ORIGINAL RESEARCH

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Role of Low-dose Intramuscular Ketamine in Vascular Access in Pediatric Patients with Sedation Anesthesia in Magnetic Resonance Imaging

Pediyatrik Olguların Damaryolu Erişiminde Kullanılan Düşük Doz İntramusküler Ketaminin, Manyetik Rezonans Görüntülenmesinde Sedasyon Anestezisindeki Yeri

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Abstract

Objective: While there are few studies on the use of ketamine for sedation during magnetic resonance imaging (MRI) of pediatric patients, we aimed to investigate the effects of low-dose ketamine administered intramuscularly for vascular access on hemodynamics, sedation and recovery, and MRI quality for the first time.

Method: A total of 193 pediatric patients aged 3 months to 15 years who received sedation anesthesia for MRI were included in this study. Ninety-nine subjects in the group (Group K) administered ketamine 2.5 mg/kg and below intramuscularly and the propofol-control group (Group C), where 94 subjects were not administered intramuscular ketamine, were divided into two groups. The groups were compared in terms of demographic data, sedation and procedure times, anesthetic drug doses, Ramsay sedation score, hemodynamic parameters, recovery time, modified Aldrete recovery scores, MRI quality, and side effects.

Results: The mean values of first dose and additional dose propofol mg/kg in Group K were 0.56 (0.45/0.71) - 0 (0/0), respectively, whereas in Group C the values were 1.11 (0.87/1.33) - 0.14 (0/0.5), respectively. In Group K, the mean systolic arterial pressures, diastolic arterial pressures, and median values of mean arterial pressures during the procedure were found to be higher than those of Group C (p<0.001; =0.001; <0.001, respectively). While the jaw-thrust maneuver was performed in two

Öz

Amaç: Pediyatrik olguların, manyetik rezonans görüntüleme (MRG) işlemi esnasında sedasyon amaçlı ketamin kullanımına dair sayılı miktarda çalışma mevcutken, ilk kez çalışmamızda intramusküler yoldan damar yolu erişimi için uygulanılan düşük doz ketaminin hemodinamik, sedasyon ve derlenme ve MRG kalitesi üzerine olan etkilerini araştırmayı amaçladık.

Yöntem: Bu çalışmaya MRG işlemi için sedasyon anestezisi alan 3 ay-15 yaş arası toplam 193 pediyatrik hasta dahil edildi. Doksan dokuz kişi intramusküler ketamin 2,5 mg/kg ve altında uygulanılmış grup (Grup K) ve 94 kişi intramusküler ketamin uygulanılmayan propofol kontrol grubu (Grup C) olarak, iki grup halinde oluşturuldu. Gruplar, demografik veriler, sedasyon ve işlem süreleri, anestezik ilaç dozları, Ramsay sedasyon skoru, hemodinamik parametreler, derlenme süresi, modifiye Aldrete derlenme skorları, MRG kalitesi ve yan etkiler açısından karşılaştırıldı.

Bulgular: Grup K'de ilk doz ve ek doz propofol mg/kg ortalama değerleri sırasıyla 0,56 (0,45/0,71) -0 (0/0) iken, Grup C'de değerler sırasıyla 1,11 (0,87/1,33) - 0,14 (0/0,5) olarak bulundu. Grup K'de işlem sürecindeki sistolik arteriyal basınç, diastolik arteriyal basınç ve ortalama arteriyal basıncın medyan değerleri Grup C'nin değerlerinden daha yüksek bulundu (sırasıyla p<0,001; =0,001; <0,001). Grup K'de iki hastada çene itme-kaldırma manevrası uygulanılırken, Grup C'de bir hastada hava

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Abstract

patients in Group K, airway was required in one patient in Group C. The relationship between the groups in terms of MRI quality was found to be statistically significant (p<0.016).

Conclusion: It has been observed that low-dose intramuscular ketamine (2.5 mg/kg and less) used in vascular access provides a positive efficacy and safety profile with less sedative additional drugs, even in agitated children during sedation anesthesia during pediatric MRI, and better MRI quality is achieved.

Keywords: Intramuscular ketamine, magnetic resonance imaging, pediatrics, propofol, sedation

Öz

yolu aparatı ihtiyacı olmuştur. MRG kalitesi açısından gruplar arasındaki ilişkinin istatistiksel olarak anlamlı olduğu görüldü (p<0,016).

Sonuç: Damar yolu erişiminde kullanılan düşük doz intramusküler ketaminin (2,5 mg/kg ve altı), pediyatrik MRG esnasında sedasyon anestezisinde ajite çocuklarda dahi daha az sedatif ek ilaçla olumlu etkinlik ve güvenilirlik profili sağladığı, daha mükemmel MRG kalitesine ulaşıldığı gözlemlenilmiştir.

Anahtar kelimeler: İntramusküler ketamin, manyetik rezonans görüntüleme, pediyatri, propofol, sedasyon

Introduction

In pediatric cases, computed tomography and magnetic resonance imaging (MRI) have become more common; therefore, the provision of adequate sedation in such instances is important (1). MRI has become the imaging modality of choice for pediatric cases because it can provide non-invasive, multiplanar, and high-contrast imagingwith respect to blood flow, myelin maturation, hemoglobin breakdown products, and greater sensitivity. The disadvantages are that the imaging time tends to be longer (45-60 minutes) with image quality is affected by patient movements (2). Immobility and patient compliance are important factors in ensuring imaging quality; therefore, anesthesia and/or deep sedation are often necessary in pediatric MRI to minimize motion-related artifacts in almost all of the pediatric population, as in adult patients with claustrophobia, mental retardation, anxiety, and communication difficulties (3,4).

Ketamine not only results in deep sedation and analgesia, but the side effects, respiratory depression and cardiovascular, are minimal (5). It can be used either intramuscularly (im) or intravenously (v), with the profiles for both applications seen to be safe and efficacious; rates for respiratory side effects are also low (6). Numerous studies of ketamine use have reported a favorable safety profile with reduced airway complications. However, one of the most important disadvantages is the long recovery time (7). It can be administered both v and m and is widely used in situations where vascular access is limited (8). Nystagmus is common; eyes usually remain open. While the sympathomimetic pathway is frequently stimulated, tidal volume and functional residual capacity are retained because of relaxation in the bronchial smooth muscles (9).

Airway obstruction, laryngospasm, apnea, and hypoxia are the primary adverse events with respect to ketamine usage, with a reported overall rate of 3.9%. Of these, the rarest is laryngospasm, with a rate of 0.3% (10). With sedation/analgesia techniques, the patient's anxiety, restlessness, and pain can be reduced or completely eliminated. In addition, in initiatives that require immobility, such as pediatrics and non-cooperative adult patients, the success of the initiative by preventing movement is increased. Ketamine is a good analgesic. It is used in painful interventions. Minimal respiratory and cardiac depressant effects With ketamine, patient movement increase; therefore, movement it should be used with caution in undesirable interventions (11).

During diagnostic imaging tests, children require adequate sedation and appropriate doses of anesthetic agents for a successful examination to occur with minimal complications. The aim of this article was to examine the effect of low-dose m ketamine, which is used for vascular access, on sedation anesthesia in a group of pediatric patients who were accepted for MRI and compared with other sedative drugs. This study investigates low-dose (≤2.5 mg/kg) m ketamine, administered for vascular access during MRI in the pediatric population, with respect to its stability, safety, and efficacy on the assumption that it resulted in potentially fewer airway complications, sufficient immobility, and better quality MRI.

Materials and Methods

Approval for this study was obtained from the Local Ethics Committee of the University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital (2018/48). The study included pediatric inpatients and outpatients aged 3 months to 15 years, ASA < IV, not allergic to any agent used in the study, and not presenting

a contraindication, who had been referred to the MRI unit for magnetic resonance diagnostic imaging under sedation for a total of four months. Patients aged 3 months and older than 15 years, who underwent mask, laryngeal mask, and/or endotracheal intubation under general anesthesia, who underwent imaging without anesthesia in the presence of their parents, and who experienced adverse events were excluded from the study. As an anesthesia application outside the operating room, oral or m sedative agents are used in the MRI unit in the pediatric patient group to provide routine vascular access. This study aimed to determine the perioperative effects, efficacy, and safety of these drugs. For this purpose, patients who received or did not receive m ketamine for vascular access before the imaging procedure were compared and evaluated. Two groups of 193 patients in total were created. The 99 patients in Group K received m ketamine (≤2.5 mg/kg), whereas the 94 subjects in Group C (as the propofol-control group) were not administered m ketamine.

The hemodynamic status and degree of sedation before, during, and after imaging were monitored by an anesthesiologist and an anesthesia technician. The presence of vascular access determined which of the two groups the patients were assigned to. Intramuscular ketamine of 2.5 mg/kg was administered to patients without vascular access, and when adequate sedation was achieved, cannula intervention was performed. In both groups, an extension line was placed in all vascular access cannulas so that the contrast agent used in MRI and additional doses of anesthetic drugs could be easily administered without creating a tactile stimulus. The drugs and the saline solution administered afterwards were administered as an v bolus. Monitoring devices for pulse oximetry, electrocardiography, non-invasive blood pressure measurement, and capnography were attached to the children before induction. Intravenous propofol was titrated and administered to both groups, where there was loss of consciousness after the use of midazolam at 0.02 mg/kg during induction, absence of eyelash reflex, and no response to a face mask. A further dose of propofol (0.25-0.5 mg/kg on average) was administered if the patient retained consciousness during imaging. A Ramsay sedation scale (RSS) level of 4 to 5 was maintained upon completion of imaging. When the imaging was completed, the child was brought to the recovery room. When they were within the pre-sedation values, at a modified Aldrete recovery score (MARS) of 10 points, i.e., when hemodynamic values were ±20% of their pre-sedation values, the child was discharged if fully conscious.

Patient demographic data, American Society of Anesthesiology (ASA) physical status, MRI area, time until induction, MRI times, total sedation time, sedative doses administered until unconsciousness, total and further doses of propofol, along with basal values, systolic arterial pressures (SAP), diastolic arterial pressures (DAP), mean arterial pressures (MAP), apex heart rate (HR), rates of respiration, end-tidal carbon dioxide ($EtCO_2$) measurements, and oxygen saturations (SpO_2) were reviewed and recorded. During the recovery period, 0^{th}, 15^{th}, 30^{th} minutes RSS values, 0^{th}, 15^{th}, and 2^{nd} hour MARS values and the period when the MARS was 10 points, developed side effects, and MRI quality were noted as per both of the forms for anesthesia and recovery follow-up. The groups were compared with respect to the examined parameters.

Statistical Analysis

SPSS 26.0 (IBM Corporation, Armonk, New York, United States) and PAST 3 (Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001). Paleontological statisticswere employed for variable analysis. The Shapiro-Wilk francia test was used to determine univariate data conformity to the normal distribution, and the Levene test was used to evaluate the homogeneity of variance. Multivariate data conformity to the normal distribution was evaluated using the Mardia test. with the Dornik and Hansen omnibus test and the Box-M test used in relation to variance homogeneity. In comparing two independent groups according to the quantitative variables, the Independent-Samples t-test and Bootstrap results were employed, as was the Mann-Whitney U test in conjunction with the Monte Carlo results. The combination of paired-samples t-test and Boostrap results were used for a comparison of two-repeat measurements of the dependent quantitative variables. The Wilcoxon signed rank test was used in conjunction with the Monte Carlo simulation results, while an examination of the interaction of repeated quantitative measurements of variables according to groups was undertaken with the general linear model repeated ANOVA test. The Pearson chi-square, Fisher's Exact, and Fisher-Freeman-Halton tests were tested with the Monte Carlo simulation technique when comparing the categorical variables with each other, and the Benjamini-Hochberg-corrected p-value results were used for column ratio comparisons. In the tables, the mean (standard deviation) and median (percentile 25/percentile 75) were used for the expression of the quantitative variables, as was n (%) for the categorization variables. A 95% confidence level was used for the analysis of the variables, and where the p-value was less than 0.05, this was

considered significant. Repeated analyses of variance are used to analyze variables showing normal distribution and variance homogeneity. To test this, the Mardia and Dornik and Hansen omnibus tests are used for normal distribution and the Box-m test is used for homogeneity of variance. In our study, we evaluated the multivariate normality test and Mardia and Dornik and Hansen omnibus tests to make repeated measurements and choose the right analysis from hypothesis tests. This test tests normality in terms of both kurtosis and skewness. There were cases where our parametric tests were not appropriate for analyzing the results of these analyses. Therefore, it was tested using non-parametric analyses.

Results

A comparison of Groups K and C was made with respect to both clinical and demographic data (Table 1).

Between the groups, SpO_2, HR, SAP, DAP, MAP, respiratory rate, and $EtCO_2$ were comparable hemodynamic parameters. In Group K, the mean SAP, DAP, and median values of MAP during the procedure were higher than those in Group C ($p<0.001$; $=0.001$; <0.001, respectively) (Table 2).

The relationship between the groups in terms of propofol used in the first dose (mg/kg) and that in the additional dose (mg/kg) was statistically significant ($p<0.001$; and $=0.005$, respectively) (Figure 1, 2). In a comparison between groups, the mean values of the first dose and additional dose of propofol (mg/kg) in Group K were 0.56 (0.45/0.71) - 0 (0/0), respectively, while in Group C, the values were 1.11 (0.87/1.33) - 0.14 (0/0.5), respectively (Table 1).

Baseline and mean values after sedation initiation, and the median measurements of the change calculations between the baseline and mean values in the RSS analyses of the groups were found to be significantly different ($p<0.001$; $=0.003$; <0.001, respectively). Accordingly, the median values of change in Group K from the beginning of sedation to the end showed a positive increase compared with those in Group C. The increase was found to be statistically significant (the median values of change were 2.0 and 2.8, respectively) (Figure 3).

In the 0^{th} minute, with respect to MARS values at awakening between the groups ($p<0.001$), it was seen that there were statistically significant differences. Group K, 0^{th} minute MARS values were found to be lower than Group C averages. MARS measurements at the 15^{th} and 120^{th} minutes showed no statistically significant differences ($p=0.066$; $=0.999$, respectively) (Figure 4). The time the MARS was 10 points between the groups was also statistically significantly different: in Group K, the time to MARS 10 points was found to be twice as long as that for Group C ($p<0.001$) (Table 1).

Airway intervention was performed in three patients. While the jaw-thrust maneuver was performed in two patients in Group K, an airway was required in one patient in Group C (Table 1).

A comparison of the groups with respect to the presence of nausea-vomiting showed that the relationship at both the 30^{th} and 60^{th} minutes was statistically significant, with a higher incidence of nausea and vomiting in Group K than in Group C ($p=0.010$; $=0.034$, respectively).

A statistically significant difference was also found in the relationship between the groups in terms of MRI quality ($p<0.016$) (Figure 5).

One of the 210 children who met the study criteria could not complete the MRI scan due to a power outage. In the other case, the patient was awakened due to excessive secretions and coughing, and 15 were excluded from the analysis because of parent support. In patients included in the study, 135 of the brain, 18 of the whole abdomen, 13 of the lumbar vertebrae, 12 of the pituitary gland, 10 of the whole spinal cord, 6 of the orbita, 6 of the extremities, 6 of the cervical, 4 of the thorax, 3 of the neck, 2 of the sacral, and 2 of the face MRI was applied.

Discussion

The use of MRI has increased in the pediatric patient group because it can be examined without exposure to radiation during medical diagnosis, disease staging, and follow-up. While older children and adolescents without neurological disabilities can go through this process using glasses and while watching movies without sedation, younger children, in particular those under 5 years of age, require pharmacological assistance, sedation, or general anesthesia (12).

The use of ketamine for sedation in pediatric patients is common because the incidence of complications, for example, cardiorespiratory depression, is low compared with the effects often observed following benzodiazepine or narcotic usage. It also provides sedation with effective analgesia during in- and out-of-operating room procedures. Although the administration route can be oral, rectal, or intranasal, the most effective and commonly used methods for the anesthesia of pediatric patients are v and m. Its effect begins 5 min following its use m with an effective duration of approximately 45 min (13).

Table 1. Comparison of the groups according to demographic and clinical variables

	Total (n=193)	Group C (n=94)	Group K (n=99)	p
	n (%)	n (%)	n (%)	
Gender (girl)	82 (42.5)	36 (38.3)	46 (46.5)	0.308[c]
Age (year)				0.254[c]
3-6 months	40 (20.7)	24 (25.5)	16 (16.2)	
6-12 months	24 (12.4)	10 (10.6)	14 (14.1)	
>1 year	129 (66.8)	60 (63.8)	69 (69.7)	
	Median (q1/q3)	Median (q1/q3)	Median (q1/q3)	
Height (cm)	75 (64/90)	73 (61/89)	77 (67/91)	0.143[u]
Weight (kg)	11 (8/15)	10.25 (7.5/16)	11.5 (9/15)	0.511[u]
Induction time (min)	9 (3/14)	3 (2/4)	14 (10/17)	**<0.001**[u]
MRI time (min)	16 (12/25)	15 (12/22)	20 (12/26)	0.130[u]
Sedation time (min)	26 (20/35)	20 (15/25)	35 (26/41)	**<0.001**[u]
Recovery time(10) (min)	8 (5/10)	5 (5/10)	10 (5/12)	**<0.001**[u]
First dose of midazolam (mg/kg)	0.02 (0.02/0.02)	0.02 (0.02/0.02)	0.02 (0.02/0.02)	0.943[u]
First dose of propofol (mg/kg)	0.83 (0.5/1.15)	1.11 (0.87/1.33)	0.56 (0.45/0.71)	**<0.001**[u]
Additional dose of propofol (mg/kg)	0.06 (0/0.2)	0.14 (0/0.5)	0 (0/0)	**0.005**[u]
Total dose of propofol (mg/kg)	0.93 (0.5/1.4)	1.25 (0.9/1.7)	0.59 (0.5/1)	**<0.001**[u]
	n (%)	n (%)	n (%)	
ASA				**<0.001 ff**
I	113 (58.5)	39 (41.5)	74 (74.7) **A**	
II	76 (39.4)	51 (54.3) B	25 (25.3)	
III	4 (2.1)	4 (4.3) B	0 (0)	
Movement				0.249 ff
No	153 (79.3)	69 (73.4)	84 (84.8)	
Minimal	30 (15.5)	18 (19.1)	12 (12.1)	
Moderate	6 (3.1)	4 (4.3)	2 (2)	
Intensity	4 (2.1)	3 (3.2)	1 (1)	
Airway intervention	3 (1.5)	1 (1.1)	2 (2)	0.999[f]
Increased secretion	4 (2.1)	0 (0)	4 (4)	0.122[f]
Atropin sulfate	14 (7.3)	6 (6.4)	8 (8.1)	0.784[c]
Metoklopramid hydrochloride	4 (2.1)	1 (1.1)	3 (3)	0.622[f]
Flumazenil	1 (0.5)	0 (0)	1 (1)	0.999[f]
Bradycardia	12 (6.2)	7 (7.4)	5 (5.1)	0.560[c]
Apnea (10 sn)	1 (0.5)	0 (0)	1 (1)	0.999[f]
SpO_2<90	3 (1.6)	2 (2.1)	1 (1)	0.613[f]
Agitation	3 (1.6)	0 (0)	3 (3)	0.247[f]
Nightmare	2 (1)	0 (0)	2 (2)	0.498[f]
Diplopia	12 (6.2)	0 (0)	12 (12.1)	**<0.001**[c]
Unsuccessful sedation	3 (1.6)	1 (1.1)	2 (2)	0.999[f]
Three or more additional doses	6 (3.1)	3 (3.2)	3 (3)	0.999[f]
MR sequence repetition	6 (3.1)	3 (3.2)	3 (3)	0.999[f]

t: Independent t-test (Bootstrap), Mann-Whitney U test (Monte Carlo), ff: Fisher-Freeman-Halton (Monte Carlo), f: Fisher's Exact test (Monte Carlo), [c]: Pearson chi-square test (Monte Carlo); post hoc test: Benjamini-Hochberg correlation, q1: 1st quartile, q3: quartile, SD: Standard deviation, MR: Magnetic resonance, MRI: Magnetic resonance imaging, American Society of Anesthesiology

Table 2. Comparison of the groups' hemodynamic parameters, including basal and mean values, and according to their variations

	Group C (n=94)	Group K (n=99)	p
	Median (q1/q3)	**Median (q1/q3)**	
SpO_2			
Bazal	99.0 (99.0/99.0)	99.0 (99.0/99.0)	0.775[u]
Mean	98.6 (98.0/99.0)	98.9 (98.3/99.0)	0.311[u]
Variation	-0.1 (-1.0/0.0)	0.0 (-0.7/0.0)	0.588[u]
p-value (Bazal vs. Mean)	**0.001[w]**	**<0.001[w]**	
Pulse			
Bazal	132.5 (118.0/151.0)	135.0 (125.0/146.0)	0.716[u]
Mean	117.2 (102.0/127.7)	116.0 (105.5/128.4)	0.558[u]
Variation	-17.6 (-23.7/-13.0)	-18.0 (-24.0/-10.6)	0.503[u]
p-value (Bazal vs. Mean)	**<0.001[w]**	**<0.001[w]**	
SAP			
Bazal	101.0 (94.0/111.0)	113.0 (100.0/124.0)	**<0.001[u]**
Mean	96.0 (90.0/103.0)	104.0 (95.0/112.0)	**<0.001[u]**
Variation	-5.0 (-9.0/-2.0)	-8.0 (-17.0/-0.5)	**0.039[u]**
p-value (Bazal vs. Mean)	**<0.001[w]**	**<0.001[w]**	
	Mean (SD)	**Mean (SD)**	
DAP			
Bazal	62.5 (11.3)	70.4 (11.7)	**<0.001[t]**
Mean	58.9 (7.9)	62.8 (7.3)	**0.001[t]**
Variation	-3.5 (7.2)	-7.6 (9.3)	**0.001[ra]**
p-value (Bazal vs. Mean)	**<0.001[e]**	**<0.001[e]**	
MAP			
Bazal	75.9 (10.7)	84.1 (11.5)	**<0.001[t]**
Mean	71.5 (8.0)	76.2 (7.9)	**<0.001[t]**
Variation	-4.4 (6.7)	-7.9 (8.8)	**0.002[a]**
p-value (Bazal vs. Mean)	**<0.001[e]**	**<0.001[e]**	
Respiratory rate			
Bazal	27.7 (7.8)	26.0 (6.9)	0.111[t]
Mean	26.1 (6.8)	24.7 (6.2)	0.138[t]
Variation	-1.7 (4.5)	-1.3 (4.4)	0.626[ra]
p-value (Bazal vs. Mean)	**0.001[e]**	**0.003[e]**	
$EtCO_2$			
Bazal	30.9 (2.8)	31.2 (3.0)	0.414[t]
Mean	32.1 (2.3)	32.2 (2.5)	0.697[t]
Variation	1.2 (1.6)	1.0 (1.7)	0.392[ra]
p-value (Bazal vs. Mean)	**<0.001[e]**	**<0.001[e]**	

[ra]General Linear Model Repeated ANOVA (Wilks' Lambda), [t]: Independent t-test (Bootstrap), Mann-Whitney U test (Monte Carlo), [w]: Wilcoxon signed ranks test (Monte Carlo), [e]: Paired t-test (Bootstrap), [f]: Fisher's Exact test (Monte Carlo), Pearson chi-square test (Monte Carlo), post hoc test: Benjamini-Hochberg correlation, q1: 1st quartile, q3: 3rd quartile, SD: Standard deviation, MAP: Mean arterial pressures, SAP: Systolic arterial pressures, DAP: Diastolic arterial pressures

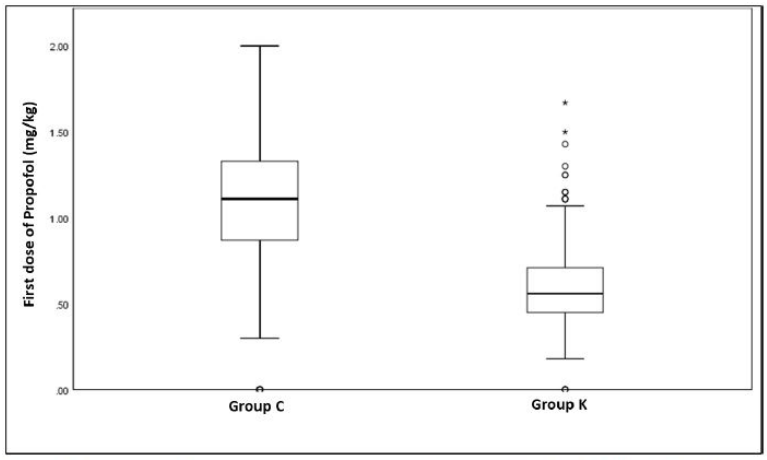

Figure 1. Comparision of first dose of propofol bolus between the groups. Propofol used in the first dose (mg/kg) was statistically significant (p<0.001). Group C (as the propofol-control group), Group K received im ketamine (≤2.5 mg/kg)

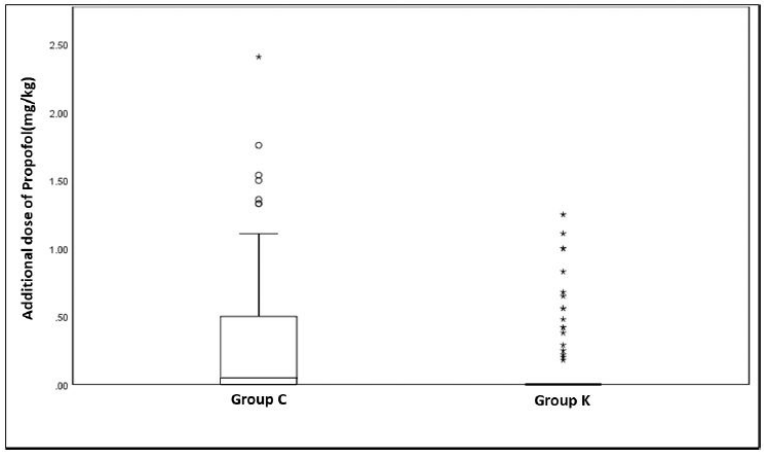

Figure 2. Comparision of additional dose of propofol bolus between the groups. The additional dose propofol (mg/kg) was statistically significant (p=0.005). Group C (as the propofol-control group), Group K received im ketamine (≤2.5 mg/kg)

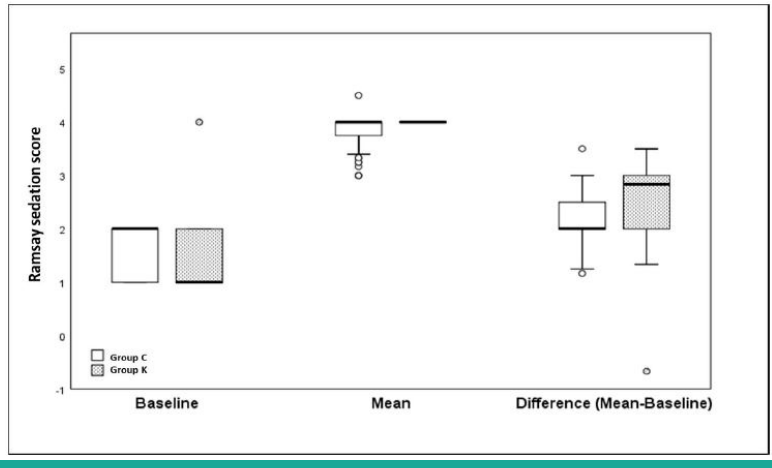

Figure 3. Comparison of the change calculations between the baseline and mean values in the Ramsay sedation scores between the groups. Group C (as the propofol-control group), Group K received im ketamine (≤2.5 mg/kg)

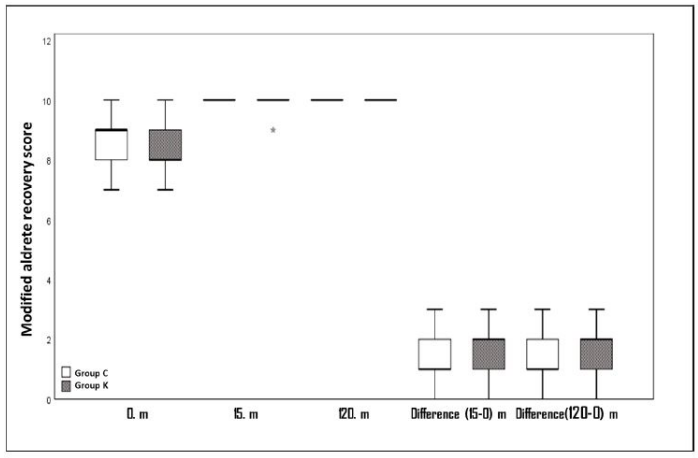

Figure 4. Illustrates the modified Aldrete recovery scores between the groups at each time. Group C (as the propofol-control group), Group K received im ketamine (≤2.5 mg/kg)

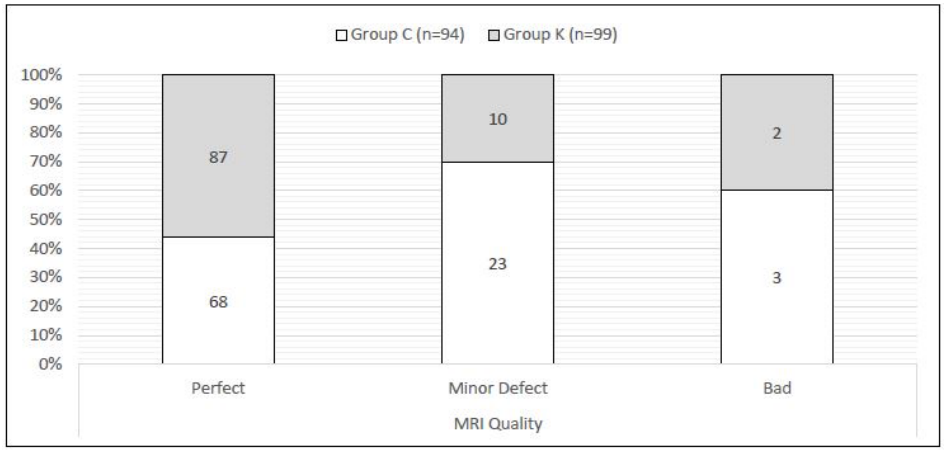

Figure 5. Bar chart of relationship between groups in terms of magnetic resonance imaging (MRI) quality. The scan quality was statistically comparable for the groups (p<0.016). Group C (as the propofol-control group), Group K, received im ketamine (≤2.5 mg/kg)

When ketamine is administered m for venous cannulation, it provides adequate analgesia with unique dissociative anesthesia, airway reflexes are usually preserved, and respiratory depression rarely occurs (14).

A comparison of the efficacy and quality of low-dose m ketamine (≤2.5 mg/kg), used for v access, with propofol in sedation anesthesia during pediatric MRI was undertaken in this study. According to the main findings, we observed that with m ketamine, without the need for additional doses of propofol, effective sedation, excellent immobility, and better MRI quality were achieved in more agitated children, based on RSS.

Eich et al. (15) reported that both bolus propofol requirement and total propofol consumption were lower in the propofol-ketamine group to which low-dose v ketamine was added, and recovery was faster. Tomatir et al. (16) showed that with small doses of ketamine (0.5 mg/kg), a scan in pediatric MRI could be completed successfully, with hemodynamic stability observed where both the induction and maintenance doses of propofol were lower (1.5 mg/kg, 75 mcg/kg/day). Sethi et al. (17) found that boluses of both propofol and ketamine (1 mg/kg each) administered during induction allowed sedation to be maintained with less propofol infusion (50 mcg/kg/min). As in the literature, it was found that the bolus doses of propofol used in induction in the ketamine group were half as low as those in the control group, and in the ketamine group, no additional propofol as a maintenance dose was required.

In the literature, it was seen that ketamine, which is used in different combinations in children for procedural sedation both in MRI and in the emergency department as well as

in laser applications, provides adequate sedation based on RSS (18-20). However, in a study that included intranasal ketamine use, it was reported that sedation failure was more common than intranasal dexmethotimidine (21). In our study, the depth of sedation was observed to be more consistent during the procedure in the ketamine group, and an increased level of sedation was found consistent with the effective level of m ketamine. Sedation failure, additional dose administration, and repeat MRI were observed in three patients in each group, with no difference observed. Although unsuccessful sedation was recorded in one patient with apnea in the control group, the procedure was stopped in 2 patients in the ketamine group because of excessive secretion and coughing.

In a study by Schmitz et al. (22) in which they compared two different propofol sedation regimens with and without ketamine in MRI, the MARS in the ketamine-propofol group gave evidence of faster normalization when compared to the propofol mono group recovery time [38 (22-65) - 54 (37-77) minutes], which was found to be significantly shorter. However, in a study comparing ketofol with a single agent, there is low evidence that recovery time is better (14). Shah et al. (23) showed that both mean total sedation and recovery times were shorter in the ketamine/propofol group than in the ketamine group. In our study, the mean total sedation and recovery times to MARS 10 were longer in the ketamine group than in the control group. MARS was determined as 10 points in both groups at the 15th minute measurements. We think that the efficacy of ketamine continues on average for 35 min of sedation, and that the lower first and total doses of propofol in the propofol group (1.1 mg/kg, 1.25 mg/kg, respectively) when compared with those used in other studies in the literature have an effect on recovery time.

Suryaprakash and Tham (24) observed that the effect of m ketamine on nausea-vomiting was correlated with age when used for pediatric procedural sedation in emergency contexts. In this same work, it was also seen that the patient was not predisposed to vomiting by the initial dose of ketamine (3 kg/mg or 4 kg/mg). Ketamine-sedation-associated vomiting was observed at a rate of 8.4% in pediatric patients, and there was a higher risk in children ≥8 years of age (24).

Akin et al.'s (25), which were used on auditory brainstem response test in pediatric cases, attributed the lower incidence of both nausea and vomiting in both groups (propofol and propofol-ketamin) to the fact that propofol has antiemetic properties by antagonizing dopamine D2 receptors, which was also similar to that in our study. In our study, we found that the 30th and 60th minute nausea-vomiting scores were higher in patients who were administered m ketamine.

In the study in which low-dose ketamine was added to propofol and compared solely with propofol, repetition of patient motion and single-sequence MRI were observed at a lower rate of 12.3% and 7%, respectively, in the ketamine group. As a result, they were found to provide equally suitable and safe imaging quality in both groups (15). Schmitz et al. (22) showed in their studies that long-term MRI was impaired more frequently due to patient movement in the ketamine-propofol group, and more sedative drugs were needed due to movement. We believe that the high rate of excellent MRI quality in the ketamine group observed in our study was due to effective and deep sedation despite low-dose ketamine usage (≤2.5 mg/kg).

Study Limitations

The limitations of our study are that it is a single-center study and data were collected from our own clinical experience.

In summary, during MRI, with respect to the m dose of ≤2.5 mg/kg we applied in pediatric cases, it was observed that ketamine maintains hemodynamic stability, has very few side effects, and achieves excellent MRI quality.

Conclusion

We believe that m ketamine, which we used to provide vascular access in pediatric patients, should be supported by further studies in terms of its effect on sedation and the recovery period, and that different dose ranges and agents should be evaluated in both MRI and other sedation procedures. The most appropriate doses that can provide immobility and their possible combinations with the most appropriate agents should be investigated in future studies.

Ethics

Ethics Committee Approval: Approval for this study was obtained from the Local Ethics Committee of the University of Health Sciences Turkey, İstanbul Bakırköy Dr. Sadi Konuk Training and Research Hospital (2018/48).

Informed Consent: Not necessary for this manuscript.

Authorship Contributions

Surgical and Medical Practices: N.Y., Nu.Y., Concept: N.Y, A.D., Z.S., Design: N.Y., Nu.Y., A.S.Ş., Data Collection or Processing: N.Y., Nu.Y., K.A., Analysis or Interpretation: K.A.,

A.D., Z.S., Literature Search: N.Y., K.A., A.S.Ş., A.D., Z.S., Writing: N.Y., A.S.Ş.

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