Original Article

Comparison of airway collapsibility following single induction dose ketamine with propofol versus propofol sedation in children undergoing magnetic resonance imaging: A randomised controlled study

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ABSTRACT

Background and Aims: Adequate sedation is essential for children undergoing magnetic resonance imaging (MRI) console. Propofol is commonly used for sedation, but it has the drawback of upper airway collapse at higher doses, which may be overcome by ketamine. This study was designed to evaluate the beneficial effect of ketamine on propofol in preventing airway collapse. **Methods:** Fifty-eight children undergoing MRI were randomised to Group P (propofol bolus dose followed by infusion or Group KP (bolus dose of ketamine and propofol followed by propofol infusion). The primary aim is to compare the upper airway cross-sectional area (CSA) and diameters (transverse diameter [TD] and anteroposterior diameter [APD]) obtained from MRI during inspiration and expiration. **Results:** Upper airway collapse as measured by delta CSA in mean (SD) [95% confidence interval] was statistically more significant between the two groups [at the soft palate level, 16.9 mm^2 (19.8) [9.3–24.4] versus 9.0 mm^2 (5.50) [6.9–11.1] ($P = 0.043$); at the base of the tongue level, 15.4 mm^2 (11.03) [11.2–19.6] versus 7.48 mm^2 (4.83) [5.64–9.32] ($P < 0.001$); at the epiglottis level, 23.9 (26.05) [14.0–33.8] versus 10.9 mm^2 (9.47) [7.35–14.5] ($P = 0.014$)]. A significant difference was obtained for TD at all levels and for APD at the soft palate and base of tongue level. **Conclusion:** Adding a single dose of ketamine to propofol reduced the upper airway collapse significantly, as evidenced by the MRI-based measurements of upper airway dimensions, compared to propofol alone.

Keywords: Airway collapse, airway dynamics, airway obstruction, children, ketamine, magnetic resonance imaging, propofol, sedation

INTRODUCTION

There is a growing need for magnetic resonance imaging (MRI) for monitoring and diagnosing a wide range of medical and surgical illnesses in children.[1] MRI has the efficacy benefit of high-resolution images of tissue anatomy and quantitative function. Certain aspects such as loud noises, the confined bore of the magnet and required immobility to prevent the motion artefacts are essential for the successful performance of imaging in children under six years and for those with developmental delay, claustrophobia, involuntary movements and convulsions.[2] A single sedative/hypnotic is preferred for obtaining immobility for nonpainful MRI procedures because the combination of two or more sedating medications may have the potential for adverse outcomes.[2] Propofol is most commonly

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preferred in children for sedation.[3] Nonetheless, deep sedation with high doses can predispose to airway obstruction, while lower doses may cause movement, necessitating repetition of an MRI scan.[3,4] Ketamine provides a patent airway with minimal effect on a respiratory drive and a stable haemodynamic profile. Its combination provides adequate sedation and ventilatory functions and positively affects mood during early cognitive recovery.[3-6] Though infusion in children for sedation is commonly achieved using a variety of agents, its effect on paediatric airway dynamics has not been quantified.[7]

The primary outcome of the study is the measurement and comparison of upper airway cross-sectional area and diameters (transverse and anteroposterior) obtained by MRI of the upper airway at the level of the soft palate, base of the tongue and epiglottis during inspiration and expiration. The secondary objectives were recovery time, the requirement of rescue dose of propofol, procedural complication, discharge time and quality of MRI image obtained.

METHODS

This randomised controlled study was conducted in a tertiary care centre after obtaining approval from the institutional ethics committee (vide approval number JIP/IEC/2017/0437, dated 15.03.2018), and trial registration at the Clinical Trials Registry-India (vide registration number CTRI/2018/05/013798, www.ctri.nic.in). It was conducted according to the Helsinki Declaration 2013 and good clinical practice. Informed written consent was obtained from the parents of the children or their guardians for their children to participate in the study and for the use of the child's data for research and educational purposes.

Patients scheduled for an MRI brain under sedation were enroled during the study period from March 2018 to January 2020. The study included 58 children aged 1–6 years belonging to the American Society of Anesthesiologists (ASA) Physical Status (PS) I/II. Children with airway and craniofacial anomalies, congenital heart disease history, gastro-oesophageal reflux disease or uncontrolled seizure disease were excluded from the study. All parents/guardians were instructed to maintain adequate nil per oral status for the child during pre-anaesthetic evaluation as per standard ASA guidelines. Patients were randomised using the block randomisation technique with blocks of 10 in a 1:1 proportion. Concealment to the group allocation was done using a sequentially numbered opaque sealed envelope technique. Children were allocated to either the propofol group (Group P) or ketamine along with the propofol group (Group KP). The anaesthesiologist not involved in the study administered the drug based on randomisation. The data collector was blinded to the group allocation.

On the day of the MRI, after ensuring adequate fasting status, an intravenous (IV) cannula was secured and pre-anaesthetic medication, including IV glycopyrrolate (10 μg/kg) and midazolam (50 μg/kg), was administered 10 min before the scheduled time to facilitate parental separation. After shifting the children inside the MRI suite, MRI-compatible monitors like pulse oximeter (SpO_2) and nasal end-tidal carbon dioxide ($EtCO_2$) were attached, and baseline parameters were recorded. Sealed opaque envelopes containing the allocation details were opened by an attending anaesthesiologist, who administered the study drugs according to the group allocation: Group P (IV propofol) or Group KP (IV ketamine plus propofol). Children belonging to Group P were sedated with an IV 5 ml saline and IV propofol 0.5 mg/kg bolus followed by IV propofol boluses, if required till sedated. Then, IV propofol infusion was started at 100 μg/kg/min to maintain sedation. Whereas children in Group KP were sedated with IV 1 mg/kg of ketamine followed by IV propofol boluses till they got sedated and then IV propofol infusion at 75 μg/kg/min to maintain sedation. An adequate level of sedation is defined as a sedation score of 5 or 6 of the Ramsay Sedation Score (RSS). RSS scores are defined as: '1- Patient anxious and agitated or restless, or both; 2- co-operative, oriented and tranquil patient; 3- patient responds to commands only; 4- patient exhibits brisk response to a light glabellar tap or loud auditory stimulus; 5- patient exhibits a sluggish response to a light glabellar tap or loud auditory stimulus; 6- patient exhibits no response to glabellar tap'. Anaesthesiologists who had administered ketamine initially were setting the infusion requirement for that particular child based on the group to which they belong. Then, the parameters were assessed every 1 min for the first 10 min and then every 5 min during the procedure. Oxygen was provided to children through nasal prongs at 3 l/min. In both groups, propofol constituted 5% dextrose at 5 mg/ml concentration for infusion in a paediatric drip set. The infusion rate was controlled using an IV flow connector (Medi Tech Device Pvt. Ltd, Ahmedabad, India). A qualified anaesthesiologist was available inside the console to monitor the patient's

vital parameters. Patients were observed for any signs of airway obstruction by the absence of or decreased $EtCO_2$ values or fall in oxygen saturation below 92% and decreased to absent chest movements. In the event of hypoventilation or hypoxia due to airway obstruction, it was corrected by chin lift and head tilt manoeuvre, appropriately sized oropharyngeal airway placement and increasing oxygen flow to a maximum of 5 l/min. After obtaining an adequate level of sedation, the MRI scan was started, and images were obtained. The standardised position for the head was a neutral position, where the line joining the ear's tragus and the eye's lateral corner was at an angle of 110° with the horizontal plane of the MRI table. The rescue dose of IV propofol was administered as 5 mg boluses whenever the anaesthesiologist observed the patient's movement at the MRI console or the radiologist found any minor movement or scan artefacts.

The radiologist measured the airway calibre in MRI images, who was blinded to the randomised group. The images were serially numbered for later analysis. Image acquisition for MRI was made in a 1.5 T equipment (Avanto TIM; Siemens, Erlangen, Germany). T2-weighted sagittal images were acquired in the expiratory phase using the respiratory trigger by keeping the trigger box in the right hemidiaphragm. The axial images were acquired using gradient T1-weighted sequence (FL2D) in cine mode at three individual slice locations – soft palate, the base of the tongue and epiglottis–with the following parameters: slice thickness 8 mm, flip angle 15°, TR (repetition time) 50.54 msec, TE (time to echo) 3.43 msec, matrix 192 × 160 iPAT (integrated parallel acquisition time) (GRAPPA 2). The cine images gave the airway measurement throughout one respiratory cycle, and the expiratory phase measurement was taken for comparison with the T2-weighted image. An experienced radiologist took an MRI at a fixed time interval after starting sedation. After image magnification, cross-sectional area (mm^2), anteroposterior diameter (mm) and transverse diameter (mm) were obtained at the level of the soft palate, the base of the tongue and the epiglottis [Figures 1-3]. After completing the MRI scan, propofol infusion was stopped, patients were shifted to the recovery area, and recovery time (time taken to attain an RSS of 2) was recorded. The radiologist in the MRI console graded the scan quality on the following scale: 'poor- major movement causing scan pausing or a repeat of one or more scan sequences, but not necessitating a new scan; good- minor movement or scan artefacts and excellent- no movement or scan artefacts'. Inability to complete the scan due to scan interruption and need for a new scan at the preset propofol infusion rate due to gross patient movement or need for repeated propofol boluses (more than three times) successively in a short time or significant serious adverse events were recorded as sedation failure. In them, concealment was removed, and sedation was continued at the discretion of the supervising consultant anaesthesiologists, who were excluded from the study. The children were discharged on meeting the discharge criteria as per the modified Aldrete score (score >9). Children who had vomiting in the immediate post-procedure period received IV ondansetron 100 μg/kg. A phone interview was conducted within 24 h to inquire about the presence or absence of vomiting.

The sample size was calculated based on the study by Evans *et al*.[8] The mean difference in airway cross-sectional area at the level of epiglottis during

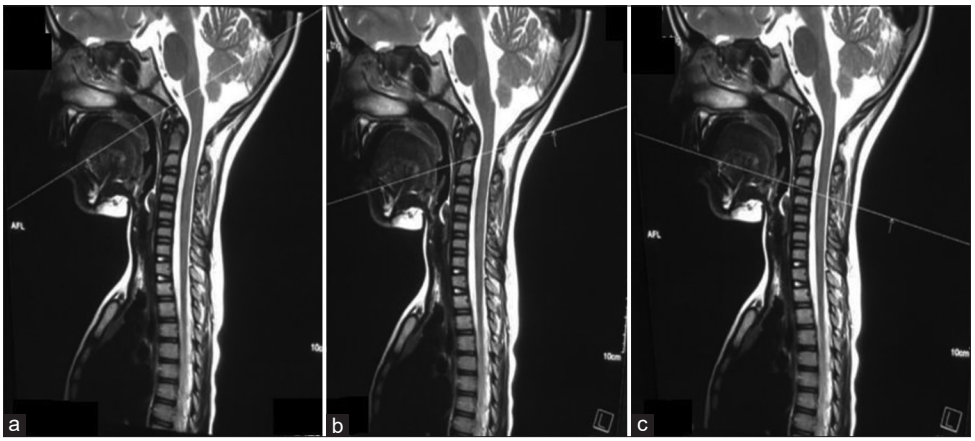

Figure 1: Magnetic resonance imaging in sagittal view: showing image acquisition at the level of (a) soft palate, (b) base of the tongue and (c) epiglottis

inspiration was assumed to be 15.7 mm^2 with a 95% confidence interval of 8.9–22.4 mm^2 following the addition of a single dose of ketamine to propofol with the power of the study at 80% and an alpha error of 0.05. The sample size was 53 patients in each group, and considering a dropout of 10%, a total of 58 patients were enroled. Statistical Package for the Social Sciences (SPSS) version 16.0 (IBM Corp, Armonk, NY, USA) statistical software was used. Distribution of continuous variables (age, weight, upper airway cross-sectional area, transverse diameter and anteroposterior diameter, recovery time, discharge time and rescue dose of propofol) is expressed as mean (standard deviation [SD]) or median (interquartile range [IQR]), and comparison of these variables between the two groups was made by paired *t*-test. Categorical variables (gender, quality of MRI image obtained, and any adverse respiratory events) are expressed as numbers and percentages and were compared using the Pearson Chi-square test. Dichotomous data (post-procedure vomiting) are expressed as numbers and percentages, and Fischer's test was used to compare these variables between two groups. All statistical analyses were performed at a 5% significance level, and a *P* value <0.05 was considered significant.

RESULTS

Fifty-eight children were enroled in the study [Figure 4]. Demographic data were similar between both groups [Table 1]. There was a statistically significant difference between the two groups for maximum and minimum values at the level of the soft palate, the base of the tongue and epiglottis ($P < 0.001$), the anteroposterior diameter at the level of the soft palate and the base of the tongue ($P < 0.001$) and the maximum and minimum transverse diameters at the level of the soft palate and epiglottis ($P < 0.001$) [Table 2]. Both groups had no significant difference in the recovery and discharge times [Table 3]. Nineteen patients in Group P and nine in Group KP required rescue doses of propofol ($P = 0.009$). The images obtained were of good to excellent quality, with an equal number of patients in both groups. None of the participants in either group had episodes of postprocedure vomiting. Only two patients in Group KP had increased upper respiratory secretions, managed with gentle oral suctioning [Table 3].

DISCUSSION

We observed that single dose of IV ketamine to propofol was sufficient to minimise the upper airway narrowing caused secondary to propofol-only sedation across different age groups, with a statistically significant difference at the level of the soft palate, base of the tongue and epiglottis.

The collapsible segment of the upper airway is the pharynx. Anaesthetic agents inhibit the respiratory activity of upper airway muscles, creating potential narrowing of the pharynx airway. It can be due to structural differences in the upper airway or functional differences in the neuromotor tone. Airway dimensions in children with neurological disabilities undergoing MRI with dexmedetomidine or propofol sedation were similar in both groups; still, the difference in collapsibility was observed with propofol-only

Table 1: Comparison of demographic characteristics between both groups

Parameters	Group P (*n*=29)	Group KP (*n*=29)
Age (months), median (IQR)	24 (18–36)	30 (18–48)
Weight (kg), mean (SD)	11.2 (3.00)	12.8 (4.10)
Male/female, *n*	19/10	17/12

IQR=Interquartile range, SD=Standard deviation, *n*=Number of patients

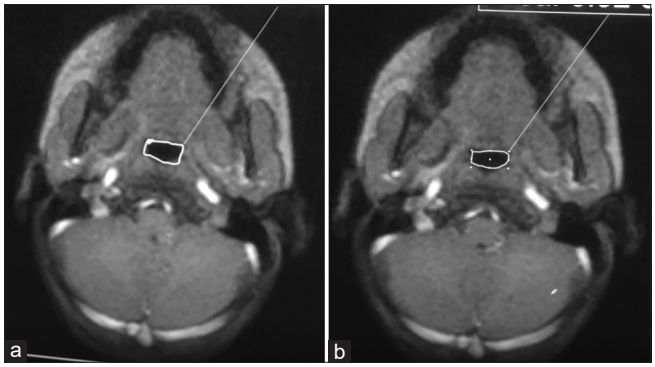

Figure 2: Magnetic resonance imaging (a) Maximum and (b) minimum cross-sectional areas at the level of the soft palate

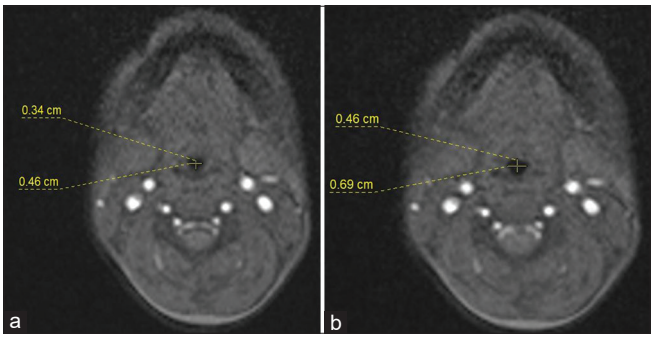

Figure 3: (a) Minimum and (b) Maximum transverse and anteroposterior diameters at the level of the epiglottis

Table 2: Comparison of difference between maximum and minimum airway dimensions at different levels

Levels	Parameter	Group P (*n*=29) Mean (SD) [95% CI]	Group KP (*n*=29) Mean (SD) [95% CI]	Mean difference [95% CI]	*P*
Soft palate	ΔCSA (mm^2)	16.9 (19.8) [9.3–24.4]	9.0 (5.5) [6.9–11.1]	7.8 [0.22–15.5]	0.043
	ΔTD (mm)	2.36 (2.33) [1.48–3.25]	1.15 (2.1) [0.35–1.95]	1.21 [0.04–2.38]	0.042
	ΔAPD (mm)	1.66 (1.15) [1.22–2.09]	0.8 (0.58) [0.57–1.02]	0.86 [0.38–1.34]	<0.001
Base of the tongue	ΔCSA (mm^2)	15.4 (11.0) [11.2–19.6]	7.48 (4.83) [5.64–9.32]	7.96 [3.48–12.4]	0.0008
	ΔTD (mm)	1.64 (1.41) [1.10–2.17]	0.91 (0.92) [0.56–1.27]	0.72 [0.09–1.35]	0.024
	ΔAPD (mm)	1.23 (1.12) [0.81–1.66]	0.67 (0.39) [0.52–0.82]	0.56 [0.12–1.00]	0.013
Epiglottis	ΔCSA (mm^2)	23.9 (26.0) [14.0–33.8]	10.9 (9.47) [7.35–14.5]	12.9 [2.66–23.2]	0.014
	ΔTD (mm)	1.80 (1.42) [1.26–2.35]	0.97 (1.00) [0.58–1.35]	0.83 [0.18–1.48]	0.012
	ΔAPD (mm)	1.50 (1.21) [1.04–1.96]	1.23 (1.02) [0.84–1.62]	0.27 [-0.31 0.86]	0.360

ΔAPD=change in anteroposterior diameter in inspiration and expiration, ΔCSA=Change in cross-sectional area in inspiration and expiration, ΔTD=Change in transverse diameter in inspiration and expiration, *n*=Number of patients

Table 3: Comparison of recovery time, discharge time and quality of image between the study groups

	Group P (*n*=29)	Group KP (*n*=29)	*P*
Recovery time (min) Mean (SD) [95% CI]	26.9 (6.19) [24.61–29.32]	27.1 (5.41) [25.11–29.23]	0.892
Discharge time (min) Mean (SD) [95% CI]	43.9 (7.98) [40.92–47.00]	42.9 (7.37) [40.16–45.76]	0.622
Poor-quality MRI, *n*	1	1	0.90
Good-quality MRI, *n*	8	5	0.64
Excellent quality of MRI, *n*	20	23	0.76

CI=Confidence interval, MRI=Magnetic resonance imaging, SD=Standard deviation, *n*=Number of patients

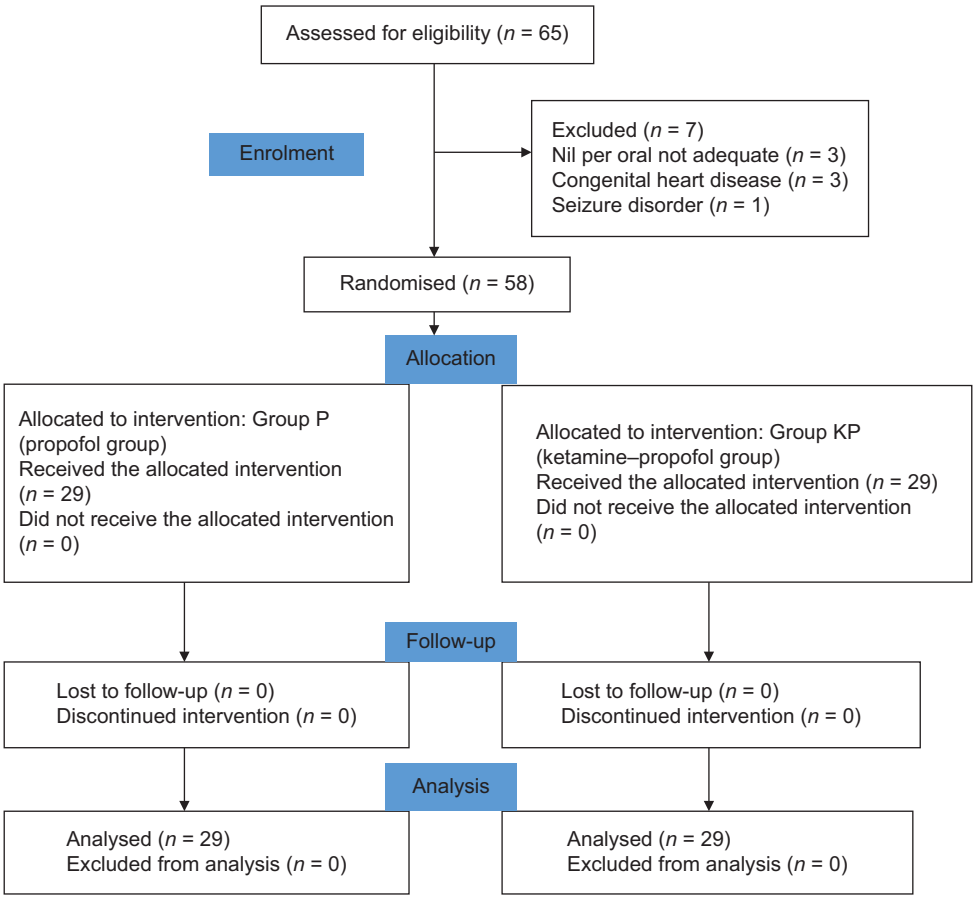

Figure 4: Consolidated Standards of Reporting trials (CONSORT) diagram showing patient progress through the study phases

sedation in transverse diameters.[9] Likewise, another study with dexmedetomidine and ketamine reported that adding ketamine did not significantly reduce the upper airway configuration compared to dexmedetomidine alone.[10] Another study reported that the midazolam–ketamine combination provided

better image quality and haemodynamic profile than the midazolam–propofol combination.[11]

Our study also found that the difference between the maximum and minimum upper airway dimensions was more remarkable in Group P compared to Group KP at all levels ($P < 0.001$). In a study, narrowing was observed throughout the entire upper airway but was more pronounced at the level of epiglottis.[8] Machata *et al*.[10] reported that narrowing of the upper airway was observed at the level of the base of the tongue. In our study, there was more difference at the level of the base of the tongue and epiglottis as well. However, we also observed an overall reduction in transverse diameter compared to anteroposterior diameter, which contrasted with a previous study.[12]

Different doses of ketamine with propofol combinations have been used as an infusion to provide sedation and analgesia for maintaining stable haemodynamics and preserving airway reflexes.[13] It results in prolonged sedation with delayed recovery as ketamine's context-sensitive half-time increases 30 min following an infusion.[12] A study by Coulter *et al*.[12] concluded that a 1:3 ratio of ketamine with propofol achieves deep sedation and analgesia with rapid onset and the shortest recovery time.[13,14] Nonetheless, we used a 1:1 ratio of ketamine and propofol bolus only at the induction time, followed by propofol infusion for maintenance. It also decreased the incidence of postprocedure nausea and vomiting.

A study by Schmitz *et al*.[15] found that the discharge time was almost twice the recovery time, whereas, in our study, the mean recovery time ($P > 0.05$) and the discharge time ($P > 0.05$) were comparable between both the groups, as it could be explained by the low rates of propofol infusion (75 and 100 μg/kg/min). Adverse effects like nausea and vomiting were seen more with the propofol–ketamine combination[15,16], but in our study, none of the patients in either group had postprocedure vomiting. Better quality of images was obtained with Group KP. However, another study states image acquisition is better in the propofol-only group.[17]

Our study has certain limitations. Airway dimensions during the awake state as a baseline value were not measured. Although previous studies have attempted to obtain baseline values by administering sevoflurane for sedation, its effect on respiratory muscle activity may impair the interpretation of airway measurements. We took MRIs of the upper airway at a fixed time interval from the beginning of the procedure; perhaps taking multiple sequences during various levels of sedation would have given a better idea of airway collapsibility with varying depths of sedation. We did not compare the incidence of emergence delirium. As the exact value of exhaled carbon dioxide was unavailable, we cannot comment on the incidence of hypoventilation with either of the two techniques.

CONCLUSION

Adding a single dose of ketamine to propofol is sufficient to minimise the narrowing of the upper airway at the level of the soft palate, base of the tongue and epiglottis compared to the propofol group, and it provides an enhanced recovery profile.

Statement on data sharing

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' institution policy.

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Conflicts of interest

There are no conflicts of interest.

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REFERENCES

1. Sethi D, Gupta M, Subramanian S. A randomized trial evaluating low doses of propofol infusion after intravenous ketamine for ambulatory pediatric magnetic resonance imaging. Saudi J Anaesth 2014;8:510-6.
2. Jung SM. Drug selection for sedation and general anesthesia in children undergoing ambulatory magnetic resonance imaging. Yeungnam Univ J Med 2020;37:159-68.
3. Aycan IO, Taseli YC, Temel H, Dinc B, Coskunfirat N, Sanli S. Magnetic resonance imaging under sedation in paediatric patients: A single institution experience. J Child Sci 2021;11:e185-92.
4. Kim S, Hahn S, Jang MJ, Choi Y, Hong H, Lee JH, *et al*.

Evaluation of the safety of using propofol for paediatric procedural sedation: A systematic review and meta-analysis. Sci Rep 2019;9:12245. doi: 10.1038/s41598-019-48724-x.
5. Ghojazadeh M, Sanaie S, Paknezhad SP, Faghih SS, Soleimanpour H. Using ketamine and propofol for procedural sedation of adults in the Emergency Department: A systematic review and meta-analysis. Adv Pharm Bull 2019;9:5-11.
6. Hayes J, Matava C, Pehora C, El-Beheiry H, Jarvis S, Finkelstein Y. Determination of the median effective dose of propofol in combination with different doses of ketamine during gastro-duodenoscopy in children: A randomized controlled trial. Br J Anaesth 2018;121:453-61.
7. Mortero RF, Clark LD, Tolan MM, Metz RJ, Tsueda K, Sheppard RA. The effects of small-dose ketamine on propofol sedation: Respiration, postoperative mood, perception, cognition, and pain. Anesth Analg 2001;92:1465-9.
8. Evans RG, Crawford MW, Noseworthy MD, Yoo SJ. Effect of increasing depth of propofol anesthesia on upper airway configuration in children. Anesthesiology 2003;99:596-602.
9. Sriganesh K, Saini J, Theerth K, Venkataramaiah S. Airway dimensions in children with neurological disabilities during dexmedetomidine and propofol sedation for magnetic resonance imaging study. Turk J Anaesthesiol Reanim 2018;46:214-21.
10. Machata AM, Kabon B, Willschke H, Prayer D, Marhofer P. Upper airway size and configuration during propofol-based sedation for magnetic resonance imaging: An analysis of 138 infants and children. Paediatr Anaesth 2010;20:994-1000.
11. Uludağ O, Doğukan M, Kaya R, Tutak A, Dumlupınar E. Comparison of the effects of midazolam-ketamine or midazolam-propofol combinations on hemodynamic stability, patient comfort, and post-anesthesia recovery in children undergoing sedation for magnetic resonance imaging procedures. Ain-Shams J Anesthesiol. 2020;12:1-7.
12. Coulter FL, Hannam JA, Anderson BJ. Ketofol simulations for dosing in pediatric anesthesia. Paediatr Anaesth 2014;24:806-12.
13. Dalal PG, Murray D, Cox T, McAllister J, Snider R. Sedation and anesthesia protocols used for magnetic resonance imaging studies in infants: Provider and pharmacologic considerations. Anesth Analg 2006;103:863-8.
14. Yilmaz G, Varol K, Esen O, Kayhan A, Salihoglu Z. Airway patency in children undergoing magnetic resonance imaging using neck collars: A single center, randomized, double-blind, prospective study. Braz J Anesthesiol 2021;71:11-6.
15. Schmitz A, Weiss M, Kellenberger C, O'Gorman Tuura R, Klaghofer R, Scheer I, *et al*. Sedation for magnetic resonance imaging using propofol with or without ketamine at an induction in a pediatrics-A prospective randomized double-blinded study. Paediatr Anaesth 2018;28:264-74.
16. Gürcan HS, Ülgey A, Öz Gergin Ö, Seçkin Pehlivan S, Yıldız K. Investigation of the effects of propofol/ketamine versus propofol/fentanyl on nausea- vomiting administered for sedation in children undergoing magnetic resonance imaging: A prospective randomized double-blinded study. Turk J Med Sci 2021;51:2120-26.
17. Mylavarapu G, Fleck RJ, Ok MS, Ding L, Kandil A, Amin RS, *et al*. Effects on the upper airway morphology with intravenous addition of ketamine after dexmedetomidine administration in normal children. J Clin Med 2020;9:3723. doi: 10.3390/jcm9113723.