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AIRWAY COLLAPSIBILITY FOLLOWING A SINGLE INDUCTION DOSE OF KETAMINE WITH PROPOFOL AND PROPOFOL SEDATION IN PEDIATRIC PARTICIPANTS UNDERGOING MRI

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ABSTRACT

Background: Adequate sedation is required for pediatric participants receiving an MRI (magnetic resonance imaging) console. Propofol is a commonly used sedative. Propofol is a commonly used sedative; nevertheless, at large dosages, it causes upper respiratory collapse, which can be compensated for by ketamine.

Aim: The current study aims to compare the airway collapsibility following a single induction dose of ketamine with propofol-to-propofol sedation in pediatric patients undergoing MRI.

Methods: The study evaluated 116 pediatric patients having MRI and were randomly separated into two groups. Group I individuals were administered propofol bolus. followed by infusion and Group II subjects were given bolus propofol and ketamine followed by propofol infusion. Upper airway diameters (APD and TD) and cross-sectional area (CSA) were compared in both groups using MRI during expiration and inspiration.

Results: The mean upper airway collapse assessed by delta CSA was significantly higher in between groups, with 16.7±19.7mm2 compared to 8.8±5.48mm2 ($p=0.03$) at the soft palate level, 15.2±11.01mm2 compared to 7.46±4.81mm2 ($p<0.001$) at the base of the tongue, and 23.7±26.03 compared to 10.7±9.45mm2 at the epiglottis level ($p=0.01$). Transverse diameter at all levels showed a statistically significant difference, as did anteroposterior diameter at the base of the tongue and soft palate level.

Conclusion: Adding a single dosage of ketamine to propofol can dramatically minimize upper airway collapse, according to MRI-based assessments of upper airway dimensions, when compared to propofol alone.

Keywords: airway collapse, ketamine, propofol, sedation, upper airway

INTRODUCTION

The need for MRI is quickly growing for the diagnosis and monitoring of different surgical and medical diseases in children. MRI is a very productive technique that provides high-resolution pictures of quantitative functions and tissue structure. Several factors, including loud noise, required immobility, and the confined bore of the magnet to prevent motion artifacts,

are critical for successful imaging in child subjects under the age of six, as well as those with developmental delays, convulsions, involuntary movements, and claustrophobia.1

A single hypnotic/sedative is preferred to ensure immobility for a painless experience during MRI procedures, but combining two or more sedative medicines may have adverse outcomes. Propofol is the most commonly used and recommended medicine for sedation in children. Furthermore, profound drowsiness at high dosages might predispose people to airway blockage, whilst lesser levels can cause movements that need repeating the MRI scan.2

Ketamine aids in maintaining a patent airway with little to no impact on respiratory drive and a steady hemodynamic profile. The combination of ketamine and propofol offers appropriate ventilatory functioning and sedation while improving mood during early cognitive recovery. However, infusion of sedative drugs in children is prevalent, and the effect on juvenile airway dynamics has yet to be studied and quantified.[3]

The study's major result is the comparison and measurement of diameters (transverse and anteroposterior) and cross-sectional areas of the upper airway at the epiglottis, base of tongue, and soft palate during expiration and inspiration using MRI. The research also sought to evaluate the quality of MRI pictures, discharge time, procedural problems, the requirement for rescue propofol dosage, and recovery time.

The purpose of this randomized controlled study was to compare and evaluate upper airway diameters (transverse and anteroposterior) and cross-sectional areas using MRI during expiration and inspiration. The research also sought to evaluate the quality of MRI pictures, discharge time, procedural problems, the requirement for rescue propofol dosage, and recovery time.

MATERIALS AND METHODS

The study subjects were from the Department of Pediatrics of the Institute. The parents/guardians of research subjects provided verbal and written informed permission. The study evaluated 116 pediatric patients aged 1-6 years of both genders who had MRI brain sedation throughout the study period and were classified as ASA (American Society of Anaesthesiologist) physical status I or II. Exclusion criteria for the trial included uncontrolled seizure disorder, gastro-oesophageal reflux disease, a history of congenital heart disease, and craniofacial and airway defects. During the pre-anaesthetic examination, all individuals were told to be NPO (nil per oral) for pediatric subjects in accordance with usual ASA guidelines. The 116 participants were randomized into two groups of 58 each, with Group I receiving a propofol bolus followed by an infusion, and Group II receiving a bolus propofol and ketamine followed by a propofol infusion.

On MRI day, after confirming NPO, an IV (intravenous) cannula was placed and pre-anaesthetic medicines such as midazolam (50 µg/kg) and IV glycopyrrolate (10 µg/kg) were delivered 10 min before evaluation to aid with parental separation. This was followed by the insertion of MRI-compatible monitors such as nasal end-tidal carbon dioxide (EtCO2) and pulse oximeter (SpO2), and baseline values were measured. The anaesthesiologist then delivered propofol or ketamine and propofol, depending on the group. Group I individuals were sedated with 5ml saline (IV) and a 0.5mg/kg IV propofol bolus, followed by IV propofol boluses as needed until sedated. The patient was then given an IV propofol infusion at 100 µg/kg/min to maintain sedation.

Group II children were sedated with 1mg/kg of IV ketamine, followed by an IV propofol bolus to achieve sedation and an IV propofol infusion at 75 µg/kg/min to maintain sedation. Adequate sedation was defined as an RSS (Ramsay Sedation Score) of 5 or 6, with scores depicted as '1- Patient anxious and agitated or restless, or both; 2- Cooperative, oriented, and tranquil patient; 3- Patient responds to commands only; 4- Patient exhibits a 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'.

The anaesthesiologist who gave the ketamine originally determined the amount of infusion needed for the pediatric based on the group they were maintained in, with parameters assessed every 1 minute for the first 10 minutes and every 5 minutes for the remainder of the treatment. Children were given 3l of oxygen per minute using nasal prongs. In all groups, propofol was mixed with 5% dextrose at a concentration of 5 mg/ml for infusion into a pediatric drip set. An IV flow connection was employed to adjust the infusion rate. Vital indicators were measured by anaesthesiologist professionals in the area. Subjects were evaluated for any indicators of airway blockage, including absent/decreased chest movements, oxygen saturation levels below 92%, and absent/decreased EtCO2 readings.

During hypoxia or hypoventilation caused by airway blockage, head tilt and chin lift techniques were employed, coupled with raising maximal oxygen flow to 5l/min and placing a suitably sized oropharyngeal airway. After achieving a sufficient degree of sedation, an MRI was performed and pictures were collected. The head was held in a neutral posture, with the line connecting the ear's tragus and the eye's lateral corner at a 110° angle to the horizontal plane of the MRI table. When the patient moved at the MRI console or the radiologist detected minimal movement or scan artifacts, the Rescue IV propofol dosage was administered as 5mg boluses. A radiologist who was ignorant of the group randomization examined MRI scans to measure airway diameter.

For convenience of reference, images were serially numbered. MRI images were acquired using 1.5 T equipment. T2-weighted sagittal pictures were obtained during the expiratory phase using the respiratory trigger, with the trigger box positioned in the right hemidiaphragm. The axial images were acquired using a gradient T1-weighted sequence (FL2D) in cine mode at three individual slice locations: epiglottis, base of the tongue, and soft palate. The parameters used were matrix 192 × 160 iPAT (integrated parallel acquisition time) (GRAPPA 2), TE (time to echo) 3.43 msec, TR (repetition time) 50.54 msec, flip angle 15°, and slice thickness 8mm. Cine pictures were used to examine the airway during the respiratory cycle, and the expiratory phase was compared to a T2-weighted image.

Experienced radiologists performed MRI scans at predetermined intervals following anaesthesia. After image magnification, transverse diameter (mm), anteroposterior diameter (mm), and cross-sectional area (mm2) were measured at the epiglottis, base of the tongue, and soft palate. After the MRI, the propofol infusion was discontinued, and the individuals were brought to the recovery area, with recovery time measured as the time it took to attain RSS score 2. The radiologist evaluated scan quality as 'poor- substantial movement causing scan stopping or a repetition of one or more scan sequences, but not demanding a fresh scan; good- moderate movement or scan artifacts; and excellent- no movement or scan artifacts'.

Sedation failure was determined by substantial major adverse events, the requirement for repeated propofol boluses (more than three times in a short period of time), the necessity for a fresh scan at the preset propofol infusion rate owing to gross patient movement, and the inability to finish the scan. These people were excluded from the research. Child participants were dismissed because their modified Aldrete score was more than 9. Ondansetron (100 μg/kg) was administered intravenously to children who vomited throughout the post-operative period.

The collected data were statistically evaluated using SPSS software version 24.0 for descriptive measures, one-way ANOVA (analysis of variance), Pearson correlation, and chi-square test. The data were presented as mean and standard deviation, as well as frequency and percentage. The p-value of <0.05 was considered statistically significant.

RESULTS

The purpose of this randomized controlled study was to compare and evaluate the diameters (transverse and anteroposterior) and cross-sectional areas of the upper airway at the epiglottis, base of tongue, and soft palate during expiration and inspiration using MRI. The research also sought to evaluate the quality of MRI pictures, discharge time, procedural problems, the requirement for rescue propofol dosage, and recovery time. The study evaluated 116 pediatric patients who had MRI and were randomly separated into two groups: Group I received a propofol bolus followed by an infusion, and Group II received a propofol bolus and ketamine followed by an infusion. The research subjects' mean ages were 23 (17-35) months and 29 (17-47) months for Groups I and II, respectively. There were 38 men and 20 females in Group I, and 34 males and 24 females in Group II accordingly. The research individuals' mean weights were 11.0±2.98 and 12.6±4.08 kg in Groups I and II, respectively (Table 1).

At the epiglottis level, ΔAPD was 1.48±1.19 and 1.21±1.00 in Groups I and II, respectively, which was statistically equivalent ($p=0.34$). Group I had considerably larger ΔTD (1.78±1.40) than Group II (0.95±0.98), with $p=0.01$. Table 2 shows a statistically significant difference in ΔCSA between Group I and Group II, with 23.7±26.03 and 10.7±9.45, respectively, with $p=0.01$. At the base of the tongue, ΔAPD was considerably greater in Group I compared to Group II (1.21±1.10 vs. 0.65±0.37, $p=0.01$). ΔTD was substantially greater in Group I compared to Group II (1.62±1.39 vs. 0.89±0.90, $p=0.02$). Table 2 shows that Group I had a significantly greater ΔCSA (15.2±10.8) than Group II (7.46±4.81), with $p=0.0007$. The study found that the difference in minimum and maximum airway dimensions at the soft palate was substantially larger in the propofol-only group (1.64±1.13) compared to the propofol and ketamine combination group (0.6±0.56) ($p<0.001$). Group I showed a substantially greater difference in ΔTD (2.34±2.31) compared to Group II (1.13±1.9) ($p=0.03$). Group I had a significantly larger ΔCSA (16.7±19.6) than Group II (8.8±5.3), with $p=0.03$ (see Table 2).

In terms of comparing MRI quality, discharge time, and recovery time in two groups of study subjects, MRI quality was poor in two subjects each from Groups I and II (p=0.88), good in 16 and ten subjects from Groups I and II (p=0.62), and excellent in 40 and 46 subjects from Groups I and II (p=0.74). The mean discharge time in Groups I and II was 43.7±7.96 and 42.7±7.35 minutes, respectively, which was non-significant with p=0.64. The mean recovery time in Groups I and II was 26.7±6.17 and 26.9±5.39 minutes, respectively, demonstrating statistical non-significance with p=0.64 (Table 3).

DISCUSSION

The study comprised 116 pediatric patients who had MRI and were randomly separated into two groups: Group I received a propofol bolus followed by an infusion, and Group II received a propofol bolus and ketamine followed by an infusion. The research subjects' mean ages were 23 (17-35) months and 29 (17-47) months for Groups I and II, respectively. There were 38 males and 20 females in Group I, and 34 males and 24 females in Group II.

The study individuals' mean weights were 11.0±2.98 and 12.6±4.08 kg for Group I and II, respectively. These findings were similar to earlier studies by Mylavarapu G. et al4 in 2020 and Gürcan HS et al5 in 2021, in which authors evaluated pediatric patients with demographic data similar to the current study while receiving ketamine and propofol anaesthetic sedation.

The study results indicated that the difference in minimum and maximum airway dimensions at varied levels, at the level of the epiglottis, ΔAPD was 1.48±1.19 and 1.21±1.00 in Groups I and II, which was statistically equivalent (p=0.34). Group I had considerably larger ΔTD (1.78±1.40) than Group II (0.95±0.98), with p=0.01.

Group I had a statistically significant greater difference in ΔCSA compared to Group II (23.7±26.03 vs. 10.7±9.45, p=0.01). These findings were consistent with the findings of Schmitz A. et al6 in 2018 and Yilmaz G. et al7 in 2021, who reported similar results to the present study in terms of transverse dimensions and cross-sectional surface area. Group I had considerably larger ΔAPD at the base of the tongue than Group II, with values of 1.21±1.10 and 0.65±0.37, respectively (p=0.01).

ΔTD was substantially greater in Group I compared to Group II (1.62±1.39 vs. 0.89±0.90, p=0.02). Group I had a significantly greater ΔCSA (15.2±10.8) than Group II (7.46±4.81), p=0.0007. These findings were consistent with the findings of Dalal PG et al8 in 2006 and Coulter FL et al9 in 2014, who also reported significantly higher differences in minimum and maximum airway dimensions at the base of the tongue for transverse, anteroposterior, and cross-sectional area dimensions in subjects undergoing propofol anaesthesia compared to combined propofol and ketamine, as seen in the current study.

The propofol solo group had a substantially larger ΔAPD (1.64±1.13) than the propofol and ketamine combination group (0.6±0.56, p<0.001). Group I showed a substantially greater difference in ΔTD (2.34±2.31) compared to Group II (1.13±1.9) (p=0.03). Group I had a significantly larger ΔCSA (16.7±19.6) than Group II (8.8±5.3), with p=0.03. Similar to this work, Uludağ O et al10 in 2020 and In 2010, Machata AM et al11 discovered variations in minimum and maximum airway diameters at the soft palate. The authors reported a significantly higher difference in transverse, anteroposterior, and cross-sectional area dimensions in subjects undergoing propofol anaesthesia compared to combined propofol and ketamine.

In the comparison of MRI quality, discharge time, and recovery time in two groups of study subjects, MRI quality was poor in two subjects each from Groups I and II (p=0.88), good in 16 and ten subjects from Groups I and II (p=0.62), and excellent in 40 and 46 subjects from Groups I and II (p=0.74).

Mean discharge time in Group I and II was 43.7±7.96 and 42.7±7.35 minutes which was non-significant with p=0.64 and mean recovery time was 26.7±6.17 and 26.9±5.39 minutes respectively in Groups I and II showing statistical non-significance with p=0.64. These findings were consistent with the findings of Sriganesh K et al12 in 2018 and Ghojazadeh M et al13 in 2019, who reported that MRI quality, discharge time, and recovery time were comparable to propofol or a combination of ketamine and propofol, as seen in the current study.

CONCLUSION

Given its limitations, the present study shows that adding a single dosage of ketamine to propofol can dramatically minimize upper airway collapse, as seen by MRI-based assessments of upper airway dimensions compared to propofol alone. Future longitudinal research with a bigger sample size and a wider age range will aid in further topic exploration.

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S. No	Parameters	Group I (n=58)	Group II (n=58)
1.	**Mean age (months)**	23 (17-35)	29 (17-47)
2.	**Gender**		
a)	Males	38	34
b)	Females	20	24
3.	**Mean weight (kg)**	11.0±2.98	12.6±4.08

Table 1: Demographic data of child subjects in the study

S. No	Parameters	Group I	Group II	p-value
1.	**Epiglottis**			
a)	ΔAPD	1.48±1.19	1.21±1.00	0.34
b)	ΔTD	1.78±1.40	0.95±0.98	**0.01**
c)	ΔCSA	23.7±26.03	10.7±9.45	**0.01**
2.	**The base of the tongue**			
a)	ΔAPD	1.21±1.10	0.65±0.37	**0.01**
b)	ΔTD	1.62±1.39	0.89±0.90	**0.02**
c)	ΔCSA	15.2±10.8	7.46±4.81	**0.0007**
3.	**Soft palate**			

a)	ΔAPD	1.64±1.13	0.6±0.56	**<0.001**
b)	ΔTD	2.34±2.31	1.13±1.9	**0.03**
c)	ΔCSA	16.7±19.6	8.8±5.3	**0.03**

Table 2: Comparison of difference in minimum and maximum airway dimensions at varying levels

S. No	Parameters	Group I (n=58)	Group II (n=58)	p-value
1.	**Mean discharge time (min)**	43.7±7.96	42.7±7.35	0.64
2.	**Mean recovery time (min)**	26.7±6.17	26.9±5.39	0.87
3.	**MRI quality**			
a)	Poor	2	2	0.88
b)	Good	16	10	0.62
c)	Excellent	40	46	0.74

Table 3: Comparison of MRI quality, discharge time, and recovery time in two groups of study subjects