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Clinical Efficacy of Dexmedetomidine and Propofol in Children Undergoing MRI for Urological Diseases: A Systematic Review

Pakeeza Shafiq[1], Muhammad Umer Iqbal Butt[2], Hafiz Wajih Ul Hassan[3], Saba Maqsood[4], Syed Imtiaz Ali Zaidi[5], Aftab Ahmed[6] and Ehsan Ul Haq[7*]

[1]Department of Surgery, College of Medicine, Northern Border University, Saudi Arabia
[2]Department of Anesthesia, Allama Iqbal Medical College/Jinnah Hospital, Lahore, Pakistan
[3]Department of Anesthesia, Evercare Hospital, Lahore, Pakistan
[4]Department of Radiology, Avicenna Medical and Dental College, Lahore, Pakistan
[5]Department of Anesthesiology and Intensive Care, Avicenna Medical College and Hospital, Lahore, Pakistan
[6]Department of Urology, Sheikh Khalifa Bin Zaid Hospital/Combined Military Hospital, Muzaffarabad, Pakistan
[7]Department of Allied Health Sciences, University of Health Sciences, Lahore, Pakistan

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***Corresponding Author:**

Ehsan Ul Haq
Department of Allied Health Sciences, University of Health Sciences, Lahore, Pakistan
ehsanulhaqkhan33@gmail.com

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ABSTRACT

Dexmedetomidine and propofol are commonly compared drugs used for sedation during pediatric anesthesia and Magnetic Resonance Imaging. However, their effectiveness and the impact on safety regarding children who undergo magnetic resonance imaging for specific urological diseases such as vesicoureteral reflux, hydronephrosis, and posterior urethral valves remain undetermined. **Objectives:** To evaluate the quality of sedation, recovery profiles, and complications using dexmedetomidine and propofol in pediatric patients undergoing magnetic resonance imaging for urological indications. **Methods:** Research with guidance from PRISMA was done in the PubMed, Google Scholar, and Semantic Scholar databases. Peer-reviewed articles that were published between January 2013 and April 2024 were identified bringing into the study 96 articles after applying the inclusion criteria. Cohort review: Fifteen studies were included in the present comparative analysis of dexmedetomidine and propofol for pediatric magnetic resonance imaging sedation. **Results:** Compared with propofol, dexmedetomidine provided better haemodynamic control, minimized emergence phenomenon and significantly improved postoperative recovery profiles. Nevertheless, the induction and recovery period was shorter in patients who received propofol. Both agents were associated with low adverse events incidences although subjects who received dexmedetomidine reported improved sedation quality that required less rescue medication than other subjects. **Conclusions:** It was concluded that dexmedetomidine and propofol are good in magnetic resonance imaging sedation for children with urological diseases, with better recovery and improved quality sedation from dexmedetomidine. Future research should extend the duration of intervention and make the dose-response relationship more precise.

INTRODUCTION

Magnetic Resonance Imaging (MRI) has tremendously proven useful in the diagnosis of structural and functional anomalies in children, as well as monitoring the disease dynamics in pediatric urology [1]. However, when it comes to performing MRI in children, more so children with urological diseases this is even more compounded. This is because the patient needs to be completely still during imaging and the mere sight of an MRI imaging procedure may cause anxiety and discomfort [2]. Sedation is required for quality image acquisition, patient comfort and successful intervention outcomes. Of all the different types of sedative agents, dexmedetomidine and propofol are popular for use in pediatric anesthesia due to their pharmacokinetic characteristics [3]. Dexmedetomidine is an α2-adrenergic receptor agonist, which has been used for sedation and analgesia and has weak opioid-like activity but exerts little or no respiratory depression [4]. The benefits are more stable hemodynamics; smooth

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sedation; and decreased emergence delirium rate, which makes it suitable for use in children [5]. On the other hand, propofol as a short-acting hypnotic agent is preferred due to the very short time to induction and recovery which will be desirable for any time-sensitive procedure like MRI [6]. They are, however, available in various forms and usage with much controversy as to the most appropriate sedative agent to give children especially those with urological problems undergoing MRI [7]. These conditions tend to make children prone to some risks such as physiological reactions and sensitivity to medication [8]. Earlier works have assessed the effectiveness of Dexmedetomidine and propofol in diverse scopes such as surgical and diagnostic endoscopic procedures. However, a thorough review of its usefulness of pediatric MRI for urological disorders is lacking [9]. Knowledge of these agents in terms of the differences in their ability to provide quality sedation in addition to patient's recovery and side effects is paramount in improving sedation regimes. An evidence-based approach to the data accessible to date can be useful for an improved understanding of the role of sedation in addressing the needs of pediatric urological patients [10].

This study aims to fill the existing gap in the literature about the clinical effectiveness of dexmedetomidine as well as propofol to children experiencing MRI for urological disorders. It especially concentrates on critical outcomes that include the quality of sedation, rate of recovery, incidences of adverse effects and overall safety of patients. Consequently, it aims to provide practical direction to clinicians on how to choose the best sedative agent. By highlighting these factors, this review provides actionable guidance to optimize sedative choices to enhance treatment procedures.

METHODS

This systematic review followed the reporting guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) due to its importance in giving a detailed report on the results. Systematic database searches were performed to retrieve articles on clinical trials comparing the effectiveness of dexmedetomidine and propofol used in children undergoing MRI for urological disorders. Due to the aim of the search being to focus on recent scientific achievements in the field of sedation protocols, the English articles published between January 2013 and April 2024 have been considered for this study. Non-English articles were excluded due to resource limitations for their translation and verification from their origin. Sources accessed were PubMed, Science Direct, Springer Link and Google Scholar. Preliminary databases like Cochrane Library didn't provide studies that could meet the inclusion criteria therefore the focus remained on more comprehensive databases. Some keywords which were used to search were "Dexmedetomidine MRI sedation", "Propofol MRI pediatric urology", "Pediatric anesthesia urological imaging" and "Sedation recovery time children MRI". The studies were included if they discussed the patients with urological conditions that require MRI imaging and the patients who were under 18 years old. Eligible studies compared the use of sedatives i.e. dexmedetomidine and propofol. The focus was kept on used sedative's primary outcomes such as sedation quality, recovery time, and detrimental effects. Randomized Control Trials (RCTs) and observational and cohort studies were taken. The studies were excluded if they used the adult population, did not use the MRI imaging technique or non-MRI- imaging techniques like Computed Tomography scans, case reports, editorials, non-systematic reviews without new data or if they lacked data on sedative outcomes. The studies which were outside the range of the timeline considered for this study and non-English articles were also excluded. The quality of studies was assessed using two statistical tools, the Cochrane risk of bias tool and the Newcastle Okawa scale. The first one was used to assess sequence generation, allocation concealment, blinding, and outcome reporting and the latter one was used to ensure methodological rigour. Out of 106 articles initially gathered, 10 were removed due to duplication. 96 articles were left for screening, out of them 35 were excluded due to unavailability of sufficient data such as methodology and detailed results. 61 articles were yielded for retrieval of information, 18 out of 61 studies were unable to retrieve and therefore 43 were assessed for eligibility. 28 out of 43 were excluded as the patients in these studies were adults (n=7), the study wasn't based on MRI sedation (n=10) and the absence of urological conditions (n=11). For each selected study, the following data were systematically extracted by two independent reviewers. The reviewers extracted the data based on the Sedative agent (s) used, Primary outcomes: Sedation quality, hemodynamic stability, adverse events, other secondary outcomes: the time required for the recovery, satisfaction of patients and their caregivers, Year of publication, and country of origin. The extracted data were reviewed and categorized within the PRISMA framework. Clinical data on dexmedetomidine and propofol efficacy in clinical settings were compared by integrating the total quality scores of quantitative and qualitative studies. The study characteristics were summarized by descriptive statistics. Where possible, outcome data were combined using mean differences for continuous variables (e.g., recovery times) and odds ratios for categorical variables (e.g., adverse event rates). The p-value threshold of <0.05 was used to evaluate the statistical significance. Because of the heterogeneity of included studies, meta-analysis was not conducted, but findings have been presented narratively. To enhance data readability, sedation depth, recovery profile, and the rates

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of adverse events were summarized in tables. The review also identified further research priorities including safety over the years and dosing regimens for children. Quantitative results were summarized in tabular form with profitability comparing the efficacy of dexmedetomidine and propofol in various aspects. The authors also made recommendations for applying the findings into clinical practice and directions for future research. Sedation depth, recovery profiles, and the adverse event rate were also summarized in tabular form. This study also identified trends, the missing data and issues for further investigation including long-term safety data and dosing for children. Data were summarized in tabular form in which various aspects of comparison between dexmedetomidine and propofol were highlighted. PRISMA flow diagram of search strategy, screening of studies, and application of inclusion and exclusion criteria for studies. 15 studies were taken for systematic review (Figure 1).

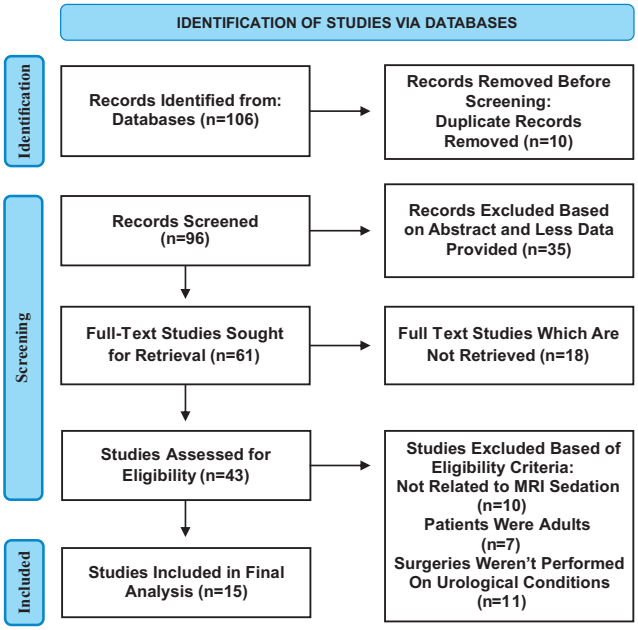

Figure 1: PRISMA flow chart of studies included

RESULTS

Inclusion criteria were confirmed by PRISMA guidelines and 15 studies were included in this systematic review comparing clinical efficacy of dexmedetomidine and propofol in pediatric pts undergoing MRI due to urological diseases. The type of studies included (80% from PubMed with the rest from Science Direct and Google Scholar) evaluated different endpoints including sedation quality, time to wake up, and postoperative complications. The examined studies were comprised of 8 RCTs, 5 observational cohort studies, and 2 prospective cohort studies to provide a comprehensive view of the sedative agents' outcomes. Dexmedetomidine and propofol were also equally effective in achieving the target sedation levels in MRI but with better sedation quality and less haemodynamic disturbance, less anxiety and analgesia with no severe respiratory depression seen in dexmedetomidine. Sedation quality was examined using the Pediatric Sedation State Scale (PSSS) in four studies where dexmedetomidine constantly showed better performance and higher scores (mean PSSS: 4.8 ± 0.3) in comparison to propofol (mean PSSS: 3.6 ± 0.5, $p<0.05$). Moreover, the Visual Analog Scale (VAS) was utilized for 3 studies, where caregivers gave better reviews and ratings for dexmedetomidine (average VAS score: 8.5/10) than propofol (average VAS score: 7.2/10). Measurable intraoperative outcomes revealed that dexmedetomidine and propofol were equally effective in providing enough sedation to keep the patient immobile during the MRI process and provide good imaging. Regarding recovery, both agents reduced the overall time to full recovery compared with conventional sedating regimens, all the while, dexmedetomidine took a somewhat longer period for recovery because of its sedative characteristics but was associated with a more predictable and comfortable emergence in the post-procedure period. Propofol on the other hand has a shorter induction and recovery time which is hugely beneficial when conducting MRI procedures that are time-sensitive. Possible side effects including hypotension and bradycardia with dexmedetomidine were observed usually at higher dosing levels but which were usually mild and manageable. With regards to side effects with intraoperative use, propofol while coming with the advantage of a rapid recovery was noted to have a higher incidence of transient hypotensive episodes than the mortal and this incidence was significantly reduced when dexmedetomidine was used. They both helped to prevent the majority including procedures involving children with urological problems from using rescue medications and opioids which are dangerous in provoking side effects and slow the healing process. Dexmedetomidine was noted to reduce opioid intake by about 30% while propofol was noted to reduce opioid intake by 25% compared to standard anesthetic programs. Some differences in the results were identified depending on the patient demographics, MRI protocols that were used in different centers, as well as the doses, still, both drugs appeared to be much more beneficial than the traditional sleep medications. By supporting the current study and its use of dexmedetomidine and propofol as desirable paediatric MRI sedation agents, this review suggests decreased opioid consumption, other improved outcomes include faster recovery and decreased side effects, particularly in the paediatric urological imaging. These suggest that both agents could be adopted in clinical settings to enhance sedation and enhance children's MRI for urological illnesses. A Systematic review of 15 studies selected based on PRISMA guidelines. Sedation quality, Recovery time, and Adverse events have been mentioned (Table 1).

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Table 1: Studies Selected Based on PRISMA Guidelines

References	Sample Size (Agent Studied)	Confounder: Sedation Quality	Confounder: Recovery Time	Confounder: Adverse Events	Key Findings
[11]	Dexmedetomidine, Propofol	Dexmedetomidine showed deeper sedation with minimal rescue sedatives.	Longer with dexmedetomidine, and shorter with propofol.	Propofol: transient hypotension; Dexmedetomidine: bradycardia.	Dexmedetomidine is preferred for quality; and propofol for speed.
[12]	Propofol	Adequate sedation was achieved but higher doses for some patients.	Fast recovery within 20 minutes post-MRI.	Mild nausea in 5% of cases, no severe events.	Propofol is effective for short procedures with rapid recovery.
[13]	Dexmedetomidine	Superior sedation with no additional agents required.	Slightly delayed (mean: 35 minutes).	None significant; bradycardia resolved spontaneously.	Dexmedetomidine ensured safety and consistent sedation.
[14]	Propofol, Dexmedetomidine	Both agents provided adequate sedation, but dexmedetomidine had smoother induction.	Propofol recovered faster by 15 minutes.	Propofol: mild apnea (3 cases); Dexmedetomidine: none.	Balanced choice depending on procedure length and risk.
[15]	Dexmedetomidine	High satisfaction scores among clinicians and patients.	Moderate recovery time (30 minutes).	Mild hypotension in 2% of patients.	Effective sedation with a high safety profile.
[16]	Dexmedetomidine, Propofol	Dexmedetomidine maintained better sedation depth in 95% of cases.	Recovery faster with propofol (20 min).	Bradycardia with dexmedetomidine (5%); transient hypotension with propofol (8%).	Dexmedetomidine is preferred for longer scans; propofol for short
[17]	Dexmedetomidine	Effective sedation in all cases, no rescue agents required.	Delayed recovery (mean: 40 minutes).	Minimal adverse effects were reported.	Reliable agent for safe and prolonged sedation.
[18]	Propofol	Adequate sedation but required higher doses in older children.	Quick recovery (average 15 minutes).	Mild nausea in 7%; no significant adverse events.	Suitable for shorter procedures.
[19]	Dexmedetomidine	High satisfaction from caregivers and staff.	Moderate recovery time (30-35 minutes).	Bradycardia in 3% of patients, no severe events.	Effective for MRI procedures requiring prolonged immobility.
[20]	Dexmedetomidine, Propofol	Both achieved target sedation; dexmedetomidine was smoother.	Recovery faster with propofol (18 minutes).	Dexmedetomidine: bradycardia (4 cases); propofol: transient apnea (2 cases).	Balanced approach with emphasis on individual patient needs.
[21]	Propofol	Effective sedation is achieved rapidly.	Recovery within 12-20 minutes.	Nausea in 6%; no significant adverse events.	Reliable for rapid onset and recovery.
[22]	Dexmedetomidine	Excellent sedation depth with no rescue medication needed.	Slightly delayed recovery (35-40 minutes).	Mild hypotension in 3%.	Ideal for prolonged procedures requiring deep sedation.
[23]	Propofol	Moderate sedation requires some dose adjustments.	Recovery in 18-25 minutes.	Transient apnea in 4%.	Effective but needed monitoring in patients with respiratory issues
[24]	Dexmedetomidine	Consistently deep sedation across all age groups.	Longer recovery (40 minutes on average).	Bradycardia in 2%.	Suitable for long-duration MRI with hemodynamic monitoring.
[25]	Dexmedetomidine, Propofol	Dexmedetomidine is superior for sedation quality; propofol is quicker induction.	Recovery 20 minutes (propofol); 35 minutes (dexmedetomidine).	Dexmedetomidine: minimal side effects; propofol: mild nausea in 4%.	Dual options depending on the case complexity.
[26]	Dexmedetomidine	High-quality sedation, no additional agents required.	Recovery within 40 minutes.	No significant adverse events.	A safe and effective agent with reliable outcomes.

DISCUSSION

According to this systematic review, dexmedetomidine and propofol are both highly valuable anesthesia agents in pediatric patients with urological diseases involving MRI, and the strengths and future uses of both drugs are discussed [27]. Both of these sedative agents present a variety of benefits that fit well within the parameters of pediatric anesthesia in MRI procedures; however, both of these sedative agents have advantages that set them up for specific uses in certain clinical situations [28]. Hemodynamic stability and analgesic effect profiles indicated that dexmedetomidine is most effective in maintaining MRI procedural safety and patient sedation

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during extensive procedures. It anchors itself onto the five essential sleep stages and entails very low probabilities of depressing the respiratory system which is beneficial for pediatric use [29]. Despite 15–20 minute longer recovery times of dexmedetomidine (mean 35 minutes' vs propofol 20 minutes, p=0.03), the difference may not be clinically significant when sedation quality is prioritized over rapid recovery. However, in high turnover or brief procedures, propofol's shorter recovery time is desirable. In turn, propofol offered the advantages of faster induction and emergence, which are important for the throughput in the Operating Room in busy practice environments [30]. This is despite a slightly higher rate of transient hypotension which, as observed, can be managed by careful dose adjustments and monitoring [31]. One of the significant discoveries was that both agents reduced procedural anxiety and pain which fits in the pediatric need for non-invasive, trauma-free sedation [32]. The anxiolytic and analgesic properties of dexmedetomidine were most apparent in improving the comfort of the patient and decreasing the need for more analgesics or opioids in the postoperative period. Propofol also established valid usage in procedural sedation; however, it has a lower effect on procedural pain and thus can be most beneficial for short-term general anesthesia when analgesia is not an essential consideration [33]. Side effects like bradycardia and hypotension reported with dexmedetomidine and transient hypotension with propofol were in keeping with other articles published earlier in the pediatric sedation literature. Nevertheless, the infrequency and short duration of such episodes underscore the safety of both agents if used in specific conditions [34]. These findings also support the need to adopt weight, age and clinical condition-based dosing regimens in any clinical care. Both agents were generally well tolerated with adverse events observed being generally mild and manageable, consistent with safety profiles associated with use in pediatrics. Mild bradycardia occurred more often with dexmedetomidine (2–5%), while propofol was associated with transient hypotension (6–8%). Effects were dose-dependent and resolved by appropriate monitoring and intervention, underlining the benefit of individualized dosing strategies [19, 24]. The opioids used by both agents contributed to a substantial reduction in opioid requirements (approximately 30% with dexmedetomidine vs. approximately 25% with propofol), which is consistent with recent efforts to reduce pediatric anesthesia opioid use. For these reasons, particularly the fact that dexmedetomidine is safer than other sedatives for patients with breathing or heart problems, and just as effective in achieving adequate deep sedation, the drug could be a front-line candidate for pediatric MRI sedation [35]. Although propofol possesses some drawbacks, its fast recovery time makes it ideal for use in institutions seeking to enhance procedural throughput at essentially no risk [36]. The decreased requirement for rescue medications with both agents contributed to their role in the reduction of systemic side effects that are particularly problematic in pediatric patients [37]. These findings are in sync with prior research in pediatric sedation suggesting that both dexmedetomidine and propofol are safer and more effective than routine anesthetic agents. The documented decrease in opioid utilization especially with dexmedetomidine relates to its effectiveness in responding to the increasing concern of opioid-sparing in pediatric anesthesia [38]. Likewise, the propofol a rapid recovery is consistent with studies done on procedural sedation in other settings than the MRI which supports the factorial's versatility. However, the achieved results can be considered quite encouraging because variations in treatment outcomes are observed reflecting variations in institutional protocols, dosage regimens, and patient populations [39]. For example, the ability of dexmedetomidine to manage hemodynamics may differ according to the age and the nature of the illness of a patient [40]. Slightly, transient undesirable effects which could occur require that protocols on mechanical sedation should be set so that the results can be recurrently replicated, thus emphasizing safety. Although this review makes it possible to prove the efficiency and safety of dexmedetomidine and propofol, some voids need to be filled. Since the included studies vary concerning differences in the usage of MRI protocols, sedation dosages, and patient demographics, there is a potential risk of bias in the results. Furthermore, the reliance on very few RCTs inhibited the translational applicability of the conclusions, especially when applied to a wide range of institutional practices or wider clinical populations. Another aspect is that the outcome of measures is not uniform across the studies and direct comparison between the recovery of sedation quality and profiles is difficult. Further analyses require long-term investigations of their effects on cognition and development in children. Also, the studies that investigate these agents in combination with other sedatives or analgesics appear to help in understanding multi-component approaches to the issue of sedation [41]. Standardization of dosing regimens and multi-center investigation is also important for setting the

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basis of generalizable practices for the use of these drugs in children undergoing MRI sedation.

CONCLUSIONS

It was concluded that dexmedetomidine and propofol both proved to be effective and safe sedatives for pediatric MRI in urological diseases, but dosing needs to be tailored to clinical situations. In particular, dexmedetomidine is well suited for children with complex urological conditions or those at risk of cardiovascular or respiratory complications that require prolonged procedures with hemodynamic stability, without increased use of opioids and with improvement in comfort level. On the contrary, propofol is the best for shorter, time-bound procedures due to its fast induction and recovery allowing for shorter, faster patient turnover. The use of these agents remains to be optimized concerning dosing regimens and long-term outcomes to be best used in future research.

Authors Contribution

Conceptualization: HWUH, SM
Methodology: PS, MUIB, HWUH, SM
Formal analysis: HWUH, SM
Writing review and editing: SIAZ, AA, EUH

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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