RESEARCH PAPER

Effectiveness of Low-dose Intravenous Dexmedetomidine, Ketamine and Nalbuphine in Preventing Emergence Agitation After Sevoflurane Anaesthesia in Children Undergoing Adenotonsillectomy: A Randomized Controlled Trial

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ABSTRACT

Background and Aims

Pediatric patients who receive sevoflurane anesthesia after adenotonsillectomy frequently experience emergence agitation. The study evaluated the effectiveness of low-dose intravenous dexmedetomidine and nalbuphine and ketamine for emergence agitation prevention.

Methods

We assigned 75 children who underwent adenotonsillectomy to three treatment groups which received dexmedetomidine 0.25 µg/kg or nalbuphine 0.1 mg/kg or ketamine 0.25 mg/kg. We measured emergence agitation using the PAED scale. The team documented pain levels using the FLACC scale while sedation levels were evaluated through the Ramsay scale and they monitored hemodynamic measurements together with rescue analgesia and complications.

Results

The study found that dexmedetomidine decreased emergence agitation rates more than nalbuphine and ketamine which resulted in 12% and 28% and 36% rates of emergence agitation ($p < 0.001$). Nalbuphine and ketamine produced lower postoperative pain scores ($p = 0.001$). The research found that dexmedetomidine caused people to experience more sedation without making them take longer to recover. The study showed stable hemodynamic patterns throughout the procedure. The ketamine group required the highest amount of rescue fentanyl which reached statistical significance ($p = 0.04$).

Conclusion

Low-dose dexmedetomidine proves to be more effective in preventing emergence agitation than nalbuphine and ketamine which both provided better pain relief. All agents showed safety for use.

Keywords: Emergence agitation, Pediatric anesthesia, Dexmedetomidine, Ketamine, Nalbuphine, Adenotonsillectomy.

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INTRODUCTION

Emergence agitation (EA) refers to a behavioral disorder which develops in patients who recover from general anesthesia. The disorder affects children who receive sevoflurane anesthesia. The condition shows itself through symptoms which include restlessness, crying, confusion and disorientation. (5) The incidence of the condition varies between 10% and 80% while preschool children face the highest risk of development.

The surgical procedure of adenotonsillectomy results in higher rates of emergence agitation because it causes patients to experience airway irritation and pain and rapid recovery from anesthesia. The condition of emergence agitation usually resolves itself but it has potential to cause various medical issues which include bleeding, dislodged catheters, blocked airways and extended time in the recovery room.

The three drugs dexmedetomidine and ketamine and nalbuphine show potential to decrease emergence agitation through their distinct neuropharmacological effects. (2) Research studies which compare different low-dose treatments for the same group of children undergoing surgical procedures have not been conducted.

The study assessed three different medical agents to evaluate their effectiveness at preventing emergence agitation after children underwent adenotonsillectomy.

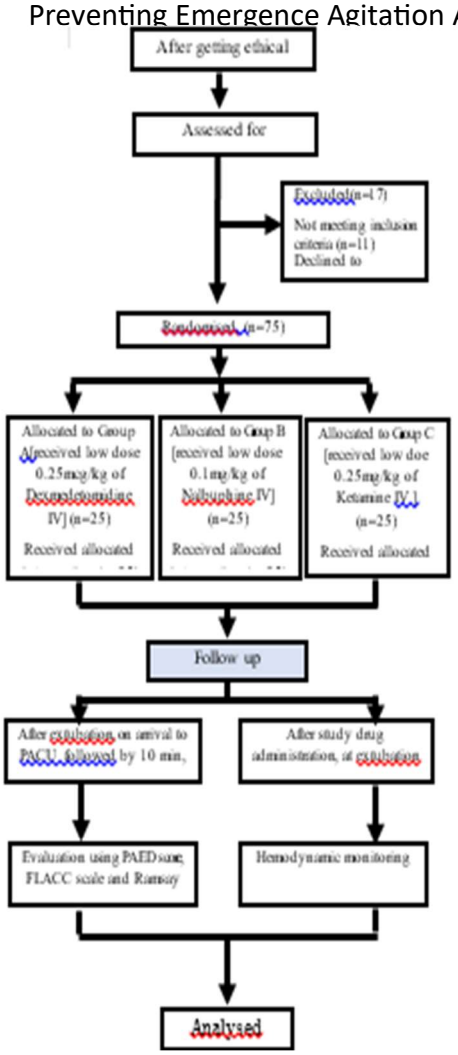
MATERIALS AND METHODS

This was a single-center, hospital-based, prospective, randomized double blinded controlled trial conducted in the Department of Anesthesiology on children's undergoing Adenotonsillectomy admitted under the department of Otorhinolaryngology, Aarupadai Veedu Medical College and Hospital, Puducherry, India between July 2024 and December 2025. The study was approved by institutional Human Ethics Committee (IHEC) with reference number AV/IHEC/01/2024/022 dated 07/06/2024 and registered with CTRI (CTRI/2025/01/078947). The participants parents were given the Participant Information Sheet in their native language, and its contents were verbally explained to ensure their understanding and satisfaction. Enrolment into study proceeded upon receipt of written informed consent. Study population included were Children aged 3–10 years of age, of both gender, who needed elective adenotonsillectomy with inclusion criteria ASA I–II, Weight 15–35 kg and surgery duration 60–90 min. Exclusion criteria were developmental delay, Bleeding disorders and parental refusal.

The sample size 75 (25 in each group) was calculated based on a similar study by Abdelzaam E et. Al., [12] The effect size of PAED score as 0.90. The level of significance and power were taken as 5% and 80% respectively. The study randomized patients into three groups by using sealed envelope technique which contained 25 participants each i.e. Group A, Group B and Group C. On arrival in the operating room, an intravenous line was secured, maintenance fluid was started, and standard ASA monitoring was applied to all patients. Patients were preoxygenated with 100% oxygen for 3 minutes. Premedication included intravenous glycopyrrolate 0.01 mg/kg, ondansetron 0.1 mg/kg, midazolam 0.03 mg/kg, and fentanyl 2 mcg/kg. Anesthesia was induced with intravenous propofol 2 mg/kg. After achieving adequate muscle relaxation with atracurium 0.5 mg/kg IV, endotracheal intubation was performed using an appropriately sized cuffed endotracheal tube. Anesthesia was maintained with a mixture of 50% oxygen and 50% nitrous oxide along with sevoflurane up to 2%, and additional doses of atracurium 0.1 mg/kg IV were administered every 20 minutes as required.

Fifteen minutes after induction, the study medications were administered: patients in Group A received dexmedetomidine 0.25 mcg/kg diluted with sterile water to a total volume of 10 ml, Group B received nalbuphine 0.1 mg/kg diluted to 10 ml, and Group C received ketamine 0.25 mg/kg diluted to 10 ml, all infused intravenously over a period of 10 minutes. Neuromuscular blockade was reversed with intravenous glycopyrrolate (0.01 mg/kg) and neostigmine (0.05 mg/kg), and extubation was performed once adequate spontaneous breathing was established along with eye opening, facial grimacing, purposeful movements, and oxygen saturation above 97%.

Emergence agitation was assessed after extubation, on arrival in the PACU, and subsequently at 10, 20, and 30 minutes using the Paediatric Anaesthesia Emergence Delirium (PAED) scale, with each component scored from 0 to 4. Pain assessment was carried out after extubation, before transfer to the PACU, on arrival in the PACU, and at 10, 20, and 30 minutes using the FLACC (Face, Legs, Activity, Cry, Consolability) scale, with scores ranging from 0 to 10. Sedation levels were evaluated in the PACU at 10, 20, and 30 minutes using the Ramsay Sedation Scale, which ranges from 1 to 6. Patients were shifted to the ward once they were fully awake, hemodynamically stable, calm, with a PAED score <10 and a FLACC score <5, and with no evidence of bleeding, nausea, or vomiting. If the PAED score exceeded 10 and the FLACC score was greater than 5, intravenous fentanyl 1 mcg/kg was administered as a rescue analgesic. Any complications, including bradycardia, postoperative nausea and vomiting, coughing, and laryngospasm, were carefully monitored and documented.



Statistical analysis

SPSS version 29 was used. Data were presented as mean ± standard deviation (SD) and as percentages where appropriate. ANOVA/Kruskal–Wallis tests applied depending on the distribution of the data.

$p < 0.05$ was the threshold for determining statistical significance.

Results

The three groups were comparable with respect to age, gender distribution, body weight, ASA physical status, and duration of surgery.

Table 1. Demographic and baseline characteristics

Parameter	Dexmedetomidine (n=25)	Nalbuphine (n=25)	Ketamine (n=25)	p value
Age (years)	6.1 ± 1.9	6.3 ± 2.0	6.0 ± 1.8	0.84
Weight (kg)	21.8 ± 4.2	22.1 ± 4.5	21.5 ± 4.0	0.77
Male/Female	14/11	13/12	15/10	0.81
ASA I / II	19 / 6	18 / 7	20 / 5	0.89
Duration of surgery (min)	72.4 ± 6.3	73.1 ± 6.8	71.9 ± 6.1	0.65

Table 2. Emergence agitation (PAED scores)

Group A demonstrated significantly lower PAED scores at all time intervals compared to Groups B and C ($p < 0.001$)

Group	Mean PAED score	Incidence of EA (PAED >10)
Dexmedetomidine	6.1 ± 2.0	3 (12%)
Nalbuphine	8.5 ± 2.4	7 (28%)
Ketamine	9.1 ± 2.6	9 (36%)

p < 0.001

Table 3. Postoperative pain (FLACC score at 10 min)

Postoperative pain was evaluated using the FLACC scale. In the early postoperative period, Groups B and C showed significantly lower FLACC scores compared to Group A ($p < 0.05$), indicating better pain control in these groups.

Group	FLACC score
Dexmedetomidine	4.2 ± 1.3
Nalbuphine	3.1 ± 1.1
Ketamine	2.9 ± 1.2

p = 0.001

Table 4. Sedation (Ramsay score at 10 min)

Sedation scores were highest in Group A during the first 20 minutes in PACU. All patients were easily arousable and none experienced delayed recovery or respiratory depression.

Group	Ramsay score
Dexmedetomidine	3.6 ± 0.6
Nalbuphine	2.8 ± 0.5
Ketamine	2.7 ± 0.5

p < 0.001

Table 5. Postoperative complications

The occurrence of postoperative nausea and vomiting, coughing, laryngospasm, and bradycardia was similar across all three groups. Two patients in Group A experienced bradycardia, which resolved on its own without the need for intervention.

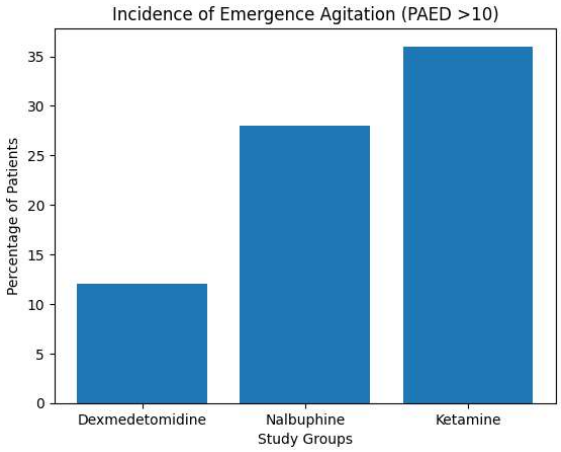
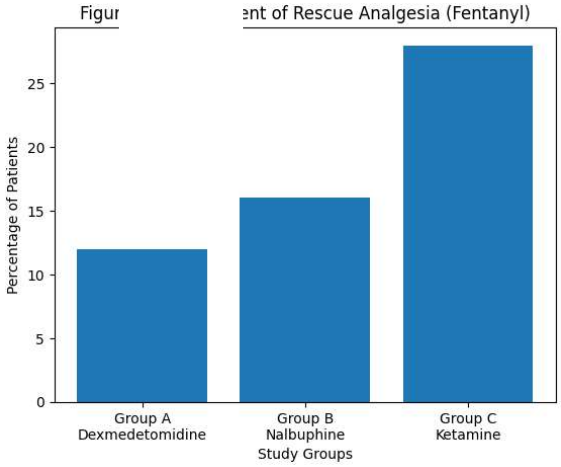
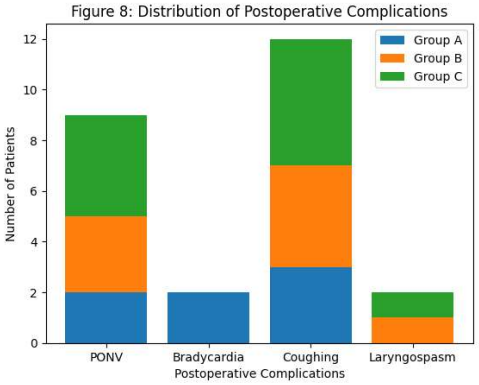


Figure 1. Incidence of Emergence agitation outcomes among study groups.



(A)



(B)

Figure 2. Safety outcomes including (A) rescue analgesia (B) Postoperative complications

DISCUSSION

Emergence agitation (EA) remains a major obstacle for pediatric anesthesia experts who use sevoflurane-based techniques. The combination of sevoflurane's quick washout and children's developing nervous systems plus their airway irritation and postoperative discomfort leads to their behavioral issues during the initial recovery period. [4] Adenotonsillectomy results in increased incidence of EA because the procedure requires airway handling and produces throat pain which intensifies both pain and sympathetic nervous system activity. The current research proves that low-dose dexmedetomidine prevents emergence agitation more effectively than nalbuphine and ketamine which provide better pain relief during the first hours after surgery. The three medications successfully maintained blood pressure control while patients experienced no negative side effects.

The incidence of EA observed with dexmedetomidine (12%) was significantly lower than with nalbuphine and ketamine. The results validate earlier randomized trials plus meta-analyses which show that α_2-adrenergic agonists have strong anti-agitation effects among pediatric patients. Dexmedetomidine works at locus coeruleus to decrease noradrenergic output and induce sleep patterns that resemble natural sleep. This neurophysiological action helps the brain process new information during emergence while it decreases delirium-like symptoms. The researchers proved that α_2 agonists decrease EA in patients while they maintain safety profile for serious adverse events thus showing a clear medical benefit for this category of treatment. [8,9]

Both nalbuphine and ketamine failed to prevent agitation but they proved effective in decreasing postoperative FLACC pain scores. [3] The relationship between pain and EA has been clearly documented with untreated pain acting as a trigger for emergence delirium. The provision of proper pain relief functions as a protective mechanism. Ketamine reduces central sensitization through its NMDA receptor blocking action whereas nalbuphine delivers κ-opioid receptor analgesia which causes little respiratory impairment. These mechanisms probably account for their superior pain relief during the initial period of recovery from surgery.

The ketamine group experienced improved pain relief during the first stage of treatment but they needed additional fentanyl for pain management. Pediatric studies indicate that ketamine provides only brief pain relief when administered at low doses. The protective effect of this treatment appears to decrease as the patient progresses through the recovery process. Nalbuphine provided extended pain relief

which matched existing research about its effects through opioid pathways. [10,14]

The dexmedetomidine group reached the highest sedation scores during their initial recovery phase but patients could still be awakened and their discharge process remained unaffected. Mason et al. [5] reported a comparable pattern of cooperative sedation with low-dose dexmedetomidine without prolonging recovery. Pediatric anesthesia practitioners prefer this sedation method because it stops children from becoming restless while keeping their ability to breathe normally.

The safety of the investigated doses has been confirmed through hemodynamic stability measurements which showed consistent results across all groups. The absence of respiratory depression is particularly important in adenotonsillectomy, where airway patency is critical. [11,15] The dexmedetomidine group experienced only a few cases of transient bradycardia which resolved on their own and matched the expected effects of α_2 agonists according to established dexmedetomidine pharmacology. [6]

The clinical outcomes demonstrate that medical professionals must select medications according to the specific needs of their patients during recovery. Dexmedetomidine shows itself as the best medication when healthcare providers need to prevent EA. The use of nalbuphine or ketamine would provide benefits for patients who require treatment after their surgery. The findings from current research show similar patterns which have been documented in previous studies that involved adenotonsillectomy patients. [11,12,13,10]

The results demonstrate that EA manifests as a neurobiological phenomenon which maintains its independence from both anaesthetic pharmacodynamics and nociceptive modulation and from behavioral disturbances. [1,7] Arousal pathways together with pain pathways must be controlled simultaneously to achieve effective prevention. Future research should examine three areas: multimodal regimens, ongoing behavior evaluation and parental satisfaction and cost-effective methods which will lead to better recovery results for children.

CONCLUSION

The most effective treatment solution to prevent emergence agitation in children who undergo adenotonsillectomy with sevoflurane anesthesia requires low-dose intravenous dexmedetomidine. Nalbuphine and ketamine provide superior early postoperative analgesia but are less effective in agitation control. The three medications demonstrated safe usage through their ability to maintain stable hemodynamic function. The primary goal of preventing emergence agitation makes dexmedetomidine the most suitable treatment choice.

LIMITATIONS

The study contains multiple limitations. The research was conducted at a single hospital which treated a small number of patients thus making it difficult to apply the results to other settings. The study only tracked patients during their initial recovery time which prevented researchers from studying their long-term behavior results. The research needs to be conducted in larger multicentric studies which should have extended follow-up times to confirm the findings and to determine optimal dosing methods.

DECLARATIONS

Ethical approval:
The study was approved by the Institutional Ethics Committee.

Patient consent:
Written informed consent was obtained from parents or legal guardians.

Financial support and sponsorship:
Nil.

Conflicts of interest:
There are no conflicts of interest.

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Cover Letter to Editor

Dear Editor,

We wish to submit our original research manuscript entitled “Effectiveness of Low-dose Intravenous Dexmedetomidine, Ketamine and Nalbuphine in Preventing Emergence Agitation After Sevoflurane Anaesthesia in Children Undergoing Adenotonsillectomy: A Randomised Controlled Trial” for consideration for publication in the Indian Journal of Anaesthesia.

Emergence agitation remains a major challenge in paediatric anaesthesia. Our prospective double-blinded randomised controlled trial compares three commonly used agents in a uniform surgical population and demonstrates that low-dose dexmedetomidine significantly reduces emergence agitation while maintaining haemodynamic stability. We believe the findings are clinically relevant and contribute meaningful evidence to paediatric anaesthetic practice.

This manuscript is original, has not been published previously, and is not under consideration for publication elsewhere. All authors have approved the final manuscript and agree with its submission. Ethical approval was obtained, and informed consent was secured from all participants’ guardians.

We confirm that there are no conflicts of interest and no financial support influencing this work.

We hope our study will be of interest to readers of the Indian Journal of Anaesthesia. Thank you for considering our manuscript.

Sincerely,

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