СРПСКИ АРХИВ
ЗА ЦЕЛОКУПНО ЛЕКАРСТВО
SERBIAN ARCHIVES
OF MEDICINE

Address: 1 Kraljice Natalije Street, Belgrade 11000, Serbia
☏ +381 11 4092 776, Fax: +381 11 3348 653
E-mail: office@srpskiarhiv.rs, Web address: www.srpskiarhiv.rs

Paper Accepted* **ISSN Online 2406-0895**

Original Article / Оригинални рад

Nataša Marković[1,2,♣], Goran Rakić[1,3], Ranko Zdravković[1,4], Bojan B. Mihajlović[1,5], Dragan Turanjanin[1,3], Nebojša Milovanović[6]

Comparison of procedural sedation using dexmedetomidine and the combination of dexmedetomidine / s-ketamine during magnetic resonance examination of the endocranium in children

Поређење процедуралне седације применом дексмедетомидина и комбинације дексмедетомидин / с-кетамин, током магнетно-резонантног прегледа ендокранијума код деце

[1]University of Novi Sad, Faculty of Medicine, Novi Sad, Serbia;
[2]University Clinical Center of Vojvodina, Department of Anesthesia and Perioperative Medicine, Novi Sad, Serbia;
[3]Institute for Child and Youth Health Care of Vojvodina, Clinic for Pediatric Surgery, Novi Sad, Serbia;
[4]Institute of Cardiovascular Diseases of Vojvodina, Department of Cardiovascular Surgery, Sremska Kamenica, Serbia;
[5]Institute of Cardiovascular Diseases of Vojvodina, Department of Cardiology, Sremska Kamenica, Serbia;
[6]Medika College for Vocational Studies in Healthcare, Belgrade, Serbia

Received: October 30, 2025
Revised: January 21, 2026
Accepted: January 23, 2026
Online First: February 2, 2026
DOI: https://doi.org/10.2298/SARH251030011M

*__Accepted papers__ are articles in press that have gone through due peer review process and have been accepted for publication by the Editorial Board of the *Serbian Archives of Medicine*. They have not yet been copy-edited and/or formatted in the publication house style, and the text may be changed before the final publication.

Although accepted papers do not yet have all the accompanying bibliographic details available, they can already be cited using the year of online publication and the DOI, as follows: the author's last name and initial of the first name, article title, journal title, online first publication month and year, and the DOI; e.g.: Petrović P, Jovanović J. The title of the article. Srp Arh Celok Lek. Online First, February 2017.

When the final article is assigned to volumes/issues of the journal, the Article in Press version will be removed and the final version will appear in the associated published volumes/issues of the journal. The date the article was made available online first will be carried over.

♣**Correspondence to:**
Nataša MARKOVIĆ
University of Novi Sad, Faculty of Medicine, 21000 Novi Sad, Serbia
E-mail: 911024d22@mf.uns.ac.rs

Comparison of procedural sedation using dexmedetomidine and the combination of dexmedetomidine / s-ketamine during magnetic resonance examination of the endocranium in children

Поређење процедуралне седације применом дексмедетомидина и комбинације дексмедетомидин / с-кетамин, током магнетно-резонантног прегледа ендокранијума код деце

SUMMARY

Introduction/Objective There is an increasing number of children requiring magnetic resonance imaging (MRI) of the brain as a diagnostic procedure. During the scan, it is necessary for the child to remain still for an extended period. This is often challenging due to the patient's age, the nature of the illness.

The aim of this study was to evaluate the quality and safety of procedural sedation in children undergoing MRI of the brain by comparing two different sedation protocols.

Methods The study included 60 participants, aged 1 to 18 years, who required sedation during MRI of the brain. Using simple randomization, they were divided into two groups: the dexmedetomidine group (DEX group) was sedated with dexmedetomidine, and the dexmedetomidine/S-ketamine (DEX/KES group) received a combination of dexmedetomidine and S-ketamine.

Results Our results showed that the time to achieve adequate sedation was significantly shorter in the DEX/KES group (6.37 ± 3.62 min) compared to the DEX group (9.03 ± 3.48 min) (p = 0.005). During the initial 10 minutes, the average dexmedetomidine dose was identical in both groups (1.59 mcg/kg). However, during the continuous infusion phase until the end of sedation, the average dexmedetomidine dose was 1.47 mcg/kg in the DEX/KES group versus 1.60 mcg/kg in the DEX group. Analysis of hemodynamic parameters showed better stability in the DEX/KES group. Complications occurred more frequently in the DEX group.

Conclusion The dexmedetomidine/S-ketamine group provides a faster onset of sedation, better hemodynamic stability, lower total doses of sedatives, and fewer complications compared to dexmedetomidine alone.

Keywords: procedural sedation; S-ketamine; dexmedetomidine; magnetic resonance imaging; MRI

САЖЕТАК

Увод/Циљ Све је већи број деце која захтевају преглед магнетном резонанцом (МРИ) ендокранијума као дијагностичке процедуре. Током снимања, потребно је да дете буде мирно дужи временски период. Отежавајућу околност чини узраст пацијента, као и природа болести због које су често неуролошки измењени и некооперабилни. Циљ ове студије био је да се испита квалитет и сигурност процедуралне седације код деце током МР прегледа ендокранијума, поређењем две различите седационе шеме.

Методе Студија је обухватила 60 испитаника, узраста од 1 до 18 година, која захтевају седацију током магнетне резонанце ендокранијума. Простом рандомизацијом подељени у две групе: група дексмедетомидин (група ДЕКС) је седирана дексмедетомидином и група дексмедетомидин/С-кетамин (група ДЕКС/КЕС) комбинацијом дексмедетомидин/С-кетамин.

Резултати Наши резултати су показали да је време постизања адекватне седације било значајно краће у ДЕКС/КЕС (6,37 ± 3,62 мин) у односу на ДЕКС групу (9,03 ± 3,48 мин) (п = 0,005). Када се посматра иницијална доза током првих 10 минута, средња доза дексмедетомидина била је идентична у обе групе (1,59 мцг/кг), али у фази континуиране инфузије до краја седације просечна доза декмедетомидина износила је 1,47 мцг/кг у ДЕКС/КЕС, наспрам 1,60 мцг/кг у ДЕКС групи. Анализа хемодинамских параметара показала је већу стабилност у ДЕКС/КЕС групи. Компликације су биле ретке и чешће у ДЕКС групи.

Закључак Комбинација дексмедетомидине/С-кетамин обезбеђује бржи увод у седацију, бољу хемодинамску стабилност, нижу укупну дозу седатива и мање компликација у поређењу са групом која је примала само дексмедетомидин.

Кључне речи: процедурална седација; С-Кетамин; дексмедетомидин; магнетна резонанца; МРИ

INTRODUCTION

In recent years, there has been an increasing number of children requiring magnetic resonance imaging (MRI) of the brain (endocranium) as a diagnostic procedure [1]. Children undergoing

brain MRI are admitted as outpatients, and after the diagnostic procedure, they are expected to be fully awake as soon as possible and without any additional complications, as they are discharged home [2]. With the global economic downturn, financial pressures, a shortage of medical personnel, and long patient waiting lists, healthcare institutions have found it increasingly difficult to complete the necessary elective surgeries and imaging procedures. Outpatient anesthesia has provided a cost-effective and efficient way to manage scheduled patients, reduce waiting list volumes, and thereby improve patient satisfaction [3].

Procedural sedation in pediatrics poses a challenge due to the need to maintain the child's safety, comfort, and cooperation, while minimizing adverse effects. Among the available sedatives, dexmedetomidine (DEX) is increasingly used due to its combined sedative and analgesic properties [4]. One of the key advantages of dexmedetomidine over other sedative agents is that it maintains spontaneous breathing and airway patency, even at higher doses. However, when administered rapidly and in higher doses, cases of bradycardia, hypotension, and sinus arrhythmia have been reported [4, 5, 6]. Continuous infusion rates of dexmedetomidine can vary from 0.2–3 μg/kg/h. Dose titration is not standardized [7]. Its relatively slow onset of sedation, insufficient depth, and potential for hemodynamic instability represent clinical limitations. To overcome these limitations, it is often combined with other agents.

S-ketamine is a relatively new drug used in pediatric patients. The main difference between ketamine and S-ketamine lies in the fact that ketamine is a racemic mixture, meaning it contains equal parts (50/50) of two mirror-image molecules: S-ketamine and R-ketamine. S-ketamine consists solely of the S-ketamine form [8]. It is twice as potent as ketamine and can provide more reliable sedation and analgesia with a lower risk of side effects [9]. Clinical studies have shown that S-ketamine has twice the potency of ketamine in terms of hypnotic and analgesic

effects, with fewer psychiatric side effects. To achieve the same depth of sedation, the required dose of racemic ketamine is 50% higher compared to the necessary dose of S-ketamine [10]. Some findings suggest that S-ketamine provides 50% better recovery of cognitive function and the same depth of anesthesia compared to the racemic ketamine mixture [11]. Ketamine differs from other sedatives in that it has a stimulating effect on the cardiovascular system (causing increased blood pressure, tachycardia, and cardiac output). This occurs due to its sympathomimetic action on the cardiovascular system and inhibition of norepinephrine reuptake [12].

The aim of this study was to evaluate the quality and safety of procedural sedation in children undergoing brain MRI by comparing two different sedation protocols: dexmedetomidine alone and a combination of dexmedetomidine and S-ketamine.

METHODS

This prospective, randomized clinical study was conducted at the Clinic for Pediatric Surgery, Institute for Child and Youth Health Care of Vojvodina. The study was carried out in the period from December 1, 2024, to February 15, 2025. The study protocol complies with the Declaration of Helsinki, and the study was initiated after obtaining approval from the Ethics Committee of the Institute for Child and Youth Health Care of Vojvodina. Parents of the children included in the study signed informed consent after being properly informed about the procedure.

The study included patients aged 1 to 18 years who required sedation during MRI of the brain (endocranium). A total of 60 patients were enrolled. Eligible participants were under 18 years of age, regardless of sex, and classified as ASA (American Society of Anesthesiologists) I–III.

Patients classified as ASA IV, as well as those hospitalized in intensive care units, intubated, sedated, or on mechanical ventilation, were excluded from the study. Patients were randomly assigned using simple randomization into one of two groups:

- group dexmedetomidine (group DEX) sedated with dexmedetomidine only
- group dexmedetomidine/S-ketamine (group DEX/KES), sedated with a combination of dexmedetomidine and S-ketamine.

All patients were previously evaluated in the Preoperative Anesthesia Assessment Clinic, where medical history was taken and standard examinations were conducted (clinical and pediatric examinations, electrocardiography (ECG), laboratory tests, and additional specialist consultations if needed). The MRI scans were performed under sedation, following the 1-4-6 fasting rule (clear fluids up to 1 hour, breast milk up to 4 hours, and solid food up to 6 hours before the procedure).

All safety measures and equipment were ensured during the procedure, including an anesthesia machine, oxygen supply, appropriately sized nasal and oral airways, a laryngoscope with different blades, endotracheal tubes, introducers, face masks, and all necessary emergency drugs and equipment.

All patients received premedication in the preoperative room 20 minutes before the MRI scan: intramuscular midazolam at 0.1 mg/kg and atropine at 0.01 mg/kg.

In Group DEX (30 patients), dexmedetomidine was administered at a dose of 1.5–2 mcg/kg over 10 minutes until adequate sedation (Ramsay Score 6) was achieved, followed by continuous infusion at 1–2 mcg/kg/h during the procedure.

In Group DEX/KES, an initial bolus dose of S-ketamine (0.5 mg/kg) was given, followed by

dexmedetomidine 1–1.5 mcg/kg until adequate sedation (Ramsay Score 6) was reached. Then, a continuous infusion of dexmedetomidine at 1–2 mcg/kg/h was maintained during the procedure.

The level of sedation was assessed using the Ramsay Sedation Scale, based on the patient's response to sound, verbal commands, or tactile stimulation (Table 1). Once a Ramsay score of 6 and hemodynamic and respiratory stability were achieved, patients were transferred to the MRI scanner. If a Ramsay score of 6 was not achieved after 10 ± 5 minutes of infusion or if sedation was inadequate, additional bolus doses of either dexmedetomidine or ketamine were administered, depending on the group.

Inadequate sedation was defined as difficulty completing the procedure due to patient movement during MRI scanning. Sedation was managed to maintain a Ramsay score of 6, with continuous infusion throughout the procedure. Monitoring included vital signs such as blood pressure (BP), heart rate (HR), transcutaneous oxygen saturation (SpO_2), time to achieve sedation, wake-up time, need for additional medication, and any complications.

All children breathed spontaneously throughout the procedure with oxygenation via face mask. Recovery time was defined as the period from discontinuation of the infusion until achieving a Ramsay score of 2. The quality of sedation was assessed based on the success of completing the MRI without movement and the need for additional sedation, while safety was evaluated through vital signs and the occurrence of complications.

Ethics: The study protocol got approval from the Ethics Committee of the Institute for Child and Youth Health Care of Vojvodina (November 29, 2024; No. 17-43).

RESULTS

The average dose of dexmedetomidine administered over 10 minutes to achieve sedation was identical in both groups (1.59 mcg/kg). However, the continuous dexmedetomidine doses during the MRI procedure were lower in the DEX/KES group (1.47 mcg/kg) compared to the DEX group (1.60 mcg/kg). The results are presented in Table 2**.**

The time required to achieve sedation was significantly shorter ($Z = -2.913$; $p = 0.000$) in the DEX/KES group compared to the DEX group, as shown in Table 3. The median time in the DEX group was 10 minutes (range: 6.75–10 minutes), while in the DEX/KES group it was 6 minutes (range: 3–8.50 minutes).

The comparison of systolic blood pressure at different time intervals in both groups is presented in Table 4. In the DEX group, where continuous infusion of dexmedetomidine was administered without additional sedatives, an increase in the mean systolic arterial pressure was recorded after 10 minutes; however, by the end of the procedure, the mean value had decreased. There were no clinically significant fluctuations. In the group that received the combination of dexmedetomidine and ketamine, systolic arterial pressure remained highly stable throughout the procedure. After 10 minutes, the median value remained the same as at baseline, with a minimal decrease observed at the end of the procedure. Results of the Mann–Whitney U test showed no statistically significant difference between the groups in systolic arterial pressure values at any of the three time points ($p > 0.05$).

Based on the results of the Friedman test, a statistically significant difference was observed across the three time points for systolic arterial pressure in the DEX group ($\chi^2 = 6.158$; $df = 2$; $p = 0.046$), whereas in the DEX/KES group, no significant difference was found ($\chi^2 = 0.080$; $df = 2$; $p = 0.961$).

The values of Kendall's coefficient of concordance were W = 0.103 for the DEX group and W = 0.001 for the DEX/KES group, indicating that the differences were not consistent among most participants in the DEX group, while in the DEX/KES group, there was a complete absence of changes between time points.

Wilcoxon's test in the DEX group revealed a statistically significant increase in systolic arterial pressure after 10 minutes compared to the baseline (Z = -2.057; p = 0.040) and compared to the end of the procedure (Z = -2.173; p = 0.030). For all other time point comparisons, no statistically significant differences were found (p > 0.05).

Heart rate (HR) values at the three measured time points by group are presented in Table 5.

Based on the results of the Wilcoxon test and data from Table 5, a statistically significant decrease in HR was observed 10 minutes after the administration of the loading dose of dexmedetomidine in both the DEX group (Z = -3.776; p = 0.000) and the DEX/KES group (Z = -1.959; p = 0.049).

According to the Mann–Whitney U test, there was no statistically significant difference in HR values between the groups at baseline and at the end of the procedure. However, a statistically significant difference was found 10 minutes after drug administration (Z = -2.079; p = 0.038), in favor of the DEX/KES group.

The Friedman test showed a statistically significant difference in HR values across the three time points in both the control group (χ^2 = 13.270; df = 2; p = 0.001) and the experimental group (χ^2 = 26.991; df = 2; p = 0.000).

However, Kendall's coefficient of concordance was W = 0.221 in the control group, indicating that differences between the three time points existed but were not consistently present across all participants. In contrast, W = 0.450 in the group receiving the combination of

dexmedetomidine and ketamine indicates moderately strong and relatively uniform differences among patients.

All patients maintained spontaneous breathing throughout the procedure.

The wake-up time from sedation in both groups indicates a greater number of patients with a wake-up time shorter than 5.93 minutes in the DEX group and shorter than 6.93 minutes in the DEX/KES group. The results are presented in Table 6.

Complications were rare and occurred more frequently in DEX group.

The most common complication in the group that received only DEX was bradycardia, present in four (13.3%) patients, whereas in the DEX/KES group, no patients experienced this hemodynamic disturbance.

In the DEX group, two patients (6.7%) experienced enuresis, and one patient (3.3%) required conversion to general anesthesia. In the DEX/KES group, one patient developed tachycardia, and one patient experienced a technical error.

Nausea and vomiting were not observed in either group. Additionally, hypotension, hypertension, and oxygen desaturation were not observed (see Table 7).

DISCUSSION

There are numerous clinical studies in children that have examined sedation during MRI using dexmedetomidine alone, confirming that at high doses it provides adequate sedation for pediatric MRI studies without respiratory complications, but it is associated with cardio-inhibitory changes. It leads to a lowering of blood pressure and bradycardia [13,14]. Some

studies have also investigated combinations of dexmedetomidine and ketamine for pediatric sedation, demonstrating better sedation outcomes than using dexmedetomidine or ketamine alone. The onset of sedation and recovery are faster while maintaining hemodynamic and respiratory stability, with possible adverse events such as nausea, vomiting, and hallucinations attributed to the action of ketamine [15,16]. However, to our knowledge, the use of dexmedetomidine–S-ketamine has not been evaluated for MRI sedation in children.

The results of our study showed good sedation quality achieved in 26 out of 30 patients (86.7%) in both groups, indicating that both methods were highly effective in a clinical setting.

Our findings align with previous research confirming that dexmedetomidine is a safe and effective option for procedural sedation in children [17,18]. Similar findings were reported by Gao et al. [19], who demonstrated that the combination of dexmedetomidine with racemic ketamine allows better sedation control and shorter time to achieve the desired sedation level compared to dexmedetomidine alone.

Our results showed that the time to achieve adequate sedation was significantly shorter in the DEX/KES group compared to the DEX group, confirming our primary hypothesis that the combination of dexmedetomidine and S-ketamine enables faster sedation induction. These results are consistent with previous studies in adults using the combination dexmedetomidine/ketamin compared to dexmedetomidine alone [20].

When observing the induction phase (initial dose during the first 10 minutes), the median dexmedetomidine dose was identical in both groups. However, during the continuous infusion phase until the end of sedation, a 7.5% difference indicates a potentially lower need for additional medication in the DEX/KES group due to the additive sedative effect of S-ketamine.

Although the initial doses were identical, the reduced need for continuous dexmedetomidine

administration in the DEX/KES group has clinically significant potential to reduce the risk of adverse cardiovascular effects associated with higher cumulative doses [20].

Hemodynamic parameter analysis showed that changes in systolic arterial pressure were milder in the DEX/KES group. In the DEX group, after the loading dose, results showed the expected, clinically significant bradycardia, whereas changes in the DEX/KES group were milder.

These data suggest that the presence of S-ketamine contributed to a more stable hemodynamic response during sedation, likely due to its mild sympathomimetic action which mitigates the hypotensive effects of dexmedetomidine.

Oxygen saturation remained stable in both groups throughout the observed period, indicating that neither dexmedetomidine nor S-ketamine significantly affected respiratory function. Preserved respiratory stability, even in sedated patients, represents a key safety element of the protocol. These findings are consistent with literature data on dexmedetomidine [21] and S-ketamine [22].

Regarding recovery time from sedation, although differences were present, they did not reach statistical significance, but clinically favored the group receiving only DEX. There is a study in adults comparing recovery time with ketamine combination, showing opposite results to ours, where recovery time was faster [23].

Concerning complications, excellent sedation quality was achieved in both groups. The most common complication in the DEX group was bradycardia, which in one case required medication therapy. No bradycardia was recorded in the DEX/KES group. This suggests a potential cardio-protective role of S-ketamine when combined with dexmedetomidine.

Other adverse reactions (tachycardia, conversion to general anesthesia) were rare and evenly distributed among the groups. No urgent pharmacological intervention was needed in any case.

In two cases in the DEX group, enuresis occurred after a bolus dose of dexmedetomidine, described as a possible effect after higher doses of dexmedetomidine [24, 25]. Vomiting can occur during or after procedural sedation; however, no episodes of nausea or vomiting were reported in any patient regardless of whether they received dexmedetomidine or S-ketamine. There were also no cases of agitation, hallucinations, or delirium, which are commonly described complications after racemic ketamine administration [9]. Our results confirm the study by Chen et al., showing that S-ketamine has fewer side effects and may reduce postoperative delirium in children [26].

CONCLUSION

Our study results show that the combination of dexmedetomidine and S-ketamine provides faster sedation induction, better hemodynamic stability, lower total sedative dose, and fewer complications compared to dexmedetomidine alone. Future research should focus on more precisely defining the optimal doses and ratios of these drugs for different types of procedures. It is particularly important to further investigate the advantages of S-ketamine over the racemic form. Additional randomized studies with larger samples would enable more precise clinical recommendations and broader application of this combination in everyday practice.

Conflict of interest: None declared.

REFERENCES

1. Ageel M. Review of pediatric sedation and anesthesia for radiological diagnostic and therapeutic procedures. J Radiat Res and Appl Sci. 2024;17(1):100833. [DOI: 10.1016/j.jrras.2024.100833]
2. Stern J, Agarwal A, Pozun A. Pediatric Procedural Sedation. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025. Jan–. [PMID: 34283466]
3. Vanderhoek SM, Varughese AM, Kudchadkar SR. Pediatric Ambulatory Anesthesia: Confronting Challenges, Embracing Opportunities. Anesth Analg. 2025;140(3):596–8. [DOI: 10.1213/ANE.0000000000007169] [PMID: 39466626]
4. Janse van Rensburg E, Indiveri L, Mogane P. The Perioperative Use of Dexmedetomidine in Paediatric Patients. Children (Basel). 2025;12(6):690. [DOI: 10.3390/children12060690] [PMID: 40564648]
5. Reel B, Maani CV. Dexmedetomidine. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025. Jan–. [PMID: 30020675]
6. Zhang J, Yin J, Li Y, Zhang Y, Bai Y, Yang H. Effect of dexmedetomidine on preventing perioperative respiratory adverse events in children: A systematic review and metaanalysis of randomized controlled trials. Exp Ther Med. 2023;25(1):286. [DOI: 10.3892/etm.2023.11985] [PMID: 37206556]
7. Angelopoulou VA, Pouliakis A, Alexiou N, Ioannidi P, Vagiona D, Ekmektzoglou K, et al. The effects of dexmedetomidine on children undergoing magnetic resonance imaging: a systematic review and meta-analysis. Children (Basel). 2023;10(6):948. [DOI: 10.3390/children10060948] [PMID: 37371178]
8. Savić Vujović K, Jotić A, Medić B, Srebro D, Vujović A, Žujović J, et al. Ketamine, an Old-New Drug: Uses and Abuses. Pharmaceuticals (Basel). 2023;17(1):16. [DOI: 10.3390/ph17010016] [PMID: 38276001]
9. Turanjanin D, Rakić G, Drašković B. S(+)-ketamin - pregled farmakoloških dejstava i kliničke primene (S(+)-ketamin: farmakologija i klinička primena). Serbian Journal of Anesthesia and Intensive Therapy. 2023;45(5-6):93–105. [DOI: 10.5937/sjait2306093T]
10. Jelen LA, Young AH, Stone JM. Ketamine: A tale of two enantiomers. J Psychopharmacol. 2021;35(2):109–23. [DOI: 10.1177/0269881120959644] [PMID: 33155503]
11. Passie T, Adams HA, Logemann F, Brandt SD, Wiese B, Karst M. Comparative effects of (S)-ketamine and racemic (R/S)-ketamine on psychopathology, state of consciousness and neurocognitive performance in healthy volunteers. Eur Neuropsychopharmacology. 2021;44:92–104. [DOI: 10.1016/j.euroneuro.2021.01.005] [PMID: 33487513]
12. Goddard K, Sampson C, Bedy SM, Ghadban R, Stilley J. Effect of Ketamine on Cardiovascular Function During Procedural Sedation of Adults. Cureus. 2021;13(3):e14228. [DOI: 10.7759/cureus.14228] [PMID: 33948417]
13. He Z, Du J, Xue X, Yang L. Effects of Dexmedetomidine on Hemodynamics and Anesthesia Effect of Different Doses of General Anesthesia in Patients Undergoing Hepatobiliary Surgery. Contrast Media Mol Imaging. 2023;2023:9798685. [DOI: 10.1155/2023/9798685] [PMID: 35935309]
14. Yang H, Fu Y, Deng F, Shao Y, Lu YG, Song JC. Median Effective Dose of Dexmedetomidine Inducing Bradycardia in Elderly Patients Determined by Up-and-Down Sequential Allocation Method. Int J Med Sci. 2022;19(6):1065–71. [DOI: 10.7150/ijms.71380] [PMID: 35813293]
15. Grégoire C, De Kock M, Henrie J, Cren R, Lavand'homme P, Penaloza A, et al. Procedural Sedation with Dexmedetomidine in Combination with Ketamine in the Emergency Department. J Emerg Med. 2022;63(2):283–9. [DOI: 10.1016/j.jemermed.2022.01.017] [PMID: 35550843]
16. Singh A, Iyer KV, Maitra S, Khanna P, Sarkar S, Ahuja V, et al. Ketamine and dexmedetomidine (Keto-dex) or ketamine and propofol (Keto-fol) for procedural sedation during endoscopic retrograde cholangiopancreatography: Which is safer? A randomized clinical trial. Indian J Gastroenterol. 2022;41(6):583–90. [DOI: 10.1007/s12664-022-01291-y] [PMID: 36576697]
17. Fonseca FJ, Ferreira L, Rouxinol-Dias AL, Mourão J. Effects of dexmedetomidine in non-operating room anesthesia in adults: a systematic review with meta-analysis. Braz J Anesthesiol. 2023;73(5):641–64. [DOI: 10.1016/j.bjane.2021.12.002] [PMID: 34933035]
18. Alotaibi NS. Pediatric sedation outside the operating room integrating dexmedetomidine for MRI and CT scan procedures: A systematic review. Saudi J Anaesth. 2024;18(4):540–4. [DOI: 10.4103/sja.sja_236_24] [PMID: 39600467]
19. Gao PF, Li SY, Li Y, Zhao L, Luo Q, Ji Y. The comparison of ketamine-dexmedetomidine (ketadex) and ketamine-propofol (ketofol) for procedural sedation in pediatric patients: A meta-analysis of randomized controlled trials. 2022;8(10):e11166. [DOI: 10.1016/j.heliyon.2022.e11166] [PMID: 36303919]
20. Riccardi A, Serra S, De Iaco F, Fabbri A, Shiffer D, Voza A. Uncovering the Benefits of the Ketamine-Dexmedetomidine Combination for Procedural Sedation during the Italian COVID-19 Pandemic. J Clin Med. 2023;12(9):3124. [DOI: 10.3390/jcm12093124] [PMID: 37176565]
21. Vutskits L. Dexmedetomidine in paediatric anaesthesia: a call for action? Br J Anaesth. 2024;133(2):245–6. [DOI: 10.1016/j.bja.2024.05.029] [PMID: 38926029]

22. Deng J, Yu YF, Tang ZG, Lei HJ, Tan CC. Efficacy and safety of low-dose esketamine for painless gastrointestinal endoscopy in adults: a systematic evaluation and meta-analysis. Front Pharmacol. 2024;15:1364546. [DOI: 10.3389/fphar.2024.1364546] [PMID: 38645560]
23. Li HP, Liu KP, Yao L. Dexmedetomidine in combination with ketamine for pediatric procedural sedation or premedication: A meta-analysis. Am J Emerg Med. 2021;50:442–8. [DOI: 10.1016/j.ajem.2021.08.073] [PMID: 34492589]
24. Chen Z, Chen T, Ye H, Chen J, Lu B. Intraoperative dexmedetomidine-induced polyuria from a loading dose: a case report. J Int Med Res. 2020;48(4):300060520910643. [DOI: 10.1177/0300060520910643] [PMID: 32237944]
25. Kutluer Karaca N. Dexmedetomidine-induced polyuria in the intensive care unit: a case report. Emergency and Critical Care Medicine. 2023;3(2):81–3. [DOI:10.1097/EC9.0000000000000055]
26. Chen Y, Ru F, Ye Q, Wu X, Hu X, Zhang Y, et al. Effect of S-ketamine administered at the end of anesthesia on emergence delirium in preschool children undergoing tonsillectomy and/or adenoidectomy. Front Pharmacol. 2023;14:1044558. [DOI: 10.3389/fphar.2023.1044558] [PMID: 36874017]

Table 1. Ramsay sedation scale

Response	Level
Awake and anxious, agitated, or restless	1
Awake, cooperative, accepting ventilation, oriented, or tranquil	2
Awake, responds only to commands	3
Asleep, brisk response to light, glabella tap, or loud noise	4
Asleep, sluggish response to light, glabella tap, or loud noise	5
Asleep, no response to light, glabella tap, or loud noise	6

Table 2. Dexmedetomidine dose (mcg/kg) continuously by groups

Value	DEX	DEX/KES
Average	1.60	1.47
SD	0.33	0.30
Min	1	1
Max	2.5	2
Mediana[#]	1.5[ns]	1.5
ICR (P25–P75)	0.37 (1.48–1.85)	0.20 (1.30–1.50)

SD – standard deviation; ICR – interquartile range; P25 – 25th percentile; P75 – 75th percentile;
[#]Mann–Whitney U test;
[ns] no statistically significant difference

Table 3. Time required to achieve sedation by groups

Value	DEX	DEX/KES
Average	9.03	6.37
SD	3.42	3.68
Min	2	1
Max	15	15
Mediana[#]	10[a]	6
ICR (P25–P75)	3 (6.75–10)	6 (3–8.50)

SD – standard deviation; ICR – interquartile range; P25 – 25th percentile; P75 – 75th percentile;
[#]Mann–Whitney U test;
[a]$p < 0.01$

Table 4. Systolic arterial blood pressure (mm Hg) at three examined times according to groups

Parameters	Average	SD	Min	Max	Mediana[#]	ICR (P25–P75)
DEX (n = 30)						
At the introduction	100.67	11.80	80	125	100.00[ns]	20 (90.00–110.00)
After 10 minutes	106.10	11.02	90	130	106.50 [ns]	18 (95.75–113.50)
At the end	101.23	12.07	82	133	99.00 [ns]	12 (92.75–104.25)
DEX/KES (n = 30)						
At the introduction	100.77	9.46	80	120	100.00	15 (94.75–110.00)
After 10 minutes	102.83	10.49	90	120	100.00	23 (90.00–113.25)
At the end	100.17	11.39	85	120	95.50	20 (90.00–110.00)

SD – standard deviation; ICR – interquartile range; P25 – 25th percentile; P75 – 75th percentile;
[#]Mann–Whitney U test;
[ns] no statistically significant difference

Table 5. Heart rate (beats/min) at three examined times by groups

Parameters	Average	SD	Min	Max	Mediana[#]	ICR (P25–P75)
DEX (n = 30)						
At the introduction	107.83	15.790	75	138	106.50	21 (98.00–118.75)
After 10 minutes	90.50	17.547	57	125	88.00	26 (79.25–105.25)
At the end	95.77	13.531	68	115	97.00[ns]	22 (86.00–107.75)
DEX/KES (n = 30)						
At the introduction	110.27	22.095	70	160	107.50[ns]	27 (94.00–121.00)
After 10 minutes	104.20	24.633	60	170	100.00[a]	21 (90.50–111.25)
At the end	94.07		61	120	96.50	19 (84.25–102.75)

SD – standard deviation; ICR – interquartile range; P25 – 25th percentile; P75 – 75th percentile
[#]Mann–Whitney U test;
[a] $p < 0,05$;
[ns] no statistically significant difference

Table 6. Time of awakening from sedation by groups

Parameters	DEX	DEX/KES
Average	5.93	6.93
SD	4.21	4.74
Min	2	2
Max	16	20
Mediana[#]	5	6[ns]
ICR (P25–P75)	6 (3–8.5)	7 (2.75–10)

SD – standard deviation; ICR – interquartile range; P25 – 25th percentile; P75 – 75th percentile; [#]Mann–Whitney U test;

[ns] no statistically significant difference

Table 7. Incidence of complications during sedation in the study groups (n (%))

Complication	DEX (n = 30)	DEX/KES (n = 30)
No complication [#]	24 (80)	29 (96.7)[ns]
Bradycardia	4 (13.3)	0 (0)
Tachycardia	0 (0)	1 (3.3)
Wetting	2 (6.7)	0 (0)

Values are expressed as a number (percentage);

[#] χ^2 test;

[ns] no statistically significant difference

