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Anesthesia practices during magnetic resonance imaging in pediatric patients

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ABSTRACT

Aims: The use of magnetic resonance imaging (MRI) is becoming increasingly common for diagnostic and therapeutic purposes in pediatric cases. Among children who are too young to cooperate with the procedure or in those with anxiety. anesthesia may be required to minimize excessive motion and optimize image quality. The aim of this study was to determine the efficacy and associated complications of different anesthesia techniques used during MRI in pediatric patients at our hospital.

Methods: Anesthesia charts and computer records of pediatric patients who had undergone MRI under anesthesia between January 2021 and January 2023 in a training and research hospital were retrospectively reviewed. The patients were categorized into four groups according to their anesthesia maintenance protocols to compare their efficacy and associated complications.

Results: Of the 358 included patients. only 2% underwent MRI under general anesthesia using a laryngeal mask airway (LMA). whereas the rest underwent MRI under sedation. In our hospital. the most commonly used technique for MRI under anesthesia in pediatric patients involved sevoflurane inhalation using a simple facemask and airway (54.5%). and the lowest complication rate (0.8%) was observed in those who underwent only anesthesia induction without the administration of an agent for the maintenance of anesthesia.

Conclusion: Outpatient anesthesia is generally considered the most effective and comfortable method for sedation during MRI. The results of this study suggest that anesthesia involving sevoflurane inhalation with a simple face mask applied to preserve spontaneous breathing is an effective and safe method for pediatric patients undergoing MRI.

Keywords: Magnetic resonance imaging. pediatrics. anesthesia. sevoflurane

INTRODUCTION

Outpatient anesthesia is becoming increasingly common in pediatric procedures. and members of the anesthesia team are expected to provide care in very different areas. including. but not limited to. interventional radiology. radiation oncology. and cardiac catheterization laboratories. To provide safe anesthesia. experienced anesthesiologists must be aware of the specific characteristics and environmental risks in these different units and manage perioperative processes accordingly.[1] In pediatric anesthesia management performed outside the operating room. maintenance methods may include intubation. controlled or spontaneous breathing with a laryngeal mask. local anesthesia. and spontaneous breathing with oxygen support. depending on the reason for anesthesia.[2] Magnetic resonance imaging (MRI) performed outside of the operating room is a valuable radiological imaging method for diagnosis and treatment monitoring that is being increasingly used in pediatric patients. who sometimes require anesthesia during the procedure.[3] The need for prolonged immobility in a closed and noisy area. the requirement for intravenous (IV) injections of contrast material. and the anxiety resulting from separation from parents make MRI a highly anxiety-inducing procedure for children.[4] Therefore. anesthesia is the most appropriate method for ensuring this process occurs smoothly.

In pediatric populations. anesthesia for MRI should maintain the hemodynamic balance without harming the physiology and metabolism of patients while ensuring recovery occurs safely in a short time period. as it is usually an outpatient or ambulatory procedure.[5] IV anesthetic agents such as propofol. ketamine. midazolam. and dexmedetomidine as well as inhalational agents such as sevoflurane are used either individually or in combination for sedation in pediatric anesthesia management during MRI.[6] The most critical requirement for anesthesia during such procedures is the provision of equipment that is MRI-compatible.

The aim of this study was to evaluate the anesthesia techniques used during MRI in pediatric patients at our hospital. The secondary aim was to compare the efficacy and associated complications of these anesthesia techniques.

METHODS

This single-center. retrospective cohort study included pediatric patients who had undergone MRI under anesthesia between January 2021 and January 2023 at Gülhane Training and Research Hospital. University of Health Sciences. Ankara. This study was approved by the University of Health Sciences. Gülhane Clinical Researches Ethics Committee (Date: 10.09.2024. Decision No: 2024/441) and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. As the study was retrospective in nature. voluntary informed consent was not obtained from the patients.

This study included all patients with an American Society of Anesthesiologists (ASA) physical status classification of 1–3 who were younger than 18 years of age. who had undergone MRI under anesthesia. and whose medical data were not missing. Data from 358 pediatric patients who met the inclusion criteria were collected retrospectively by reviewing computer records and anesthesia follow-up forms. The patients were categorized into the following four groups according to the anesthesia maintenance practices: Group 1. cases in which no anesthetic agent was administered for anesthesia maintenance; Group 2. cases in which only an inhalational agent was administered for anesthesia maintenance; Group 3. cases in which an IV anesthetic agent was administered for anesthesia maintenance; and Group 4. cases in which both IV and inhalational agents were administered in combination for anesthesia maintenance.

Outpatient or ambulatory anesthesia for MRI was performed by various anesthesiologists. each of whom had more than ten years of experience. The type of anesthesia administered to the patients was determined at the discretion of each anesthesiologist according to the age of the patient. the presence of comorbidities. the anatomical area in which MRI was being performed and the number of areas evaluated. and the duration of the procedure. An MRI-compatible anesthesia device (Lamtec 880; Pneupac. Luton. UK) and bedside monitoring equipment (Invivo 3150 Magnitude MRI Monitor Full System) were used in all cases. with the anesthesia-related equipment being used in the MRI unit. Heart rate. peripheral blood oxygen saturation (SpO2). and capnography (with a face mask. endotracheal tube. or laryngeal mask) were routinely monitored during anesthesia. Sedated patients with a sedation score of 2 or 3 according to the University of Michigan Sedation Scale (UMSS) received follow-up assessments (**Table 1**). When the heart rates of the children fell below the normal limits for their age group. bradycardia was assumed. and atropine (0.02 mg/kg. IV) was administered (Table 2). When SpO_2 levels fell below 90%. hypoxia was assumed. and necessary interventions were performed. Following the procedure. patients were transferred to the recovery room. where the SpO_2 and heart rate were continuously monitored and evaluated according to the Modified Aldrete Score (Table 3); the patients were discharged once the score reached 10.

Table 1. The University of Michigan Sedation Scale (UMSS)

Score	Description
0	Awake and alert
1	Minimally sedated : tired/sleepy. appropriate response to verbal conversation and or sound (calling child's name)
2	Moderately sedated : somnolent/sleeping. easily aroused with light tactile stimulation (lightly touching arm. face and leg)
3	Deeply sedated : deep sleep arousable only with significant physical stimulation (tickling their feet)
4	Unarousable : unresponsive to feet tickle

Table 2. Normal pediatric heart rates

Age (Years)	Range of normal heart rates (beats per minute)
Neonate <30 days	120-160
1-6 months	110-140
6-12 months	100-140
1-2 years	90-130
3-5 years	80-120
6-8 years	75-115
9-12 years	70-110
13-16 years	60-110
>16 years	60-100

Demographic data. ASA information. details about the MRI acquisition sites and number of sites. contrast agent use. peripheral vascular access management. premedication. anesthesia induction and maintenance. airway management. MRI acquisition. total length of stay. movement during the procedure. complications encountered. and interventions were recorded in the data forms and analyzed.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows. version 25.0 (IBM Corp.. Armonk. NY. USA). The normality of the data distribution for each variable was determined using the Kolmogorov-Smirnov test. Data are expressed as numbers. percentages. median values with an interquartile range (IQR). or minimum and maximum values. Categorical variables were evaluated using the chi-square test. quantitative measurement data were evaluated using the Kruskal–Wallis test. and intragroup pairwise comparisons were conducted using the Mann-Whitney U test. Statistical significance was set at $p<0.05$. For intragroup pairwise comparisons of continuous data (six paired groups). the Bonferroni correction was applied. and a corrected p value of 0.0083 (0.05/6) indicated a statistically significant difference.

Table 3. Modified aldrete scoring system

Criteria	Characteristics	Points
Activity	Able to move 4 extremities	2
	Able to move 2 extremities	1
	Unable to move extremities	0
Respiration	Able to breathe deeply and cough freely	2
	Dyspnea or limited breathing	1
	Apneic	0
Circulation	BP +/- 20% of pre-anesthetic level	2
	BP +/- 20-49% of pre-anesthetic level	1
	BP +/- 50% of pre-anesthetic level	0
Consiousness	Fully awake	2
	Arousable on calling	1
	Not responding	0
Oxygen saturation	Able to maintain O_2 saturation >92% on room air	2
	Needs oxygen to maintain O_2 saturation >90%	1
	O_2 saturation <%90 even with supplemental oxygen	0

(BP:Blood Pressure. O_2 : Oxygen)

Table 4. Demographic data. ASA scores. comorbidities and antiepileptic drug use of the groups

	Total n=358	Group 1 n=58 (%16.2) No maintenance anesthesia	Group 2 n=219 (%61.1) Maintenance with inhalation anesthesia	Group 3 n=63 (%17.5) Maintenance with IV anesthesia	Group 4 n=18 (%5) Maintenance with inhalation and IV anesthesia	P
ASA. n (%)						
I	185 (51.7)	37 (63.8)	115 (52.5)	27 (42.9)	6 (33.3)	
II	154 (43.0)	16 (27.6)	94 (42.9)	33 (52.4)	11 (61.1)	
III	19 (5.3)	5 (8.6)	10 (4.6)	3 (4.8)	1 (5.6)	0.085
Additional Disease. n (%)						
Yes	159 (44.4)	21 (36.2)	93 (42.5)	33 (52.4)	12 (66.7)	
No	199 (55.6)	37 (63.8)	126 (57.5)	30 (47.6)	6 (33.3)	0.067
Gender n (%)						
Woman	137 (38.3)	25 (43.1)	80 (36.5)	25 (39.7)	7 (38.9)	
Man	221 (61.7)	33 (56.9)	139 (63.5)	38 (60.3)	11 (61.1)	0.823
Use of antiepileptic drugs. n (%)						
Yes	44 (12.4)	6 (10.3)	27 (12.4)	9 (14.3)	2 (11.8)	
No	312 (87.6)	52 (89.7)	191 (87.6)	54 (85.7)	15 (88.2)	0.932
Age (Year)	3.0 (0.5-5.0 [0.0-16.0])	3.0 (0.5-4.6 [0.0-16.0])	2.0 (0.5-5.0 [0.0-16.0])	4.0 (2.0-6.0 [0.0-12.00])	3.0 (1.7-6.5 [0.5-10.0])	<0.001
Weight (kg)	13.0 (9.0-20.0 [2.9-63.0])	12.7 (7.8-18.2 [3.0-63.0])	12.0 (8.0-18.0 [2.9-46.0])	16.0 (12.0-22.0 [6.5-41.00])	14.5 (10.0-21.2 [8.0-35.0])	0.001

(IV: Intravenous. ASA: American Society of Anesthesiologists Classification)

RESULTS

Of the 358 children who had undergone MRI under anesthesia. 137 (38.3%) were girls and 221 (61.7%) were boys. In terms of the categorization based on the type of anesthesia administered for maintenance. 219 (61.1%) patients comprised Group 2. 63 (17.5%) made up Group 3. 58 (16.2%) met the criteria for Group 1. and 18 (5.0%) were classified in Group 4. A total of 185 (51.7%) patients had an ASA 1 physical status classification. and there was no statistically significant intergroup difference. A significant intergroup difference was observed in terms of age. with the patients in Group 2 being significantly younger (p<0.001). Similarly. the weights of the children differed significantly between the groups. with those in Group 3 being heavier. (Table 4).

In 316 patients (88.3%). MRI was conducted in one anatomical region. the most common being the brain in 294 cases (82.1%). whereas MRI of more than one anatomical region was performed in 42 cases (11.7%). The highest number of single-region MRI scans was performed in Group 2. which also exhibited the highest use of contrast material (p=0.016 and p=0.001. respectively).

Peripheral vascular access was performed while patients were awake in most cases (76.8%) and was conducted most frequently in Group 1; the most common access site was dorsum of the hand (67.6%). and successful access was most often achieved in a single attempt (80.7%). There was no significant intergroup difference in terms of the number of peripheral vascular access attempts or the access site (Table 5).

Table 5. Peripheral vascular access (PVA) management of the groups

	Total n=358	Group 1 n=58 No maintenance anesthesia	Group 2 n=219 Maintenance with inhalation anesthesia	Group 3 n=63 Maintenance with IV anesthesia	Group 4 n=18 Maintenance with inhalation and IV anesthesia	P
Way of opening PVA . n (%)						
Awake	275 (76.8)	52 (89.7)	157 (71.7)	55 (87.3)	11 (61.1)	<0.001
Sedatized state	15 (4.2)	5 (8.6)	5 (2.3)	4 (6.3)	1 (5.6)	
Under anestesia	68 (19.8)	1 (1.7)	57 (26.0)	4 (6.3)	6 (33.3)	
Opening region of PVA. n (%)						
Over the hand	242 (67.6)	44 (75.9)	137 (62.6)	45 (71.4)	16 (88.9)	0.079
Brachial region	80 (22.3)	11 (19.0)	53 (24.2)	15 (23.8)	1 (5.6)	
Over the foot	31 (8.7)	3 (5.2)	26 (11.9)	1 (1.6)	1 (5.6)	
Other	5 (1.4)	0 (0.0)	3 (1.4)	2 (3.2)	0 (0.0)	
Initiative number of PVA. n (%)						
1	289(80.7)	49 (84.5)	174 (79.5)	54 (85.7)	12 (66.7)	0.596
2	53 (14.8)	7 (12.1)	33 (15.1)	8 (12.7)	5 (27.8)	
3	13 (3.6)	2 (3.4)	10 (4.6)	0 (0.0)	1 (5.6)	
4	3 (0.8)	0 (0.0)	2 (0.9)	1 (1.6)	0 (0.0)	

(PVA: Peripheral Vascular Access)

Table 6. Evaluation of premedication approaches in groups

	Total n=358	Group 1 n=58 No maintenance anesthesia	Group 2 n=219 Maintenance with inhalation anesthesia	Group 3 n=63 Maintenance with IV anesthesia	Group 4 n=18 Maintenance with inhalation and IV anesthesia	P
Premedication. n (%)						
Yes	168 (46.9)	41 (70.7)	72 (32.9)	45 (71.4)	10 (55.6)	<0.001
No	190 (53.1)	17 (29.3)	147 (67.1)	18 (28.6)	8 (44.4)	
Premedication application pathway. n (%)						
No	190 (53.1)	17 (29.3)	147 (67.1)	18 (28.6)	8 (44.4)	**<0.001**
PO	11 (3.1)	3 (5.2)	3 (1.4)	4 (6.3)	1 (5.6)	
IV	155 (43.3)	36 (62.1)	69 (31.5)	41 (65.1)	9 (50.0)	
IM	2 (0.6)	2 (3.4)	0 (0.0)	0 (0.0)	0 (0.0)	
Premedication Agent. n (%)						
No	190 (53.1)	17 (29.3)	147 (67.1)	18 (28.6)	8 (4.4)	<0.001
Midazolam	166 (46.4)	39 (67.2)	72 (32.9)	45 (71.4)	10 (55.6)	
Ketamin	2 (0.6)	2 (3.4)	0 (0.0)	0 (0.0)	0 (0.0)	

(PO: peroral. IV: intravenous. IM: intramuscular)

Table 7. Airway and anesthesia management of the groups

	Total n=358	Group 1 n=58 No maintenance anesthesia	Group 2 n=219 Maintenance with inhalation anesthesia	Group 3 n=63 Maintenance with IV anesthesia	Group 4 n=18 Maintenance with inhalation and IV anesthesia	P
Type of anesthesia induction. n (%)						
Inhale	80 (22.3)	1 (1.7)	69 (31.5)	3 (4.8)	7 (38.9)	<0.001
Propofol	231 (64.5)	35 (60.3)	145 (66.2)	40 (63.5)	11 (61.1)	
Ketamin	1 (0.3)	1 (1.7)	0 (0.0)	0 (0.0)	0 (0.0)	
Ketamin + Propofol	41 (11.5)	16 (27.6)	5 (2.3)	20 (31.7)	0 (0.0)	
No induction	5 (1.4)	5 (8.6)	0 (0.0)	0 (0.0)	0 (0.0)	
Anesthesia maintenance airway equipment. n (%)						
Nasal Cannula	16 (4.5)	12 (20.7)	1 (0.5)	3 (4.8)	0 (0.0)	<0.001
Airway and simple face mask	283 (79.1)	30 (51.7)	195 (89.0)	43 (68.3)	15 (83.3)	
LMA	7 (2.0)	0 (0.0)	5 (2.3)	0 (0.0)	2 (11.1)	
Just a simple face mask	52 (14.5)	16 (27.6)	18 (8.2)	17 (27.0)	1 (5.6)	
Breathing pattern under anesthesia. n (%)						
spontaneous respiration	351 (98.0)	58 (100.0)	214 (97.7)	63 (100.0)	16 (88.9)	0.015
controlled breathing	7 (2.0)	0 (0.0)	5 (2.3)	0 (0.0)	2 (11.1)	

(LMA: Laryngeal Mask Airway)

Table 8. MRI scan time and length of stay in MRI room

	Total n=358	Group 1 n=58 No maintenance anesthesia	Group 2 n=219 Maintenance with inhalation anesthesia	Group 3 n=63 Maintenance with IV anesthesia	Group 4 n=18 Maintenance with inhalation and IV anesthesia	P
MRI scan time	15.0 (10.0-20.0 [7.0-105.0])	10.0 (10.0-13.25 [7.0-30.0])	15.0 (10.0-20.0 [7.0-105.0])	16.0 (15.0-30.0 [9.0-68.0])	18.0 (13.5-20.5 [10.0-65.00])	<0.001
Length of stay in MRI room	20.0 (15.0-30.0 [10.0-110.0])	15.0 (14.0-20.0 [10.0-42.0])	20.0 (16.5-30.0 [12.0-110.0])	25.0 (20.0-40.0 [14.0-78.0])	24.5 (19.0-35.0 [15.0-80.0])	<0.001

MRI: Magnetic resonance imaging

Table 9. Complications during and after MRI

		Total n=358 No maintenance anesthesia	Group 1 n=58 Maintenance with inhalation anesthesia	Group 2 n=219 Maintenance with IV anesthesia	Group 3 n=63 Maintenance with inhalation and IV anesthesia	Group 4 n=18	P
Awakening during MRI scan. n (%)		38 (10.6)	8 (13.8)	12 (5.5)	14 (22.2)	4 (22.2)	<0.001
During and after MRI scan complications. n (%)		38 (10.6)	3 (5.2)	21 (9.6)	9 (14.3)	5 (27.8)	0.036
Desaturation		14 (3.9)	2 (3.4)	4 (1.8)	5 (7.9)	3 (16.6)	<0.001
Total n=14	**No intervention**	2 (14.2)	0 (0.0)	1 (25.0)	1 (20.0)	0 (0.0)	0.246
	Chin lift	5 (35.7)	0 0.0)	1 (25.0)	2 (40.0)	2 (66.6)	
	Airway	3 (21.4)	2 (100.0)	0 (0.0)	1 (20.0)	0 0.0)	
	PPV	4 (28.4)	0 (0.0)	2 (50.0)	1 (20.0)	1 (3.3)	
Laryngospasm		10 (2.8)	0 (0.0)	7 (3.2)	3 (4.8)	0 (0.0)	0.360
Bradycardia		11 (3.1)	0 (0.0)	8 (3.7)	2 (3.2)	1 (5.6)	0.482
Vomiting		2 (0.6)	0 (0.0)	2 (0.9)	0 (0.0)	0 (0.0)	0.735
Emergence delirium		3 (0.8)	0 (0.0)	3 (1.4)	0 (0.0)	0 (0.0)	0.589
Delayed complication		16 (4.5)	2 (3.4)	3 (1.4)	6 (9.5)	5 (27.8)	<0.001

(PPV: Positive Pressure Ventilation)

Premedication was not administered to 190 children (53.1%). Premedication was most commonly administered in Group 3 (71.4%). with IV being the most common route of administration (in 65.1% of cases) and midazolam being the most commonly administered agent (in 71.4% of cases) (p<0.001) (Table 6).

Anesthetic induction using IV propofol was most commonly performed in Group 2 (64.5%). The second most common means of induction was through the use of inhalational agents (22.3% of cases) (Table 7).

In terms of airway management. spontaneous breathing was the most common method during MRI under anesthesia in children (351/358; 98%); only seven patients were required general anesthesia using controlled breathing with laryngeal mask airway (LMA). which occurred most frequently in Group 4. The most commonly used airway equipment in anesthetized patients under spontaneous breathing was an airway and simple face mask (79.1%) (Table 7).

The mean MRI acquisition time was 15 (10.0–20.0 [7.0–105.0]) minutes. with the longest duration observed in Group 4 (p<0.001). However. the mean total time spent in the MRI room from the induction of anesthesia to awakening was 20 (15.0–30.0 [10.0-110.0]) minutes. with significantly lower times observed in Group 1 (p<0.001). (Table 8).

The frequency of awakening during MRI significantly differed between the groups and was most common in Groups 3 and 4; however. no significant difference was observed between those two groups (p>0.05).

During MRI. complications developed in 10.6% of cases. with the most and least frequent complications occurring in Groups 4 and 1. respectively. The most common complication was desaturation (3.9%). and the most commonly used interventional method in such patients was the chin-lift maneuver (35.7%). One patient exhibited an allergic reaction following contrast material administration and was treated with IV antihistamines. One patient experienced an epileptic attack and was treated with IV propofol; upon termination of seizure activity and stabilization. the procedure was resumed. and the patient was hospitalized in the pediatric neurology clinic. One patient in Group 2 experienced severe laryngospasm. and the MRI was terminated after it was determined that the cause was an upper respiratory tract infection (Table 9).

DISCUSSION

This study compared the efficacy and safety of different anesthesia maintenance methods during MRI in children. In our hospital. the most commonly used technique for anesthesia during MRI in pediatric patients was sevoflurane insufflation with an airway and simple face mask. and the fewest complications occurred in those who received sevoflurane inhalational anesthesia. suggesting that is the safest and most effective technique for pediatric patients undergoing MRI under anesthesia.

Because MRI does not involve radiation. it is preferred over other imaging techniques for diagnosis and treatment follow-up in children. In this patient population. however. anesthesia is often required to ensure absolute immobility during imaging and to alleviate anxiety caused by prolonged confinement.[1] Pediatric anesthesia is a specialized field owing to the many anatomical. airway. and physiological differences between infants. children. and adults.[7] In addition. anesthesia applications during MRI require additional experience because of the comorbidities frequently observed in children who require such imaging. the fact that only MRI-compatible devices can be used. and properties related to the structure of the MRI device and the room in which it is situated.

Children requiring MRI frequently have comorbidities such as neurological disorders. vascular malformations. and oncological tumors.[8] Although MRI has certain advantages over other imaging techniques. such as high image quality. superiority in revealing pathology. and the absence of radiation. the fact that it frequently requires anesthesia can result in short- and long-term risks related to the agents used for induction or maintenance. Contrary to what has been reported in the literature. this study demonstrated that the majority of the patients had an ASA 1 physical status classification. possibly due to the increasing frequency of usage and the wider range of indications that have emerged in recent years. However. for the aforementioned reasons. it is believed that MRI should be used more selectively. especially in children.

Many different techniques for sedation and general anesthesia can be applied during MRI. and many studies have been conducted to determine the optimal methodology. For example. Schulte-Uentrop and Goepfert[8] reported that sedation was preferred over general anesthesia in children without comorbidities. In contrast. however. Malviya et al.[9] suggested that general anesthesia during MRI in children can induce greater immobility and less hypoxemia than sedation. Inhalational agents such as sevoflurane. IV anesthetic agents such as propofol. ketamine. dexmedetomidine. midazolam. and pentobarbital. or different combinations of these agents can be used during these procedures.[10,11] Briggs et al.[12] argued in favor of sevoflurane as the ideal anesthetic agent for MRI in children for both induction and maintenance. Bryan et al.[13] found no difference in terms of respiratory complications in a study comparing sevoflurane and propofol administration. although a higher MRI success rate was observed with sevoflurane anesthesia. and Tahsin et al.[14] showed that the recovery time of pediatric MRI cases performed using sevoflurane was shorter than that of procedures performed using IV anesthetic agents such as propofol. ketamine. and dexmedetomidine. Although it has been shown that the use of sevoflurane in anesthesia management in pediatric patients may be associated with emergence delirium.[15] the present study failed to detect a significant difference in the frequency of this complication between patients in who did and did not receive sevoflurane for anesthesia management. In this study. sedation was selected more frequently than general anesthesia. IV propofol was most commonly used for anesthesia induction. and the sevoflurane insufflation technique was most commonly used for anesthesia maintenance; such preferences are likely related to the belief that these methods are the most effective for MRI under anesthesia. while simultaneously aiming to promote the fastest recovery. as these are generally outpatient or ambulatory procedures.

Recent studies have revealed that repeated or prolonged exposure to anesthetic drugs. especially up to the age of three years. may adversely affect neurodevelopment in children.[16] Therefore. many new non-anesthetic procedures have been proposed to facilitate MRI applications in children. such as having them watch movies. listen to music. and perform relaxation techniques or engage in play therapies. along with family training. Additionally. MRI-compatible equipment that allows for feeding and sleeping during procedures or promotes immobilization has been used successfully in infants.[16,17] For example. Barkovich et al.[18] recommended that the feeding and swaddling method should be prioritized for MRI in children younger than three months of age. In our hospital. unanesthetized MRI methods in children have been attempted only in older individuals in the form of suggestions; however only one 12-year-old has been persuaded. which allowed for the successful completion of the MRI procedure. It is likely that the low success rate is attributable to the large number of patients resulting in time-related limitations. the lack of experience among staff. and the lack of MRI-compatible devices for listening to music and watching movies. In our hospital. the only devices used for this purpose are headphones to prevent exposure to loud noises; however. some studies have shown that the use of headphones under anesthesia for this purpose can also decrease spontaneous arm–leg mobility.[19]

A review of the literature revealed that the most common cause of failure during MRI is patient mobility. with the most important contributor being the inadequate depth of anesthesia in children undergoing MRI.[20] Inadequate anesthesia may adversely impact MRI quality. prolong the working time of staff. increase costs associated with repeated imaging. and enhance anxiety in patients and their family members. In this study. awakening during MRI occurred most commonly in cases in which anesthesia maintenance was performed solely with IV anesthetics or with IV anesthetic agents in combination with inhalational anesthesia; these instances of awakening are likely attributable to the fact that IV anesthetics were administered via intermittent boluses rather than through continuous perfusion.

Although serious complications related to anesthesia for MRI in children such as cardiac arrest are rare. minor unwanted complications such as laryngospasm. desaturation. vomiting. and allergies may be frequently encountered.[21] These minor adverse complications may become life-threatening if not managed correctly by taking necessary precautions. No serious complications such as cardiac or respiratory arrest were observed in the present study. and the most common complication was desaturation. with the chin-lift maneuver often serving as a sufficient intervention. It is believed that these complications would be encountered less frequently when anesthetic procedures outside the operating room are performed by healthcare personnel who are experienced in both anesthesia and pediatrics.

Limitations

The limitations of this study are that it was retrospective in nature. and anesthesia induction and maintenance were performed using different agents and by different anesthesiologists. However. one of the aims in this study was to assess the management of MRI under anesthesia in children when performed by anesthesiologists with different levels of experience. Prospective studies with larger sample sizes are warranted.

CONCLUSION

Procedures requiring prolonged periods of immobilization. such as MRI. continue to be difficult to perform owing to practical difficulties in some populations. including in pediatric patients. Outpatient or ambulatory anesthesia is currently considered the most effective and comfortable method for optimizing image quality and ensuring rapid recovery. However. it is important to minimize the associated risks while simultaneously ensuring an adequate depth of anesthesia. Ultimately. the results of this study suggest that sevoflurane insufflation with the preservation of spontaneous respiration is an effective and safe method for pediatric patients undergoing MRI under anesthesia.

ETHICAL DECLARATIONS

Ethics Committee Approval

This study was approved by the University of Health Sciences. Gülhane Clinical Researches Ethics Committee (Date: 10.09.2024. Decision No: 2024/441).

Informed Consent

Because the study was designed retrospectively. no written informed consent form was obtained from patients.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declare that they have all participated in the design. execution. and analysis of the paper. and that they have approved the final version.

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