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Review Article

Drug selection for sedation in magnetic resonance imaging

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ABSTRACT

Magnetic resonance imaging (MRI) is extensively used for the diagnostic purposes. Patients who undergo MRI usually spend 30 to 45 minutes in a magnetically confined, loud environment. Therefore, in order to obtain high-quality diagnostic images, the majority of children and agitated adults need anaesthesia or sedation to remain calm and in position. The success of sedation for MRIs has typically been evaluated based on both the safety of the procedure and its efficacy. It can be challenging to keep the patient's respiration and hemodynamic steady while achieving the profound sedation level required to stop them from moving. The purpose of this research is to review the available information about drug selection for sedation in MRI. For painless diagnostic MRI, a single sedative or anaesthetic drug without analgesia is safer than a cocktail of several sedatives. Various commonly used drugs for sedation are dexmedetomidine, ketamine, chloral hydrate, midazolam, pentobarbital among others. Each drug has its own efficacy and safety profile along with certain side effects. It is critically important for the physician to choose the sedative drug appropriately. Drugs used for sedative purposes should have some definite characteristics including quick onset of action, wide therapeutic window, predictable duration among certain others. Dexmedetomidine, which preserves respiratory drive, and propofol, which has a high effectiveness and quick recovery, are currently chosen for children having an ambulatory MRI. Also, the combination of these drugs is used to sedate patients. Research in future can significantly contribute to defining elaborated criteria for selection of drugs since the available literature is scarce and limited mainly to paediatric population studies.

Keywords: Sedation, Drug, MRI, Diagnosis

INTRODUCTION

A significant advancement in diagnosis has been made owing to the invention of magnetic resonance imaging (MRI) for use in medical research, especially with the reduction of exposure to potentially harmful ionizing radiation. The use of MRI in clinical practice is increasing because of lower costs and increased accessibility.[1]

In clinical medicine, MRI is essential for the morphological and tomographic assessment of various parenchymal organs. Different imaging techniques can be used to gather a variety of biological data, including measures of metabolic products and the perfusion volume. In addition to conventional MRI for morphological assessment, diffusion-weighted MRI or diffusion tensor imaging, arterial spin labelling, magnetic resonance elastography, magnetic resonance spectroscopy, blood oxygenation level-dependent imaging, and neurological exploration are also used to assess the brain's white matter structures, metabolites, and diseases such as fatty liver and cirrhosis and further developments in future will see a continued expansion of this set of applications.[2]

Children younger than 6 years old and those at any age with developmental delay, claustrophobia, involuntary movements or convulsions may experience anxiety due to aspects of MRI scans such as loud noises, the constrained bore of the magnet, and the necessity of immobility to prevent motion artifacts. The need for drug-induced sedation during MRI scans has significantly increased over the past ten years as a result of rising MRI usage and growing interest in children's discomfort and anxiety. For most paediatric MRI scans, absolute immobility often with breath retention for up to an hour is required under severe sedation or general anaesthesia.[3,4] The decision to use sedation or general anaesthesia during an MRI should be made specifically for each patient after weighing the advantages and disadvantages. To ensure the patient's safety and welfare; to lessen the physical pain and discomfort; to reduce anxiety and psychological trauma while maximizing the possibility of amnesia; to control movement to ensure the procedure is completed safely and efficiently; and to allow for an early, safe discharge from the hospital are the objectives of sedation during MRI especially paediatric ambulatory MRI.[5]

Patients with neurocritical illnesses frequently need brain MRI in addition to regular neurological investigations. Patients must cooperate in order to obtain MRI images. To assure motion-artifact-free images, it might be difficult to keep patients with brain dysfunction still in a dark, loud MRI scanner; this may necessitate the use of sedative medications. Patient's cooperation may not always be guaranteed by the use of sedatives, and it may even have negative side effects. Additionally, if a patient refuses to cooperate during an MRI, the lengthened scan time may raise the risk of adverse outcomes brought on by postponed care management after the patient leaves the neurological critical care unit. Therefore, managing neurocritical patients having MRI requires an appropriate sedative regimen.[6] The safety of the sedation process and its effectiveness have traditionally been used to assess the success of sedation for MRIs. It can be difficult to achieve the profound sedation level necessary to stop the patient from moving while keeping their breathing and hemodynamic stable. Additionally, having restricted access to the patient during an MRI could be dangerous. Therefore, in order to accomplish such goals, it is essential to choose the right medications and dosage.[7,8] The purpose of this research is to review the available information about drug selection for sedation in MRI**.**

METHODOLOGY

This study is based on a comprehensive literature search conducted on 18 August 2022, in the Medline and Cochrane databases, utilizing the medical topic headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any possible research, a manual search for publications was conducted through Google scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed the information about the drug selection for sedation in MRI**.** There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

A single sedative or anaesthetic drug without analgesia is safer for painless diagnostic MRI than a cocktail of several sedatives. Despite their poor sedation efficacy, protracted recovery times, and major side effects, conventional medications like chloral hydrate, pentobarbital, midazolam, and ketamine are still often used because of simple and easy administration techniques. Dexmedetomidine, which preserves respiratory drive, and propofol, which has a high effectiveness and quick recovery, are currently chosen for children having an ambulatory MRI. In new-borns or children with comorbidities, general anaesthesia with propofol or sevoflurane can also offer predictable speedy time to readiness and scan times. For an effective and secure sedation and anaesthesia for ambulatory paediatric MRI, the right drug selection and enough monitoring gear are essential.[9]

Drugs used for sedation purpose should have these mentioned characteristics; quick onset of action, predictable duration, simple titratability within the desired range of the sedation continuum, quick and consistent cessation of effects, multiple delivery options, a wide therapeutic window, minimal cardiorespiratory depression minimal drug interaction, and be minimally impacted by renal or hepatic disease. Decisions about the sedatives to be used typically depend on factors specific to the patient such as neurodevelopmental status, underlying health conditions, and prior sedation or anaesthesia history as well as specific to the procedure such as the level of cooperation or immobility required, invasiveness, and duration.[10] In order to successfully manage patients during an MRI treatment, the principles of fast-track anaesthesia must be ingrained. Research is constantly being done to determine the best anaesthetic agent for sedation during an MRI. None of the available options, including propofol, ketamine, and dexmedetomidine, can be considered an ideal anaesthetic agent because none of them has the majority of the characteristics that make an ideal

anaesthetic agent, including a quick onset, ease of titration, haemodynamic stability, maintenance of spontaneous respiration, provision of immobility, and a brief duration of action with few side effects.[11]

Commonly used drugs for sedation in MRI

Dexmedetomidine

Alpha-2 adrenoceptors are specifically and selectively agonized by dexmedetomidine. It suppresses the release of norepinephrine and stops the spread of pain signals by attaching to the presynaptic alpha-2 adrenoceptors. The sympathetic activity is inhibited by the postsynaptic alpha-2 adrenoceptors, which results in a decrease in blood pressure and heart rate. Bradycardia, hypotension, and easy arousal by weak stimulants like MRI noise are some of its frequent side effects associated with its IV treatment.[12] Patients sedated with dexmedetomidine are more awake than those treated with traditional anaesthetics. Additionally, dexmedetomidine only slightly affects respiration. Dexmedetomidine is currently widely used in paediatric intensive care off-label because of its many advantageous qualities. Dexmedetomidine has also been used in children for various conditions, such as sedation during MRIs, and other earlier papers discuss its use in the ambulatory sedation of young patients. Dexmedetomidine has been demonstrated to decrease the need for opioids, volatile anaesthetics, and intravenous anaesthetics. Dexmedetomidine premedication decreased propofol consumption in paediatric patients having MRI, but did not, by itself, sedate the majority of children. Dexmedetomidine decreased the amount of thiopental required to sedate people.[13]

Results of a retrospective review stated that in 78.5% of paediatric cases, high doses of dexmedetomidine were successful; for 21.5% of patients, additional drugs were necessary. About 25% of cases had side effects, which went away on their own.[14] Kim stated in his meta-analysis findings that when compared to the sedative effects of propofol, ketamine, and midazolam, dexmedetomidine revealed a considerably delayed start time and recovery time. There was no difference between groups in the level of sedation or the occurrence of sedation failure. Even though there was a considerable drop-in heart rate, the bradycardia that needed to be treated did not worsen. Desaturation incidents occurred less frequently when using dexmedetomidine as a sedative.[15] Boriosi concluded in his study findings that buccal dexmedetomidine with or without midazolam offers appropriate sedation for the majority of MRI scans in a chosen population of young patients with minor side effects, but given a failure rate of over 20%, adjustments to buccal dexmedetomidine dose should be examined.[16]

Ketamine

Sedation, dissociative amnesia, and analgesia are brought on by ketamine, a phencyclidine analog and N-methyl D aspartate receptor antagonist. Since MRI does not require its analgesic component, ketamine is utilized as a sedative instead. The action begins quickly within 1-2 minutes, lasts briefly for 10–15 minutes, and recovers quickly within 30–60 minutes.[17] The brief duration of action, variety of delivery methods, preservation of airway reflexes, and sympathomimetic qualities, including an increase in heart rate and blood pressure, make ketamine appealing for paediatric sedation. Although sedation can be accomplished with little respiratory depression, ketamine has a long list of unfavourable side effects that may be upsetting to both the child and the parent. These include hallucinations, emerging delirium, agitation, nausea and vomiting, hypersalivation, and laryngospasm. This medication is less than optimal for treatments where the patient must lie perfectly motionless during MRI scans because there are frequently erratic movements of the extremities. Instead of being used as the only sedative during MRI, ketamine is combined with other sedatives to balance the negative effects and boost the positive effects of each drug. By lowering the dose required of each medication for MRI sedation in children, ketamine can counteract the cardiorespiratory depression effect of propofol and extended recovery of dexmedetomidine.[6,18,19]

Results of a comparative study showed that during the MRI examination, 6 children from the dexmedetomidine group and 4 children from the ketamine group both exhibited insufficient sedation. In the ketamine group, the onset of sedation was noticeably shorter, although the time to discharge was longer. During group sedation, mean arterial pressure and heart rate considerably lowered compared to baseline dexmedetomidine. Three group members' children displayed symptoms of nausea, vomiting, and dysphoria ketamine. In contrast to ketamine, which gave appropriate sedation but with a delayed time of discharge and additional side effects, dexmedetomidine provided adequate sedation in the majority of the children without hemodynamic or respiratory distress.[20] Tammam concluded in his study findings that in terms of onset of sedation, sedation failure rate, and hemodynamic stability during paediatric MRI sedation, the combination of dexmedetomidine and ketamine was better to either dexmedetomidine or ketamine given alone.[21]

Midazolam

Midazolam is a water-soluble, short-acting benzodiazepine with anxiolytic, sedative, amanesthetic, and muscle-relaxing effects. The sedation mechanism is regulated through gamma amino butyric acid mediated enhancement of chloride conductance in the central nervous system. When administered intravenously, the onset of action normally occurs within 3–5 minutes and lasts for 30–45 minutes at a dosage of 0.1 mg/kg followed by 0.05 mg/kg after every 5 minutes and up to a maximum dose of 4 mg.[9] Results of a prospective study among claustrophobic adults showed that the 36 patients of group 2 got one or, if necessary, two pumps of a midazolam nasal spray into each nostril just before the MRI, as opposed to the 36

patients of group 1, who were given 7.5 mg of midazolam orally 15 minutes beforehand, in total 1 or 2 mg. Prior to and following MRI, patients' tolerance, anxiety, and sedation were evaluated using a questionnaire and a visual analogue scale. A five-point scale was used to rate the quality of the images. In group 1, 18/36 (50%) MRI exams had to be postponed, while 12/18 (67%) of the remaining patients got insufficient anxiety relief. In group 2, 35/36 (97%) MRI tests were successfully completed without any pertinent side effects.

Patients with group 2 had better-rated MRI images than those with group 1 ($p<0.001$). Using low-dose intranasal midazolam throughout a variety of MRI procedures can help claustrophobic patients overcome their fear. Its anti-anxiety effects outperform those of the version that is taken orally.[22]

Chloral hydrate

The sedative and hypnotic drug choral hydrate has no pain-relieving abilities. It is thought that its sedative effects are caused via the central nervous system's gamma amino butyric acid A receptor. Chloral hydrate is quickly converted into the active metabolite, trichloro ethanol, which is responsible for the sedative and hypnotic effects, after being either orally or through the rectal route. Action begins 30 to 60 minutes after application and lasts 60 to 120 minutes. Individual responses, however, might vary greatly, and sedative effects can linger for up to 24 hours. The half-life is based on age and ranges from 4 to 12 hours, with preterm and term new-borns having longer half-lives of 37 and 28 hours, respectively.

As a result, chloral hydrate may cause re-sedation after the first recovery from sedation and may still have an impact up to 24 hours later.[23] Sedation for MRI has been the subject of very few research studies in the literature, and those that are published mostly deal with paediatrics. Although this is an important topic since inadequate patient sedation may not only have a negative impact on the clinical outcome but also put patients at considerable risk, future research including meta-analysis and systematic reviews can be beneficial in studying and defining the ideal drug selection protocol for sedation in all age groups.

CONCLUSION

For effective and safe sedation during MRI, the selection of sedative drug as per the patient is of utmost importance and clinicians shall be well informed about the advantages and side effects of the sedative drugs and shall select the drug appropriately however, with the advancements in the pharmaceutics and introduction of newer medications quality and cost effectiveness need to be further improved.

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REFERENCES

1. Grover VP, Tognarelli JM, Crossey MM, Cox IJ, Taylor-Robinson SD, McPhail MJ. Magnetic Resonance Imaging: Principles and Techniques: Lessons for Clinicians. J Clin Exp Hepatol. 2015;5(3):246-55.
2. Inoue T, Kozawa E, Ishikawa M, Okada H. Application of Magnetic Resonance Imaging in the Evaluation of Nutritional Status: A Literature Review with Focus on Dialysis Patients. Nutrients. 2021;13(6).
3. Dial S, Silver P, Bock K, Sagy M. Pediatric sedation for procedures titrated to a desired degree of immobility results in unpredictable depth of sedation. Pediatric Emerg Care. 2001;17(6):414-20.
4. Kaila R, Chen X, Kannikeswaran N. Postdischarge adverse events related to sedation for diagnostic imaging in children. Pediatric Emerg Care. 2012;28(8):796-801.
5. Coté CJ, Wilson S. Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures. Pediatrics. 2019;143(6).
6. Kim JG, Lee HB, Jeon SB. Combination of Dexmedetomidine and Ketamine for Magnetic Resonance Imaging Sedation. Front Neurol. 2019;10:416.
7. Bluemke DA, Breiter SN. Sedation procedures in MR imaging: safety, effectiveness, and nursing effect on examinations. Radiology. 2000;216(3):645-52.
8. Malviya S, Voepel-Lewis T, Eldevik OP, Rockwell DT, Wong J, Tait A. Sedation and general anaesthesia in children undergoing MRI and CT: adverse events and outcomes. Br J Anaesth. 2000;84(6):743-8.
9. Jung SM. Drug selection for sedation and general anesthesia in children undergoing ambulatory magnetic resonance imaging. Yeungnam University J Med. 2020;37(3):159-68.
10. Nedoma J, Fajkus M, Martinek R, Nazeran H. Vital Sign Monitoring and Cardiac Triggering at 1.5 Tesla: A Practical Solution by an MR-Ballistocardiography Fiber-Optic Sensor. Sensors (Basel, Switzerland). 2019;19(3).
11. Magoon R, Choudhary N, Wadhawan S. Ketodex for MRI sedation in syndromic children with congenital cardiac anomalies - A case series. Indian J Anaesth. 2022;66(6):456-9.
12. Abdellatif MK, Ibrahim TH. Dexmedetomidine/propofol versus dexmedetomidine/ketamine versus dexmedetomidine as a sole agent for pediatric sedation during MRI. Ain-Shams J Anesthesiol. 2019;11(1):2.
13. Uusalo P, Lehtinen M, Löyttyniemi E, Manner T, Scheinin M, Saari TI. Premedication with intranasal dexmedetomidine decreases barbiturate requirement in pediatric patients sedated for magnetic resonance

imaging: a retrospective study. BMC Anesthesiol. 2019;19(1):22.
14. Ahmed SS, Unland T, Slaven JE, Nitu ME. High Dose Dexmedetomidine: Effective as a Sole Agent Sedation for Children Undergoing MRI. Int J Pediatrics. 2015;397372.
15. Kim JY, Kim KN, Kim DW, Lim HJ, Lee BS. Effects of dexmedetomidine sedation for magnetic resonance imaging in children: a systematic review and meta-analysis. J Anesth. 2021;35(4):525-35.
16. Boriosi JP, Eickhoff JC, Hollman GA. Safety and Efficacy of Buccal Dexmedetomidine for MRI Sedation in School-Aged Children. Hospital Pediatrics. 2019;9(5):348-54.
17. White PF, Way WL, Trevor AJ. Ketamine--its pharmacology and therapeutic uses. Anesthesiology. 1982;56(2):119-36.
18. Tomatir E, Atalay H, Gurses E, Erbay H, Bozkurt P. Effects of low dose ketamine before induction on propofol anesthesia for pediatric magnetic resonance imaging. Paediatric Anaesth. 2004;14(10):845-50.
19. Schmitz A, Weiss M, Kellenberger C, O'Gorman Tuura R, Klaghofer R, Scheer I, et al. Sedation for magnetic resonance imaging using propofol with or without ketamine at induction in pediatrics-A prospective randomized double-blinded study. Paediatric Anaesth. 2018;28(3):264-74.
20. Eldeek AM, Elfawal SM, Allam MG. Sedation in children undergoing magnetic resonance imaging comparative study between dexmedetomidine and ketamine. Egyptian J Anaesth. 2016;32(3):263-8.
21. Tammam TF. Comparison of the efficacy of dexmedetomidine, ketamine, and a mixture of both for pediatric MRI sedation. Egyptian J Anaesth. 2013;29(3):241-6.
22. Tschirch FT, Göpfert K, Fröhlich JM, Brunner G, Weishaupt D. Low-dose intranasal versus oral midazolam for routine body MRI of claustrophobic patients. Eur Radiol. 2007;17(6):1403-10.
23. Mayers DJ, Hindmarsh KW, Sankaran K, Gorecki DK, Kasian GF. Chloral hydrate disposition following single-dose administration to critically ill neonates and children. Develop Pharmacol Therap. 1991;16(2):71-7.

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