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

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ABSTRACT

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

Aim: To compare airway collapsibility following a single induction dose of ketamine with propofol-to-propofol sedation in children participants undergoing MRI.

Methods: The study evaluated 116 children 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 bolus propofol and ketamine followed by a propofol infusion.

Results: Upper airway diameters [APD (anteroposterior diameter) and TD (transverse diameter)] and cross-sectional area (CSA) were measured in both groups using MRI during expiration and inspiration. The study found that upper airway collapse measured by delta CSA was significantly higher in some groups than others, with mean values of 16.7±19.7mm2 at the soft palate, 15.2±11.01mm2 at the base of the tongue, and 23.7±26.03mm2 at the epiglottis (p=0.03). A statistically significant difference was seen in transverse diameter at all levels, as well as anteroposterior diameter at the base of the tongue and soft palate.

Conclusion: The current study concluded that adding a single dosage of ketamine to propofol can considerably prevent upper airway collapse with the evidence from MRI-based measurements of upper airway dimensions compared to propofol alone.

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

INTRODUCTION

The need for MRI (magnetic resonance imaging) 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 preferable to achieve immobility for a painless experience during MRI operations, while mixing two or more sedative medications may result in unfavorable consequences. Propofol is the most widely used and recommended medication for sedation in children. Furthermore, severe 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. A combination of ketamine and propofol offers appropriate ventilatory function 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 key outcome evaluated in the study is the comparison and measurement of diameters (transverse and anteroposterior) and cross-sectional are assessed by MRI of the upper airway at the level of the epiglottis, base of the tongue, and soft palate 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 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 the 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 research subjects were members of the Institute's Department of Radiology. The parents/guardians of research subjects provided verbal and written informed permission.

The study evaluated 116 children 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 Anesthesiologists) physical status I or II. The study excluded participants with uncontrolled seizure disorder, gastroesophageal reflux disease, a history of congenital heart disease, and craniofacial and airway defects. During the pre-anesthetic examination, all individuals were told to be NPO (nil per oral) for children subjects in accordance with usual ASA guidelines. The 116 participants were separated 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.

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Group II children were sedated with 1mg/kg of IV ketamine followed by IV propofol bolus till sedation and IV propofol infusion at 75 µg/kg/min for sedation maintenance. 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 anesthesiologist who gave the ketamine originally determined the amount of infusion needed for the children 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 anesthesiologist 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 obtained using the following parameters: matrix 192 × 160 iPAT (integrated parallel acquisition time) (GRAPPA 2), TE 3.43 msec, TR 50.54 msec, flip angle 15°, and slice thickness 8 mm. 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 anesthesia. 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 defined as substantial severe adverse events, the requirement for several 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 participants were excluded from the research. Children were discharged as they met discharge criteria following the modified Aldrete score (score >9). 100 IV µg/kg of ondansetron was given to child subjects who had vomiting in the immediate post-procedure period.

The data gathered were statistically analyzed using SPSS (Statistical Package for the Social Sciences) software version 24.0 (IBM Corp., Armonk. NY, USA) for assessment of descriptive measures, one-way ANOVA (analysis of variance), Pearson correlation, and chi-square test. The results were expressed as mean and standard deviation and frequency and percentages. 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 children 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, with 1.62±1.39 and 0.89±0.90, respectively ($p=0.02$). 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 when comparing minimum and maximum airway dimensions at the soft palate, the propofol-only group had a substantially larger ΔAPD (1.64±1.13) than the propofol and ketamine combination group. 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, which showed statistical non-significance. (table 3)

Discussion

The mean age of research participants was 23 (17-35) months for Group I and 29 (17-47) months for Group II. There were 38 males and 20 females in Group I, and 34 males and 24 females in Group II. The average weight of study participants was 11.0±2.98 and 12.6±4.08 kg for Groups I and II. These findings were comparable to earlier studies conducted by Mylavarapu G. et al4 and Gürcan HS et al5 in 2021, in which writers analyzed children participants with demographic data similar to the current study while receiving ketamine and propofol anesthetic sedation.

The study found that ΔAPD was 1.48±1.19 and 1.21±1.00 at the epiglottis level, respectively, when comparing minimum and maximum airway dimensions at different levels which was statistically comparable with p=0.34. ΔTD was substantially larger in Group I at 1.78±1.40 compared to 0.95±0.98 in Group II (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 and Yilmaz G. et al7, who found that when comparing the difference in minimum and maximum airway dimensions at the epiglottis level, the results were significantly higher for propofol 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 anesthesia compared to combined propofol and ketamine, as seen in the current study.

The propofol-only group had a substantially larger ΔAPD (1.64±1.13) compared to the propofol and ketamine combination group (0.6±0.56, p<0.001). Group I had a substantially larger ΔTD of 2.34±2.31 compared to Group II's 1.13±1.9 (p=0.03). The difference in ΔCSA was significantly greater in Group I with 16.7±19.6, compared to 8.8±5.3 in Group II (p=0.03). Similar to this study, Uludağ O et al10 in 2020 and Machata AM et al11 in 2010 found substantial variations in minimum and maximum airway dimensions at the soft palate for Authors observed transverse, anteroposterior, and cross-sectional area dimensions in participants experiencing propofol anesthesia as compared to combination 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). The mean discharge time in Groups I and II was non-significant (p=0.64), whereas the mean recovery time was 26.7±6.17 and 26.9±5.39 minutes, respectively.

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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Parameters	**Group I (n=58)**	**Group II (n=58)**
Mean age (months)	23 (17-35)	29 (17-47)
Gender		
Males	38	34
Females	20	24
Mean weight (kg)	11.0±2.98	12.6±4.08

Table 1: Demographic data of child subjects in the study

Parameters	**Group I**	**Group II**	**p-value**
Epiglottis			
ΔAPD	1.48±1.19	1.21±1.00	0.34
ΔTD	1.78±1.40	0.95±0.98	**0.01**
ΔCSA	23.7±26.03	10.7±9.45	**0.01**
The base of the tongue			
ΔAPD	1.21±1.10	0.65±0.37	**0.01**
ΔTD	1.62±1.39	0.89±0.90	**0.02**
ΔCSA	15.2±10.8	7.46±4.81	**0.0007**
Soft palate			
ΔAPD	1.64±1.13	0.6±0.56	**<0.001**
ΔTD	2.34±2.31	1.13±1.9	**0.03**
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

Parameters	Group I (n=58)	Group II (n=58)	p-value
Mean discharge time (min)	43.7±7.96	42.7±7.35	0.64
Mean recovery time (min)	26.7±6.17	26.9±5.39	0.87
MRI quality			
Poor	2	2	0.88
Good	16	10	0.62
Excellent	40	46	0.74

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