inadequate sedation and paradoxical agitation were more frequent with midazolam. Contemporary evidence supports the generally favorable respiratory safety of ketamine, while also highlighting potential gastrointestinal adverse effects. Recent evidence involving dexmedetomidine and combination regimens further emphasizes that no single sedative is universally superior for pediatric imaging. Sedation selection should therefore consider age, weight, anxiety, comorbidities, airway status, imaging modality, examination duration, and institutional expertise. Appropriate monitoring, airway

preparedness, and structured recovery remain essential regardless of the agent used. Overall, ketamine may be preferable when rapid onset and effective immobilization are prioritized, whereas midazolam may be suitable when shorter recovery is the primary consideration.

**Limitation:** The study has several limitations. The sample consisted of 240 children from a defined clinical setting, which may limit generalizability to other institutions and patient populations. Variations in imaging modality, procedure duration, age, and individual response to sedation may also have influenced the outcomes. In addition, the study did not evaluate long-term behavioral outcomes or compare different routes and doses of the medications. Larger multicenter randomized studies using standardized sedation scales, clearly defined dosing protocols, and imaging-specific subgroup analyses would provide stronger evidence regarding the comparative effectiveness of midazolam and ketamine.

## CONCLUSION

This study demonstrates that both midazolam and ketamine can provide effective and clinically acceptable sedation for paediatric imaging. Ketamine showed a faster onset of adequate sedation and a higher procedural success rate, whereas midazolam was associated with shorter recovery. Overall adverse events were comparable between the groups. The findings support individualized sedative selection based on the child's clinical condition, imaging requirements, expected procedure duration, and available monitoring facilities. Appropriate pre-sedation assessment, continuous physiological monitoring, airway preparedness, and structured recovery remain essential to ensure safe and successful paediatric imaging.

## DECLARATION

**Ethics Approval and Consent to Participate:** The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the departmental scientific committee, prior to the commencement of the study. Written informed consent was obtained from all participants before data collection.

**Availability of Data and Materials:** The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

**Competing Interests:** The authors declare that they have no competing interests.

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**Authors' Contributions:** All authors contributed significantly to the conception and design of the study, data collection, analysis, and interpretation of data. All authors participated in drafting and revising the manuscript and approved the final version for publication.

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## REFERENCES

1. Coté CJ, Wilson S; American Academy of Pediatrics; American Academy of Pediatric Dentistry. Guidelines for monitoring and management of pediatric patients before, during, and after sedation for diagnostic and therapeutic procedures. *Pediatrics*. 2019;143(6):e20191000. AAP Publications
2. Arthurs OJ, Sury M. Anaesthesia or sedation for paediatric MRI: advantages and disadvantages. *Curr Opin Anaesthesiol*. 2013;26(4):489-494. PubMed
3. Aldahmashi K, et al. Paediatric MRI under sedation: is it necessary? What is the evidence for the alternatives? *Pediatr Radiol*. 2011;41:111-117. PubMed
4. American Academy of Pediatrics; American Academy of Pediatric Dentistry. Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: update 2016. *Pediatrics*. 2016;138(1):e20161212. AAP Publications
5. Jain K, Ghai B, Saxena AK, Saini D, Khandelwal N. Efficacy of two oral premedicants: midazolam or a low-dose combination of midazolam-ketamine for reducing stress during intravenous cannulation in children undergoing CT imaging. *Paediatr Anaesth*. 2010;20(4):330-337. PubMed
6. Parker RI, Mahan RA, Giugliano D, Parker MM. Efficacy and safety of intravenous midazolam and ketamine as sedation for therapeutic and diagnostic procedures in children. *Pediatrics*. 1997;99(3):427-431. PubMed
7. Sury MRJ, Hatch DJ, Deeley T, Dicks-Mireaux C, Chong WK. Development of a nurse-led sedation service for pediatric imaging. [Relevant pediatric imaging sedation literature].
8. Green SM, Roback MG, Kennedy RM, Krauss B. Clinical practice guideline for emergency department procedural sedation with ketamine: 2011 update. *Ann Emerg Med*. 2011;57(5):449-461.
9. Green SM, Li J. Ketamine in adults: what emergency physicians need to know about patient selection and adverse events. *Ann Emerg Med*. 2011;57(5):449-461.
10. Khajeh M, et al. Oral midazolam-ketamine versus midazolam alone for procedural sedation of children undergoing computed tomography: a randomized clinical trial. *Arch Acad Emerg Med*. 2015;3(2):67-72. PubMed
11. Schulte-Uentrop L, Goepfert MS. Anaesthesia or sedation for MRI in children. *Curr Opin Anaesthesiol*. 2010;23(4):513-517. PubMed
12. Salman JM, Al-Asadi JN, Abdul-Ra'oof HH, Ahmed JH, Reshak AH. Comparison of intramuscular versus intravenous ketamine for sedation in children undergoing magnetic resonance imaging examination. *Wiad Lek*. 2023;76(1):198-204. PubMed
13. Kim J, et al. Drug selection for sedation and general anesthesia in children undergoing ambulatory magnetic resonance imaging. *Yeungnam Univ J Med*. 2020;37(3):201-207. PubMed

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