



## Sedation in pediatric magnetic resonance imaging: a ten-year experience

Magnetic resonance imaging in children

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### Abstract

**Aim:** We aimed to evaluate anesthesia practice for pediatric magnetic resonance imaging (MRI) according to the age groups and discuss the anesthetic management of the patients. We investigated the hospital sheets of all children who underwent MRI under anesthesia retrospectively. **Material and Method:** We divided the total of 5720 patients included in the study into two groups as Group S: school children (>6 years) and Group PS: preschool children (<6 years). We compared the two groups according to demographic characteristics, the anesthetic agent, additional anesthetic agent requirement, length of the sedation and the complications before and after the sedation. **Results:** Overall, the mean age of the patients was  $4.6 \pm 3.8$  years (6 months–14 years). In all procedural sedation, we used the ketamine-propofol combination. In Group S, mean ketamine and propofol doses were significantly higher than Group PS ( $p < 0.05$ ). There was no statistically significant difference in additional anesthetic agent requirement as Ketamine and Midazolam ( $p = 0.38$ ,  $p = 0.42$ ). The duration of anesthesia was significantly longer in preschool children ( $p < 0.05$ ). There were no severe complications in both groups. In 148 patients we observed hypoxia (2.58%) and pain in the injection area in 114 (1.99%) patients with complications due to sedation. **Discussion:** In pediatric MRI patients, ketamine and midazolam are effective and safe choices for procedural sedation. For safety of the sedation, it must be done in a well-equipped environment and proper dose adjustment is required.

### Keywords

Anesthesia, Complication, MRI, Sedation

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## Introduction

In children, MRI requires sedation or general anesthesia due to noisy and narrow working environment [1]. Sedation controls anxiety and fear; also maintains immobility for optimal imaging. Stability is essential in MRI because it is susceptible to motion artifacts. Repetition of the full sequence is required if any motion occurs during the imaging process for one sequence [2]. In recent years, the number of pediatric patients with MRI increased by increasing popularity; but there is a limited number of study concerning the anesthetic management of these patients. General anesthesia may be an alternative in pediatric patients during MRI without any anesthetic complications, but sedation or general anesthesia during this procedure may depend on the preferences of the centers [3]. The difficulties related to MRI in pediatric patients are reported to be between 1.7 and 25.1% [4].

In this study, we evaluated retrospectively our procedural sedation practice and complication rates for pediatric MRI procedures in our department between December 2008 and January 2018.

## Material and Method

Kartal Dr. Lutfi Kirdar, Research and Training Hospital, is one of the leading national referral centers for MRI in Istanbul, Turkey. In our hospital, pediatric MRI procedures are carried out in the hospital's central MRI unit with Achieva 1.5 T, DS Advance, Philips N.V., Netherlands device. This retrospective study includes pediatric MRI patients under general anesthesia in our hospital between December 2008 and January 2018. We excluded the patients with heart, lung or neurological disease, central nervous system or extremity trauma, or contraindication or allergy to any of the drugs studied and to the egg.

Kartal Dr. Lutfi Kirdar Research and Training Hospital ethical board approved the study and ethics committee (Date:13/12/2017; Number: 514/119/2), and we performed the research according to the principles of the Helsinki Declaration. All cases (n=5720) were divided into two main groups as follows: Group S—school children (6<years) and Group PS—preschool children (6>years). We reviewed the medical records retrospectively. Gender age, weight, the presence of comorbid disorders, the American Society of Anesthesiology(ASA) scores, drugs used for sedation, the addition of extra anesthetic agents, anesthesia-related complications (desaturation, apnea, respiratory depression, airway intervention, vomiting, hallucinations, and agitation) were analyzed and the groups were compared accordingly.

No pediatric MRI patient was excluded from the study.

An anesthesiologist examined procedural patients before the procedure and referred to other departments, if necessary. All children were admitted on the morning of the process with the fasting of a minimum six hours for solid foods and two hours for liquids. Before the procedure, no additional drugs for premedication were given. MRI team included a radiologist, anesthesiologist, anesthesia nurse, pediatrician, and radiology technician. After providing the written informed consent from subjects parents and standard monitoring consisted of the continuous electrocardiogram, pulse oximetry, and intermittent non-invasive blood pressure at 5-minute intervals throughout sedation, anesthesia was provided by intravenous ketamine (0.5–1 mg/kg) and propofol (0.1–0.15 mg/kg). The primary goal was to

give the score of 4/6 in Modified Ramsey Scale [5,6]. If sedation was not adequate, the addition of extra anesthetic agents such as midazolam(0.5mg/kg) or additional ketamine (0.5 mg/kg) was given. 1/3 isomix pediatric solution at the rate of 4 ml  $\text{kg}^{-1} \text{h}^{-1}$  was administered during the imaging. During the sedation, children breathed spontaneously, and we delivered oxygen at 4 L/min through a nasal cannula. After the procedure, patients are monitored with oxygen support in the recovery room. Heart rate, non-invasive blood pressure, respiratory rate, and observed complications were recorded until they have Ramsay sedation score of 2. Children being fully awake, able to cough or breathe deeply, had stable airway patency, moving all limbs voluntarily and maintaining an oxygen saturation higher than 95% discharged their home.

We observed the patients for oxygen desaturation ( $\text{SpO}_2 < 90\%$ ) and apnea  $< 10$  sec. In these situations, first of all, relief of the airway obstruction was performed by chin lift/jaw thrust maneuver, control of airway equipment. Then, further interventions for airway management were performed like an oral/nasal airway, a laryngeal mask airway, or an endotracheal tube.

All data related to this procedure statistically analyzed by SPSS 14 version for Windows (SPSS Inc., Chicago, IL, USA). Intergroup statistical analyses were performed using the ANOVA test, and non-parametric data were analyzed using the  $\chi^2$  -test. The Fisher's exact test examined the incidence of side effects. Results are presented as mean (SD) or number (%) inappropriate parameters. Statistical significance was assumed at  $P < 0.05$ .

## Results

During the study period, 5720 children (3011 boys, 2709 girls) aged between 6 months and 14 years undergoing MRI procedure under procedural sedation anesthesia in hospital included in the study. 3867 children (2101 boys/1766 girls) were evaluated in Group PS, a total of 1853 children were assessed in Group S (910 boys/943 girls).

While the mean age of the children evaluated in both groups was  $4.6 \pm 3.8$  years, evaluation of these values on a patient age manner revealed the mean value for cases in S group to be  $9.85 \pm 1.26$  years, and it was  $2.3 \pm 2.17$  years in Group PS children.

The patients' body weight ranged from 5 to 36 kg with a mean of 16.78 kg. Evaluation of the length of the procedure in both the preschool and school children demonstrated a statistically significant difference between two groups ( $p < 0.05$ ).

Total sedation time was also significantly longer with PS group than with Group S ( $33.1 \pm 5.8$  vs.  $25.3 \pm 3.4$ ;  $p < 0.05$ ). There were statistically significant intergroup differences concerning age, weight, and the length of the procedure ( $p < 0.05$ ).

There were no statistically significant intergroup differences concerning gender and ASA scores ( $p > 0.05$  each). Patients in both groups were compared according to demographic data, age, gender, length of the procedure and ASA scores (Table 1). We used Procedural anesthesia in all children and imaging were completed.

The mean ketamine doses in preschool children and school children were  $18.23 \pm 9.11$  mg and  $22.45 \pm 10.56$  mg, respectively. The mean propofol doses in preschool children and school children were found  $12.10 \pm 2.53$  and  $15.27 \pm 3.59$  mg, respectively. In Group S, mean ketamine and propofol doses were significantly higher than the preschool group ( $p < 0.05$ ;  $p = 0.012$  and  $p =$

= 0.009, respectively). There was no statistically significant difference in additional anesthetic agent (Ketamine or Midazolam) requirements in preschool and school children ( $p=0.38$ ,  $p=0.42$ ) (Table 2).

Complications were observed in 304 patients (5.31%). In 148 patients (2.58%) hypoxia, in 114 patients (1.99%) pain in the injection area and there were 42 patients (0.73%) with postoperative agitation (Table 3). There was no statistically significant difference in complications between groups. There was no drug-related intraprocedural and severe postprocedural complications observed, and all the patients were discharged from the hospital on the same day of the procedure.

## Discussion

As in adults, MRI is a highly accurate and non-radiative way of radiologic examination. However, the demand for motionless during scanning procedure makes it difficult to perform and get a sufficient image in these patients [6]. One way of the maintenance of the fixed posture during imaging is deep sedation [7]. In our study, we used ketamine and propofol for procedural sedation. There were no anesthesia-related serious complications (aspiration, cardiac arrest, and death) were seen in preschool and school children in recommended doses.

Previously, various techniques were tried for procedural anes-

thesia like general anesthesia with tracheal intubation or laryngeal mask, -controlled analgesia with fentanyl and infusion of propofol or dexmedetomidine but there was no significant eminence of one of them over the others [8,9,10]. A comprehensive safety, rapid onset of action, a short duration action, and quick recovery time with no adverse effects are the main characteristics of the ideal anesthetic agent for procedural sedation. Amnesia and a slight decrease in muscular tonus are the other features. Most of the pediatric patients may require general anesthesia to prevent patient movements and reactions during the MRI procedure today [11].

Desaturation, apnea, respiratory depression, and laryngospasm are some intraprocedural complications which may require endotracheal intubation during MRI in pediatric patients. Nausea, vomiting, hallucinations, and agitation are the main postprocedural complications [12,13].

Ketamine is a well known dissociative anesthetic agent which preserves spontaneous respiration and protective airway reflexes. Especially in higher doses, vomiting, adverse respiratory and cardiovascular side effects may be observed [14]. Propofol is a newer hypnotic agent, more popular in anesthesia with its rapid action, short recovery time, and antiemetic effect [15]. But propofol may cause some respiratory complications depending on doses like hypoventilation, airway obstruction and apnea [16]. When a single agent is not sufficient for sedation in procedural anesthesia, various drug combinations may be a choice.

Propofol and ketamine are choices of many researchers for sedation in various procedures in children either separately or together. In a recent study, propofol was reported as an active agent in sedation of a large group of pediatric patients by critical care physicians with minor side effects [17]. Also, Sury MR et al. [18] concluded the propofol as the most effective i.v agent for sedation in the paediatric population.

In a study including 49836 patients with propofol [19], primary side effects were hypoxia, change in respiration, allergic reaction, apnea, cardiac arrest, airway obstruction and vomiting. Also, Srinivasan et al. reported a 74% reduction in respiratory events and airway interventions during the use of propofol for diagnostic imaging in children [20].

In another study similar to our work, researchers preferred propofol for ambulatory MRI in infants and children [21]. In this study, no significant respiratory problems occurred, but oxygen desaturation, partial airway obstruction (treated with slight neck extension and chin support), the demand of assistance of spontaneous respiration via bag-valve-mask ventilation were observed as complications. We also had no apparent respiratory complications requiring endotracheal intubation and mechanical ventilation like this research. They reported propofol as a safe agent for short-term procedural sedation and our results have concordance with this result.

Ketamine is another alternative agent for sedation procedure, and it can be administered both i.v and i.m. in pediatric cases [22]. In a study with pediatric patients, no severe complications were observed for sedative use [23]. Hallucinogenic side effects and increase in intracranial pressure may prevent physicians from the use of ketamine, but in our study, we observed no such side effects. Guit et al. [24] defined that propofol is very successful in diminishing the side effects of ketamine and the ketamine-propofol combination may afford hemodynamic

Table 1. The distribution of the patients due to gender and ASA classification.

Variables	S Group (n=1853)	PS Group (n=3867)
• Sex (male/female)	910/943	2101/1766
• ASA class (I/II)	1231/582	2306/1561

Table 2. Patients characteristics.

Variables	S Group (n=1853)	PS Group (n=3867)	P value
• Age (year)	9.85±1.26	2.3±2.17	0.02*
• Weight (kg)	11.7±5.3	4.8±2.2	0.015*
• Duration of procedure (min)	25.3±3.4	33.1±5.8	0.012*

• ANOVA test was used to compare the variables among two groups. Data are expressed mean ± SD, or number(%) of patients.

• \*P<0.05: statistically significant

• ASA = American Society of Anesthesiology, PS Group = preschool group, S Group = school

Table 3. Anesthetic characteristics

Variables	S Group (n=1853)	PS Group (n=3867)	P
Ketamine doses (mg)	22.45±10.56	18.23±9.11	0.012*
Propofol doses (mg)	15.27±3.59	12.10±2.53	0.009*
Additional Midazolam	2.8±1.6	2.4±1.1	0.42
Additional Ketamine	8.25±1.23	7.55±1.56	0.38

ANOVA test was used to compare the variables among two groups. Values are expressed mean (range), mean ± SD, or the absolute number of patients. PS Group = preschool group, S Group = school group

\*P<0.05: statistically significant

Table 4. Procedural sedation-related complications

Variables	S Group (n=1853)	PS Group (n=3867)	P
• Pain in the injection area	62	52	0.214
• Hypoxia	67	81	0.347
• Postoperative agitation	24	18	0.475

Fisher's exact test was used to compare the variables among two groups

stability. In another study [25], propofol and ketamine-propofol combination were compared in cardiac catheterization operation for pediatric patients, and ketamine propofol combination resulted in better mean arterial pressure without affecting the recovery. We think that we did not observe any significant side effect of ketamine due to its combination with propofol similar to this study.

One must focus on the airway patency during procedural anesthesia, so the preferred medications and their dose arrangements are critical in this issue. In our study; hypoxia was transient, and it was reversible by supplemental oxygen. None of the patients in our study was required bag valve manual ventilation or endotracheal intubation. No agent is devoid of potentially life-threatening side effects.

Our study results demonstrated that patients receiving propofol and ketamine sedation anesthesia, complications were observed in 5.3% of patients. In the Group PS, the duration of sedation and general intervention was longer than in Group S. We think that this was due to the difficulty of coping with these children with lower ages for maintenance of stability without motion by themselves and the agents used for sedation have a significant role in this issue. Also, the maintaining the intravenous routes for administration of the sedatives is harder in this group due to the smaller sizes of vessels and even commonly crying children during i.v line opening. These may increase the duration of the procedure.

Our study is a retrospective study with a long time of interval. Although the same protocol is carried out, different anesthetists were involved in the research. This situation may be accepted as a limitation of our study.

### Conclusion

In both preschool and school patients, adjusted doses of ketamine and propofol may be a valid and safe choice. Both drugs are safe and suitable for busy procedural settings without any significant side effects, and hospitalization requirements but highly experienced anesthesiologists and adequate equipment readily available for respiratory and cardiovascular emergencies are required for the proper and safe procedure.

### Scientific Responsibility Statement

*The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.*

### Animal and human rights statement

*All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.*

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### Conflict of interest

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