Research Square

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Different anesthetic approaches on postoperative emergence agitation in pediatric patients undergoing adenotonsillectomy: a prospective randomized study

Ayfer Kaya Gök

ayferkayagok@gmail.com

Gaziosmanpaşa Eğitim Ve Araştırma Hastanesi

Zuhal Çavuş

medifema hospital

Döndü Genc Moralar

Gaziosmanpaşa Eğitim Ve Araştırma Hastanesi

Talal Çakmak

Gaziosmanpaşa Eğitim Ve Araştırma Hastanesi

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Abstract

Background

Adenotonsillectomy is among the most frequently performed pediatric surgeries worldwide. Despite its routine nature, the perioperative period is often complicated by postoperative emergence agitation (POEA), a transient state of dissociated consciousness characterized by irritability, uncooperativeness, restlessness, and crying, with reported incidence ranging from 10% to 80%. POEA reduces patient comfort and may increase the risk of perioperative complications. We aimed to compare four anesthetic approaches with respect to POEA and recovery quality in children undergoing adenotonsillectomy.

Methods

In this prospective randomized study, 100 children aged 3–10 years with American Society of Anesthesiologists (ASA) physical status I–II scheduled for adenotonsillectomy were allocated to one of four anesthetic groups: propofol bolus, ketamine bolus, lidocaine infusion, or magnesium sulfate infusion. All patients received standardized premedication, intraoperative management, and multimodal analgesia. Postoperative complications, analgesic requirements, postoperative nausea and vomiting (PONV), time to eye opening, duration of stay in the post-anesthesia care unit (PACU), vital parameters, and pain–delirium scores (Face, Legs, Activity, Cry, Consolability [FLACC] pain score; Pediatric Anesthesia Emergence Delirium [PAED] score; Modified Aldrete Score [MAS]) were recorded. Data were analyzed using Kruskal–Wallis tests with Bonferroni-adjusted post hoc comparisons and Pearson chi-square tests.

Results

Groups were comparable in age and surgical duration. Significant differences were observed in complication rates ($p = 0.046$), eye-opening times ($p = 0.001$), and PACU stay durations ($p < 0.001$). Magnesium sulfate was associated with the shortest eye-opening times and PACU stay, along with the lowest agitation scores. Propofol prolonged emergence and PACU stay, whereas ketamine and lidocaine were associated with higher complication rates. By 2 hours postoperatively, FLACC, PAED, and MAS scores were similar across all groups.

Conclusions

Among the four anesthetic strategies evaluated, magnesium sulfate infusion provided the most favorable balance of reduced POEA, shorter recovery times, and fewer complications in pediatric adenotonsillectomy. These findings support the use of magnesium sulfate as an effective adjunct in pediatric anesthetic protocols for adenotonsillectomy.

Trial registration:

Magnesium Sulfate Versus Other Anesthesia Drugs to Reduce Agitation After Adenotonsillectomy in Pediatric Patients (POEA) NCT07433231 * 02/21/2026-last release

Background

Adenotonsillectomy operations are the most common childhood surgeries. In the United States alone, tonsillectomy is performed more than 530,000 times annually in children younger than 15 years[3]. Although they are so common, still adenotonsillectomy procedures remain challenging with increased risks of morbidity and mortality for both the surgeon and the anesthesiologist [1] .

Postanesthetic emergence agitation (POEA) is a temporary state of dissociated consciousness during recovery from general anesthesia, in which the child is irritable, uncooperative, restless, and often crying. Reported incidence ranges from 10% to 80% [2], and POEA is particularly common after ear, nose, and throat (ENT) procedures, including adenotonsillectomy. POEA is usually self-limited, children suffer anxiety, fasting, they are afraid of uncertainty, pain and seperation from parents .POEA needs special consideration because it may lead to self-injury, disruption of surgical sites, removal of catheters or tubes, and delayed discharge from the post-anesthesia care unit (PACU).

Multiple risk factors contribute to POEA and can be broadly categorized as patient-related (younger age, high baseline anxiety of patient and parents, previous negative anesthetic experience), surgery-related (site of surgery, postoperative pain, airway manipulation), and anesthesia-related (type of anesthetic agent, premedication, rapid emergence, duration of anesthesia, perioperative environment) [4]. A planned, multimodal approach that considers these factors is essential for preventing POEA and improving recovery quality [5] .

Various pharmacological strategies have been investigated to reduce POEA, including propofol, ketamine, magnesium sulfate, lidocaine, opioids, benzodiazepines, clonidine, and α2-agonists, with conflicting results [6]. Magnesium sulfate and ketamine, both non-competitive N-methyl-D-aspartate (NMDA) receptor antagonists, have shown to reduce POEA [7, 8]. Conversely, propofol, known for its sedative effects, has been associated with prolonged recovery times [9]. Ketamine and lidocaine, despite their analgesic properties, have mixed efficacy reports necessitating careful consideration [10, 11, 12]. However, the optimal anesthetic strategy to minimize POEA while preserving efficient recovery remains unclear. We therefore designed a prospective randomized study to compare four anesthetic approaches —propofol, ketamine, lidocaine, and magnesium sulfate—on POEA incidence, recovery characteristics, and perioperative complications in children undergoing adenotonsillectomy.

Methods

Study design and ethics

This prospective randomized study was conducted at Gaziosmanpaşa Research and Training Hospital. The study protocol was approved by the institutional Ethics Committee, and written informed consent was obtained from the parents or legal guardians of all participants.

Patients

We enrolled 100 pediatric patients aged 3–10 years with American Society of Anesthesiologists (ASA) physical status I–II who were scheduled for elective adenotonsillectomy. Exclusion criteria included ASA III or higher, emergency surgery, communication barriers, history of allergy to any study medication, and known cognitive or developmental delay. All children were fasted according to standard guidelines.

This study was designed, conducted, and reported in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. A completed CONSORT checklist has been submitted as a supplementary file.

Randomization and anesthetic management

Patients were randomized into four groups using a computer-generated sequence:

- Magnesium sulfate (MgSO4) group: MgSO4 infusion (loading dose 30 mg/kg over 10 minutes after intubation, followed by 10 mg/kg/h infusion).
- Propofol group: propofol 1 mg/kg bolus administered before the end of surgery.
- Ketamine group: ketamine 2 mg/kg bolus administered after induction.
- Lidocaine group: lidocaine 1.5 mg/kg infusion over 15 minutes after induction.

All patients received the same premedication (intravenous midazolam 0.1 mg/kg) and standardized induction with fentanyl 1 µg/kg, propofol 2 mg/kg, and rocuronium 0.5 mg/kg. After tracheal intubation, anesthesia was maintained with sevoflurane in an oxygen/air mixture. At the end of surgery, all patients received dexamethasone 0.2 mg/kg and acetaminophen 20 mg/kg intravenously as part of a multimodal analgesic regimen.

Postoperative evaluation

Hemodynamic variables were recorded intraoperatively. After emergence, we documented time to eye opening, surgery duration, postoperative complications, need for rescue analgesia, and nausea and vomiting (PONV). Duration of stay in the post-anesthesia care unit (PACU) was recorded from arrival until the discharge. Vital signs and pain–delirium scales were assessed at 5 and 15 minutes in the PACU and at 2 hours postoperatively in the ward (Score Fig. 1, 2, 3). The following scales were used: Face, Legs, Activity, Cry, Consolability (FLACC) pain score, Pediatric Anesthesia Emergence Delirium (PAED) score, Modified Aldrete Score (MAS). Anesthesiologists responsible for intraoperative management did not participate in postoperative assessments.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics version 27 (IBM Corp., Armonk, NY, USA). Normality of continuous variables was examined using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Descriptive statistics are presented as median (minimum–maximum) and interquartile range (IQR) for continuous variables and as frequency (percentage) for categorical variables. Group comparisons for categorical variables were made using Pearson chi-square or Fisher's exact tests. Continuous variables were compared among the four groups using the Kruskal–Wallis test with Bonferroni-corrected post hoc analyses where appropriate. A p-value < 0.05 was considered statistically significant.

Results

The final analysis included 100 participants who completed the study protocol, with a complete participant flow detailed in Figure A. The four groups were similar with respect to age and surgical duration. There were no significant differences in gender distribution, incidence of PONV, or requirement for rescue analgesia among the groups (Table 1).

Table 1
Comparison of categorical variables among anesthetic groups

Variable	Subgroup	Ketamine (n = 25)	Lidocaine (n = 25)	Magnesium sulfate (n = 26)	Propofol (n = 24)	p value
Gender	Male	11 (23.9)	10 (21.7)	11 (23.9)	14 (30.4)	0.569
	Female	14 (25.9)	15 (27.8)	15 (24.8)	10 (18.5)	
Complication	No	17 (21.0)	18 (22.2)	24 (29.6)	22 (27.2)	0.046
	Yes	8 (42.1)*	7 (36.8)*	2 (10.5)	2 (10.5)	
PONV	No	23 (24.0)	24 (25.0)	26 (27.1)	23 (24.0)	0.547
	Yes	2 (50.0)	1 (25.0)	0 (0)	1 (25.0)	
Additional analgesia	No	20 (23.5)	22 (25.9)	24 (28.2)	19 (22.4)	0.494
	Yes	5 (33.3)	3 (20.0)	2 (13.3)	5 (33.3)	

Data are presented as n (%). Pearson's chi-square test; p < 0.05 considered significant. *Groups contributing to the overall p < 0.05.

The results of the comparison of age, surgical time, eye opening and PACU time parameters between the anesthesia groups are shown in Table 2. No significant difference was found between the groups in terms of age and surgical time parameters (Table 2; p > 0.05). Complication rates differed significantly between groups (p = 0.046), with higher rates observed in the ketamine and lidocaine groups compared with magnesium sulfate and propofol. Eye-opening times showed a significant difference among groups

(p = 0.001). Post hoc analysis demonstrated prolonged eye-opening times in the propofol group compared with the magnesium sulfate group. Similarly, PACU stay duration differed significantly (p < 0.001), with the propofol group having significantly longer PACU times than the ketamine, lidocaine, and magnesium sulfate groups (Fig. 1) .

Table 2

Perioperative times (Comparison of age, surgical time, eye opening time and PACU time) by anesthetic group Data are median (min–max) [interquartile range]. Kruskal–Wallis tests with Bonferroni-adjusted post hoc comparisons; p < 0.05 considered significant.

Variable	Ketamine (n = 25)	Lidocaine (n = 25)	Magnesium sulfate (n = 26)	Propofol (n = 24)	p value
Age (years)	6 (3–10) [3]	6 (3–10) [1]	6 (4–10) [3]	6.5 (3–10) [3.3]	0.998
Surgery time (min)	62 (30–130) [34]	75 (35–175) [35]	81 (45–147) [30]	67.5 (35–140) [26.3]	0.148
Eye-opening time (min)	17 (7–43) [6]	15 (8–25) [10]	11 (3–30) [7.8]	20 (10–35) [6]	0.001
PACU stay (min)	20 (15–30) [4]	15 (15–30) [5]	18 (15–30) [5]	20 (15–46) [7.8]	< 0.001

Hemodynamic and clinical variables, including mean arterial pressure (MAP), heart rate (HR), SpO2, FLACC, PAED, and MAS scores at different time points, varied across groups (Table 3). Significant differences were observed in pre-extubation HR, PACU 5-minute SpO2 and FLACC scores, and PACU 15-minute MAP and HR. Despite these early differences, by 2 hours postoperatively FLACC, PAED, and MAS scores were comparable among all groups, and all children met discharge criteria (Fig. 2) .

Table 3
Comparison of MAP, HR, SPO2, FLACC, PAED, MAS and PACU time among anesthesia agents

Variables	Ketamine (n = 25)	Lidocaine (n = 25)	MgSO4 (n = 26)	Propofol (n = 24)	p
	Median (min-max) IQR				
PREOP MAP	82(62–95)12	82(65–92)6	83.5(64–104)11.3	85(65–99)19.3	0.703
PREOP HR	118(80–146)20	110(82–140)22	115.5(81–150)24.8	105(84–140)20.3	0.282
PREOP SPO2	100(97–100)0	100(96–140)1	100(97–100)1	99(98–100)1	0.077
5. min. MAP	70(53–105)9	73(60–112)6	69.5(58–99)9.8	70(55–99)8.5	0.222
5. min.HR	106(82–135)24	108(73–139)24	111.5(72–140)25	107(10–130)16.8	0.665
5. min. SPO2	100(97–100)1	100(98–100)0	100(99–100)0	100(99–100)1	0.201
PRE Extubation MAP	75(48–100)17	68(62–90)6	68(56–95)9.5	70(60–85)6.8	0.337
PRE Extubation HR	100(77–120)16	98(54–140)13	90.5(62–130)17.8	104(80–120)16.8	**0.026**
PRE Extubation SPO2	100(98–100)1	100(98–100)0	100(99–100)0	100(98–100)1	0.308
PACU 5. min. MAP	80(68–105)10	75(68–98)10	80(66–104)7.3	75(65–85)10	0.155
PACU 5. min. HR	116(88–140)23	110(72–139)26	106(11–135)32.5	110(85–140)21	0.226
PACU 5. min. SPO2	100(97–100)0	99(97–100)2	100(94–100)1	99(98–100)1	**0.012**
PACU 5. min. FLACC	0(0–7)2	4(0–10)5	5(0–10)6	4(0–8)7	**0.018**
PACU 5. min. PAED	11(2–15)3	12(2–20)4	12(0–20)5	11(0–17)6	0.122
PACU 5. min. MAS	8(6–10)1	8(6–10)1	8(6–10)1	9(5–10)1	0.598
PACU 15. min. MAP	80(70–110)13	78(68–100)8	85(72–106)11	79(65–90)9.3	**0.003**
PACU 15. min.HR	120(98–147)20	111(77–137)15	117(90–168)21	108(79–132)11	**0.006**
PACU 15. min. SPO2	100(98–100)0	100(94–100)2	100(96–100)1	100(98–100)1	0.070

Variables	Ketamine (n = 25)	Lidocaine (n = 25)	MgSO4 (n = 26)	Propofol (n = 24)	p
	Median (min-max) IQR				
PACU 15. min. FLACC	2(0–8)3	4(0–9)2	4(0–10)5	4(0–9)5	0.175
PACU 15. min.PAED	7(0–15)5	5(2–15)6	6(0–13)8	8(0–12)8	0.833
PACU 15. min.MAS	10(5–10)1	10(8–10)1	10(2–10)1	10(6–10)1	0.905
POSTOP 2. Hour FLACC	0(0–9)0	0(0–0)0	0(0–0)0	0(0–6)0	0.092
POSTOP 2. Hour PAED	0(0–7)0	0(0–0)0	0(0–0)0	0(0–4)0	0.092
POASTOP 2. Hour MAS	10(10–10)0	10(10–10)0	10(10–10)0	10(10–10)0	1.000

Kruskal Wallis test used and post hoc Bonferroni's correction used p < 0.05 considered significant.

IQR; Interquartile range

Discussion

In this prospective randomized study of children undergoing adenotonsillectomy, we compared four anesthetic strategies—propofol, ketamine, lidocaine, and magnesium sulfate—with respect to POEA, recovery characteristics, and perioperative complications. Our principal finding was that magnesium sulfate infusion was associated with shorter emergence and PACU stay, lower agitation scores, and fewer complications relative to the other regimens.

Adenotonsillectomy is a most common pediatric procedure and POEA is a frequent postoperative complication in this operation [1, 2, 3], optimizing anesthetic management has important implications for patient safety, comfort, and resource use. POEA should be dealt with ultimate care because it's associated with life threating complications, delaying discharge and functional recovery. POEA and delirium should be considered as a vital sign, which should be followed and documented on every child in PACU[4]. Consequently, strategies that reduce POEA while preserving efficient recovery are of particular value.

Multiple risk factors contribute to POEA and can be broadly categorized as patient-related (younger age, high baseline anxiety of patient and parents, previous negative anesthetic experience), surgery-related (site of surgery, postoperative pain, airway manipulation), and anesthesia-related (type of anesthetic agent, premedication, rapid emergence, duration of anesthesia, perioperative environment) [4].

Anesthesiologist should consider a planned multimodal approach knowing all the possible risk factors, identifying and reducing the triggers. This plan must begin preoperatively and continue into the postoperative period, in order to minimize the pain, anxiety and stay safe- comfortable in PACU [5] .

A lot of environmental, supportive (parent-present induction, and preoperative education for surgery) and pharmacological interventions (several anesthetic agents and pharmacological methods such as total intravenous anesthesia, propofol, μ-opioid agonists, N-methyl-Daspartate receptor antagonists, nefopam, α2-adrenoreceptor agonists, regional analgesia, multimodal analgesia) have been suggested for POEA [5, 6]. However, the optimal anesthetic strategy to minimize POEA while preserving efficient recovery remains unclear. We therefore designed a prospective randomized study to compare four anesthetic approaches—propofol, ketamine, lidocaine, and magnesium sulfate—on POEA incidence, recovery characteristics, and perioperative complications in children undergoing adenotonsillectomy.

Total intravenous anaesthesia (TIVA) techniques have become popular in recent years, a review has shown TIVA may help to reduce the incidence of POEA[13, 14]. Propofol is commonly used to prevent or treat POEA [15], but can prolong recovery time [9], as reflected in our longer eye-opening and PACU stay times in the propofol group so it's not practical in hardworking operative rooms.

Magnesium sulfate and ketamine, both non-competitive N-methyl-D-aspartate (NMDA) receptor antagonists, have shown to reduce POEA [5, 7, 8].

Ketamine has sedative, amnestic, and analgesic properties[5]. In a study, low-dose ketamine during induction of anesthesia reduces POEA and postoperative pain following adenotonsillectomy in children[16]. Also in a meta-analysis of 13 randomized controlled trials, high degree of heterogeneity and low certainty of evidence limit the recommendations of ketamine for the prevention of emergence agitation in children undergoing surgery or imaging procedures. However, the use of ketamine is well-tolerated without any notable adverse effects across all the included trials [10, 11]. In our study, ketamine, although analgesic, was associated with higher complication rates such as increased secretions and POEA .

Magnesium sulfate is a non-competitive NMDA receptor antagonist like ketamine, which has central sedative, neuroprotective, and analgesic-sparing effects so it can reduce the incidence of POEA[8, 17]. Elsersy et al. proposed that magnesium's potential to decrease agitation might be associated with its protective role against the adverse effects of prolonged hypotension and other contributing factors on the brain [18]. Magnesium sulfate has shown to effectively control agitation without significant sedation, respiratory depression, or delayed recovery, making it particularly suitable for pediatric anesthesia [7]. But a review showed, unlike the studies in adults, there is no statistically significant effect of perioperative use of magnesium in the postoperative pain control in children undergoing tonsillectomies, but it had benefits in reducing rescue analgesia, emergence agitation incidence, and laryngospasm [19]. Our results align with previous studies suggesting that intraoperative magnesium sulfate can reduce POEA and

improve postoperative comfort. The absence of clinically important adverse events and the ease of administration further support its incorporation into pediatric adenotonsillectomy anesthetic protocols.

Intravenous infusion of lidocaine relieves postoperative sore throat and reduces POEA and coughing although it may delay recovery [20, 21, 22]. Lidocaine reduces secretion of neuropeptides in the brainstem and airway by inhibiting stimulation of sensory C fibers in the airway and reducing stimulation of the mucosa in the airway by the tracheal tube [12, 23]. The pathophysiologic changes leading to this ED are not completely understood. In adults, endothelial dysfunction due to the release of inflammatory cytokines is a common perioperative event influencing the incidence of delirium [24]. Amide-local anesthetics have been demonstrated to be able to preserve endothelial barrier function upon an inflammatory stimulus and might therefore also potentially be able to influence pathophysiologic events leading to neurologic disturbances after surgery [25, 26]. Lidocaine administered intravenously, may reduce postoperative pain and POEA but reported to extend recovery times and may cause hemodynamic fluctuations, which may explain the higher complication rates observed in our lidocaine group.

The study has limitations, including its single-center design and modest sample size, which may limit the generalizability of our findings. Additionally, while we used validated scales (FLACC, PAED, MAS), the assessment of agitation and pain in young children always carries some subjectivity. Future multicenter trials with larger sample sizes and standardized multimodal protocols would help confirm the advantages of magnesium sulfate and refine dose–response relationships.

Conclusions

Among four anesthetic strategies evaluated in pediatric adenotonsillectomy, magnesium sulfate infusion provided the most favorable profile, combining reduced postoperative emergence agitation with shorter recovery times and fewer complications. These findings support the inclusion of magnesium sulfate as a valuable adjunct in pediatric anesthesia protocols for adenotonsillectomy.

Abbreviations

ASA
American Society of Anesthesiologists
ENT
Ear, nose, and throat
FLACC
Face, Legs, Activity, Cry, Consolability
HR
Heart rate
IQR
Interquartile range

MAP
Mean arterial pressure
MAS
Modified Aldrete Score
MgSO4
Magnesium sulfate
PACU
Post-anesthesia care unit
PAED
Pediatric Anesthesia Emergence Delirium
POEA
Postoperative emergence agitation
PONV
Postoperative nausea and vomiting
SpO2
Peripheral oxygen saturation
TIVA
Total intravenous anesthesia

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethics Committee of Gaziosmanpaşa Research and Training Hospital (Approval No. 2023-65).

Clinical Trial Registry: NCT07433231 Magnesium Sulfate Versus Other Anesthesia Drugs to Reduce Agitation After Adenotonsillectomy in Pediatric Patients

It adheres to the principles outlined in the Declaration of Helsinki and the CONSORT 2010 guidelines. Written informed consent was obtained from the parents or legal guardians of all participants. We confirm our study complies with the Declaration of Helsinki.

Consent for publication

Not applicable. The manuscript does not contain any individual person’s identifiable data.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

AKG conceived and designed the study, collected data, and drafted the manuscript. ZÇ contributed to data acquisition and interpretation and critically revised the manuscript for important intellectual content. DGM contributed to statistical analysis, interpretation of data, and critical revision of the manuscript. All authors read and approved the final manuscript.

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Authors' information

Gaziosmanpaşa Training and Research Hospital, Department of Anesthesiology and Reanimation, İstanbul, Türkiye

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Figures

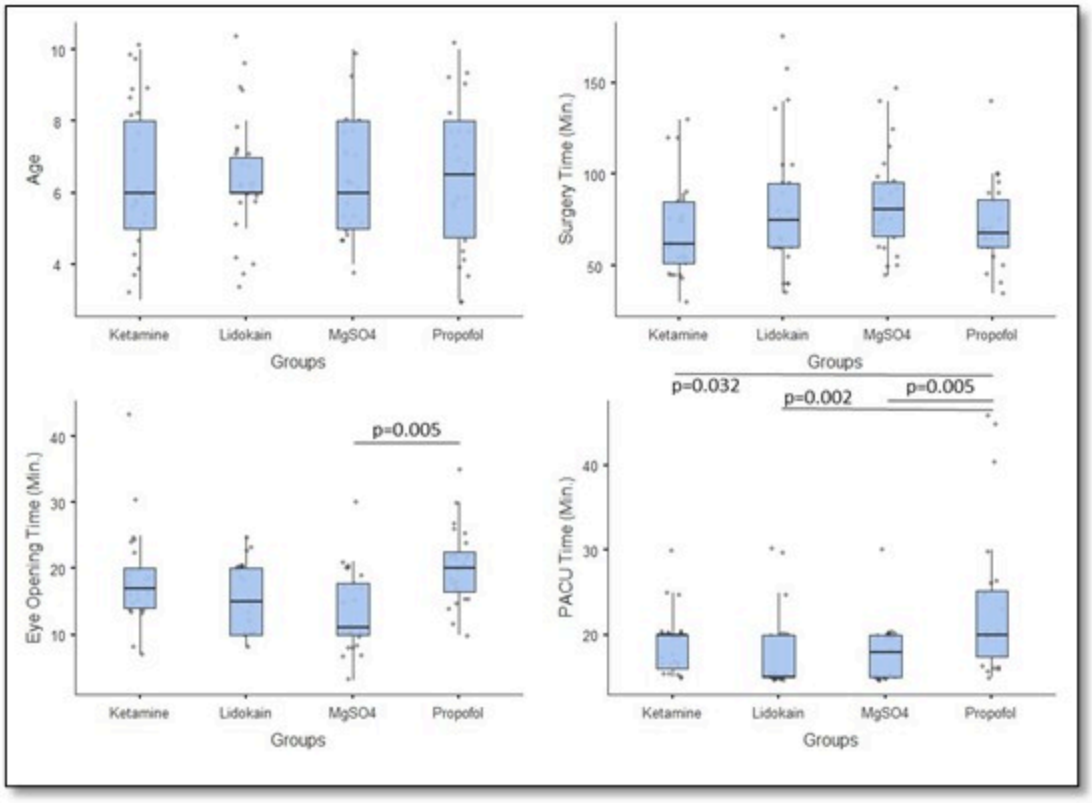


Figure 1

Comparison of age, surgical time, eye opening time and PACU time among anesthesia agents

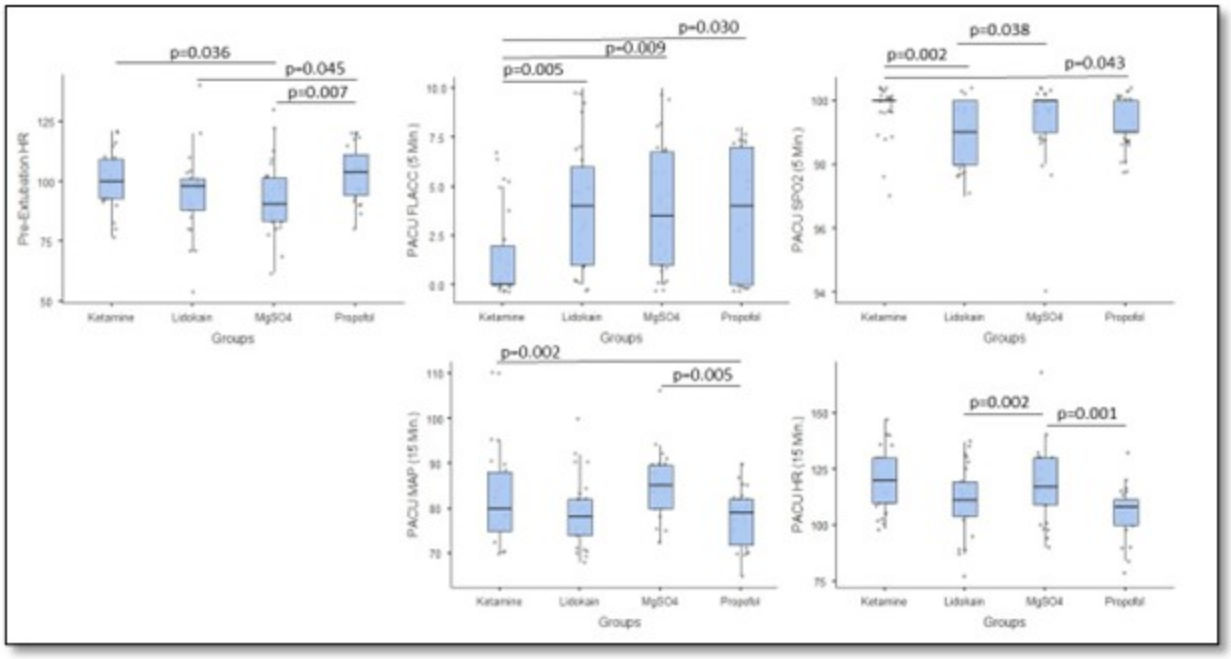


Figure 2

Comparison of a MAP, FLACC, SPO_2, heart rate in different time periods among anesthesia agents

Supplementary Files

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- scoringsystems.docx
- consortdiagram.docx
- CompletedCONSORT2010Checklist1.docx