Meta-analysis study on anesthetic sedation recovery and onset times in pediatric and elderly patients undergoing CT and MRI

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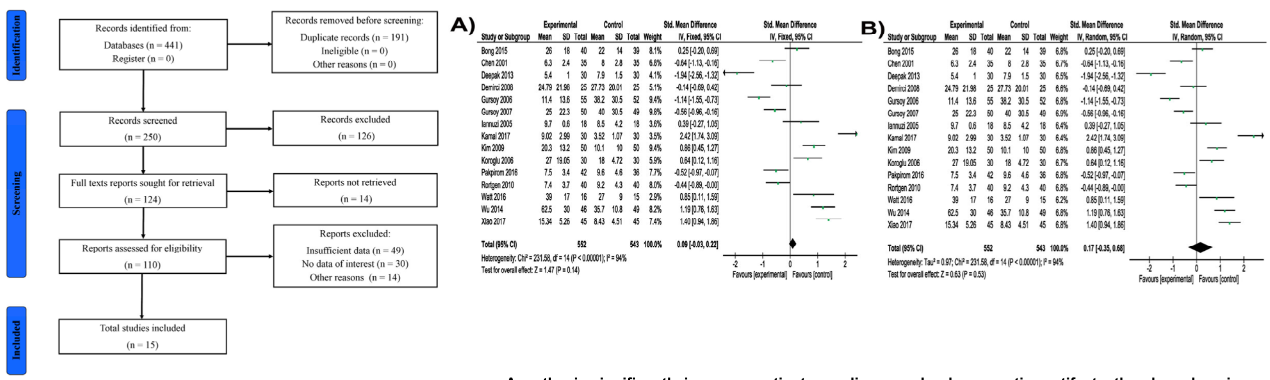
Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are crucial diagnostic modalities that require patients to remain immobile for extended periods, with anesthesia sometimes used for comfort and image quality enhancement. The study compares dexmedetomidine and propofol in reducing recovery time and sedation onset in pediatric and elderly patients undergoing CT and MRI procedures. A meta-analysis of fifteen studies assessing recovery time, sedation onset, and failed sedation between dexmedetomidine and propofol in pediatric and elderly patients during CT and MRI was conducted. The study indicated that the administration of anaesthesia markedly improved patient compliance and reduced motion artefacts in both CT and MRI ($P<0.00001$, $I^2=94\%$). The meta-analysis indicated that the mean difference (MD) in the onset of sedation was significantly faster in the control group ($P<0.00001$, $I^2=96\%$). The study reveals that dexmedetomidine and propofol anesthesia can improve patient image quality during CT and MRI procedures by reducing motion artefacts. Dexmedetomidine sedated people more quickly than propofol, but no significant differences in sedation duration were observed.

META-ANALYSIS STUDY ON ANESTHETIC SEDATION RECOVERY AND ONSET TIMES IN PEDIATRIC AND ELDERLY PATIENTS UNDERGOING CT AND MRI



A systematic review and meta-analysis were conducted using data from 15 studies, analyzing key outcomes such as recovery time, onset of sedation, and the incidence of failed sedation between dexmedetomidine and propofol.

Anesthesia significantly improves patient compliance and reduces motion artifacts, thereby enhancing image quality.

The study also underscores quicker sedation onset with dexmedetomidine but finds no notable differences in sedation duration between the drugs.

Dexmedetomidine and propofol, help patients stay still and get better images during CT and MRI. Dexmedetomidine sedated people more quickly than propofol.

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Key words: anesthesia, elderly patients, pediatric patients, propofol, dexmedetomidine, CT scan, meta-analysis, recovery time

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INTRODUCTION

Anesthesia is commonly used during medical imaging procedures such as CT scans and MRI to reduce patient anxiety and motion. Anesthesia for CT scans and MRI procedures is a specialized medical practice involving the administration of anesthesia to patients undergoing these imaging studies[1]. CT scans and MRI scans are important diagnostic tools that provide detailed images of the internal structures of the body[2]. These procedures are generally painless and non-invasive, but there are situations where patients, particularly those who are young, have severe anxiety, or have difficulty remaining still, might require anesthesia to ensure a successful and comfortable imaging session[3]. Anesthesia is primarily administered to ensure that patients remain still during the imaging procedure. Movement during the scan can lead to blurred images and the need for repeat scans, which can be inconvenient and increase radiation exposure in the case of CT scans[4]. Anesthesia helps patients, especially children or those with conditions that make them unable to stay still, to remain calm and motionless throughout the procedure[5]. The type of anesthesia used can vary depending on the patient's age, medical history, and the anticipated duration of the procedure. In many cases, mild sedation might be sufficient to relax the patient and alleviate anxiety[6]. This can be achieved using medications that make the patient drowsy and less responsive, while still maintaining their ability to breathe independently. Anesthesia for imaging procedures is typically administered by an anesthesiologist, a medical doctor specialized in anesthesia. The anesthesiologist will evaluate the patient's medical background, their present state of health, and any possible anesthesia-related risks[7]. They will then determine the appropriate type and dosage of anesthesia to be used. While anesthesia for imaging procedures is generally safe, there are potential risks associated with any anesthesia administration[8]. Patients with certain medical conditions, allergies, or sensitivities to anesthesia medications might require special attention[9]. It's important for the anesthesia team to have a complete understanding of the patient's health history to minimize potential complications. Anesthesia for CT scans and MRI procedures plays a crucial role in ensuring successful and accurate imaging, particularly in cases where patients have difficulty remaining still or experience anxiety[10]. Delivering safe sedation or anesthesia for magnetic resonance imaging (MRI) or CT scans poses distinctive challenges for the anesthesiologist. The accuracy of anesthesia shows how well the technique accomplishes to retain patients sedated and pain-free without any issues. Sensitivity is about how quickly and effectively the technician can spot and handle any problems or side effects that come up during the procedure, which is important for keeping patients safe. Both of these aspects are vital for determining how effective and safe anesthetic practices are in the operating room. Accuracy in this context refers to how effectively the anesthesia technique meets its intended goals, such as ensuring the patient remains still during the procedure to achieve high-quality imaging. Whereas sensitivity refers to the anesthesia technique's ability to appropriately respond to varying patient needs, including different levels of sedation required for specific patients. In medical diagnostics, accuracy generally measures how well a technique achieves the correct or intended result, while sensitivity focuses on how well it detects and addresses subtle variations in patient response or sedation needs. The limited patient access and the requirement for remote monitoring, with the preferred placement of the anesthesiologist outside the imaging room, make it imperative to maintain minimal anesthesia monitoring standards[11]. Therefore, the primary objective of this study is to investigate the efficacy of anaesthesia, especially comparing dexmedetomidine and propofol, in minimising the amount of time needed for patients to recover and the number of minutes it takes for them to get sedated during CT and MRI procedures in elderly and pediatric patients and access its associated outcomes such as patient comfort, success rates, adverse events, and potential benefits.

METHODS

Literature search strategy and keywords

We systematically screened digital databases such as PubMed, Scopus, Cochrane, Web of Science, and Google Scholar. The search keywords comprise: "general anesthesia", "local anesthesia", "elderly patients", "pediatric patients", "elderly", "magnetic resonance imaging", "MRI", and "CT Scan". The searched spanned from Jan 2001 until Jan 2023. Furthermore, the researchers also performed a manual search to ensure comprehensive coverage and rigorous screening of the pertinent literature, including examination of bibliographies to minimize the chance of overlooking any relevant research. Additionally, the final list of references for the retrieved articles was searched manually.

Inclusion criteria

The analysis considered only those studies that met the following criteria:

(1) Clinical studies or research articles that focus on the use of anesthesia for MRI or CT scan

(2) Subjects undergoing MRI or CT scan

(3) Studies on intervention with local anesthesia (LA), general anesthesia (GA), Comparison or any other LA or GA agents

(4) Studies which provide sufficient and non-overlapping data

(5) Studies published in English only Two reviewers independently reviewed the full text of the studies, and any that did not meet the criteria were excluded

(6) Elderly patient population (>65 years)

(7) Pediatric patient population (>6 years)

Exclusion criteria

The analysis excluded those studies that fall into the following criteria:

(1) Case reports, observational studies, review articles, conference abstracts, and letters

Table 1. Details of the included studies based on recovery time.

	Dexmedetomidine			Propofol			Ref.
Authors	Mean	SD	Total	Mean	SD	Total	
Bong 2015	26	18	40	22	14	39	12
Chen 2001	6.3	2.4	35	8	2.8	35	13
Deepak 2013	5.4	1	30	7.9	1.5	30	14
Demirci 2008	24.79	21.98	25	27.73	20.01	25	15
Gursoy 2006	11.4	13.6	55	38.2	30.5	52	16
Gursoy 2007	25	22.3	50	40	30.5	49	17
Iannuzi 2005	9.7	0.6	18	8.5	4.2	18	18
Kamal 2017	9.02	2.99	30	3.52	1.07	30	19
Kim 2009	20.3	13.2	50	10.1	10	50	20
Koroglu 2006	27	19.05	30	18	4.72	30	21
Pakpirom 2016	7.5	3.4	42	9.6	4.6	36	22
Rortgen 2010	7.4	3.7	40	9.2	4.3	40	23
Watt 2016	39	17	16	27	9	15	24
Wu 2014	62.5	30	46	35.7	10.8	49	25
Xiao 2017	15.34	5.26	45	8.43	4.51	45	26

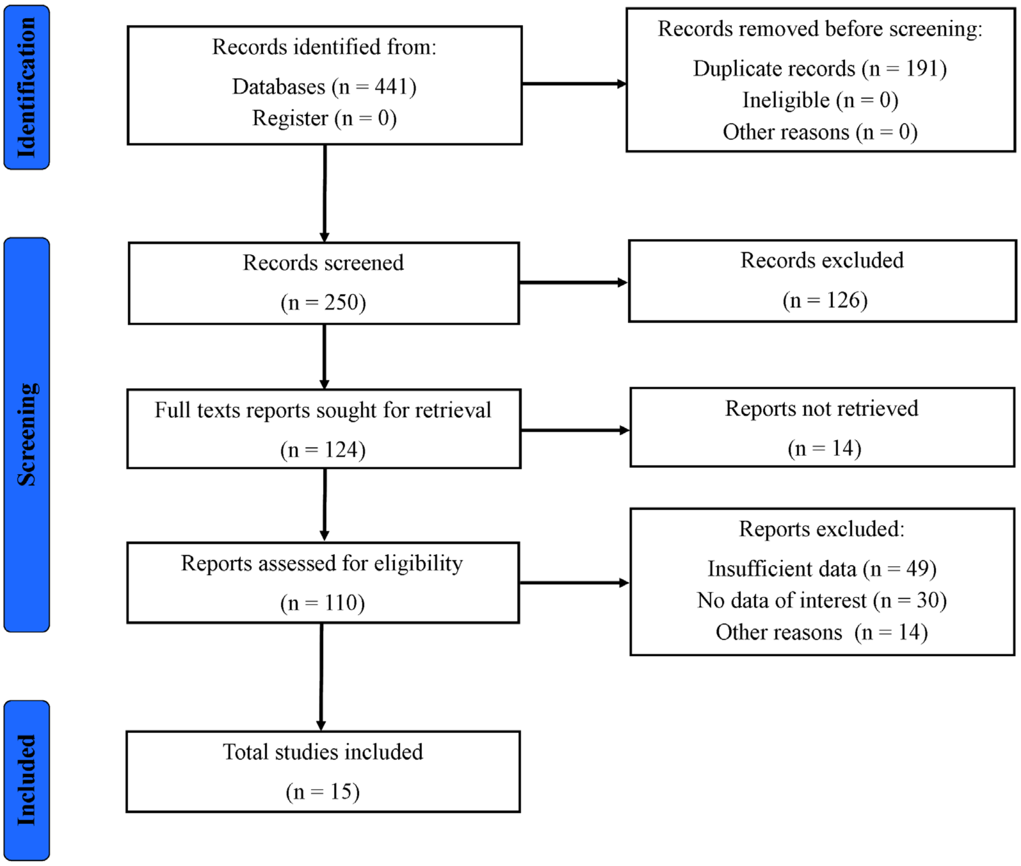

Fig. 1. PRISMA 2020 flowchart for the study protocol.

(2) Use of anesthesia involving animal study and animal experiments

(3) Studies that were not able extract original data

Data collection and extraction

Throughout the data extraction process, we diligently followed standardized procedures, with two distinct researchers independently reviewing all extracted information. This encompassed various aspects of the study and was meticulously documented in a consistent format. This format included general details such as the author, publication year, study type, number of patients, gender distribution, age range, and average age, as well as the count of nodules. It also encompassed specific details about the reference standard used. We employed both the Cochrane risk of bias tool (ROBIS) and the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool to evaluate various aspects, encompassing patient selection, index test, reference standard, flow, and timing. Each evaluated domain received a bias risk score, categorized as low, some concerns, or high. To evaluate the quality of the included studies, two co-authors performed the assessment. In instances where discrepancies arose, we either consulted with the principal investigator or enlisted a third reviewer to reach a final decision.

Data analysis and statistical assessment

The research investigations applied the Inverse-Variance method to gather continuous data, which was then presented as the mean difference (MD) along with a 95% confidence interval (CI) within a random-effect model. To evaluate the diversity in statistical results across the studies, we used a combination of visual inspection of the forest plot and statistical assessments, including I-squared (I^2) and the chi-squared test[17]. Statistical significance for all endpoints was determined with a threshold of $P<0.05$. We conducted the statistical analysis using RevMan software (version 5.4.1, Cochrane Rev Manager, Inc, USA), consistently applying the random-effect model throughout the analysis. Additionally, a sensitivity analysis was performed to assess the robustness of our results. This involved excluding studies one by one to observe the impact on the overall pooled estimate and to identify any potential outliers or studies that disproportionately influenced the meta-analysis outcomes.

RESULTS

Search results and patient characteristics

The initial search across PubMed, Web of Knowledge, and the Cochrane Library databases resulted in the identification of 441 records. Among these, 191 duplicates were eliminated. After scrutinizing the titles and abstracts, 126 articles were excluded and subsequently, 124 articles were retrieved for with full texts. Among the full texts, only 110 reports were assessed for eligibility and 93 articles were excluded. Ultimately, the final analysis included only 15 studies from different countries. The PRISMA 2020 (Preferred Reporting Items for Systematic Reviews

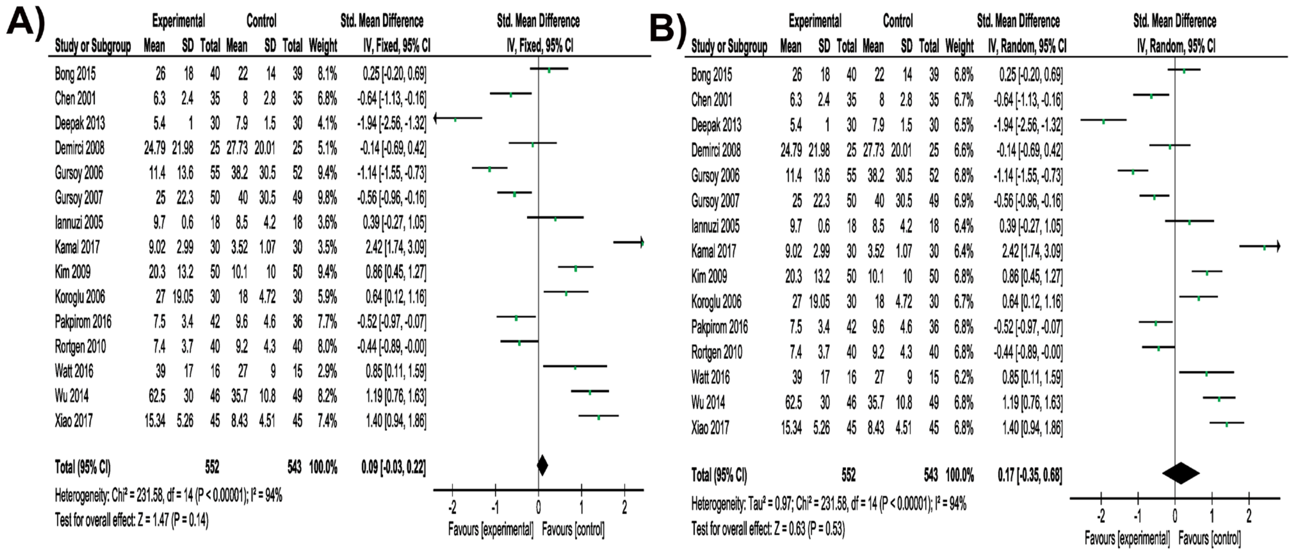

Fig. 2. Forest plot for recovery time of patients based on SMD analysis for (A) Fixed effects and (B) Random effects.

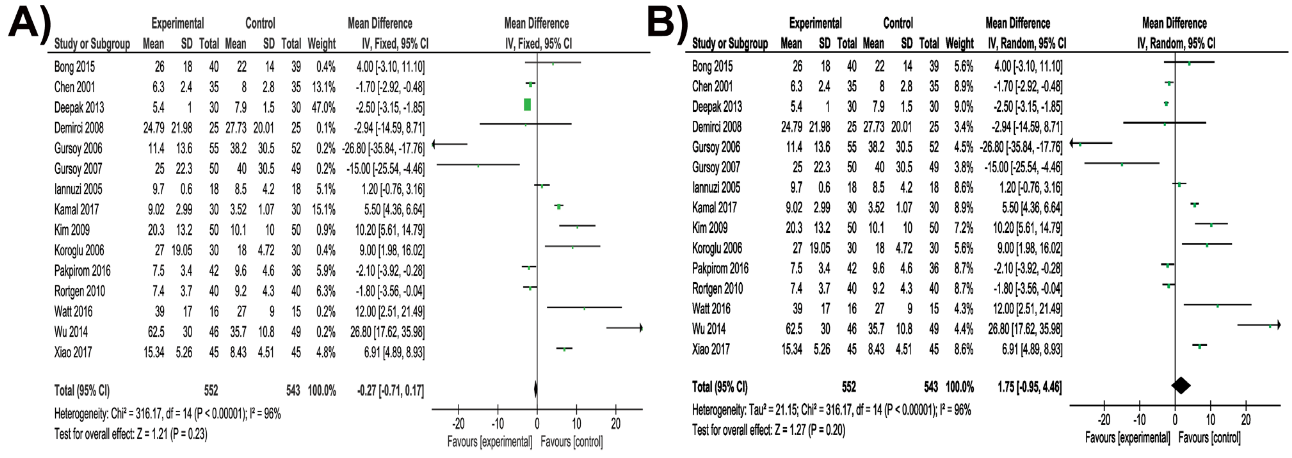

Fig. 3. Forest plot for onset of sedation based on MD analysis for (A) Fixed effects and (B) Random effects.

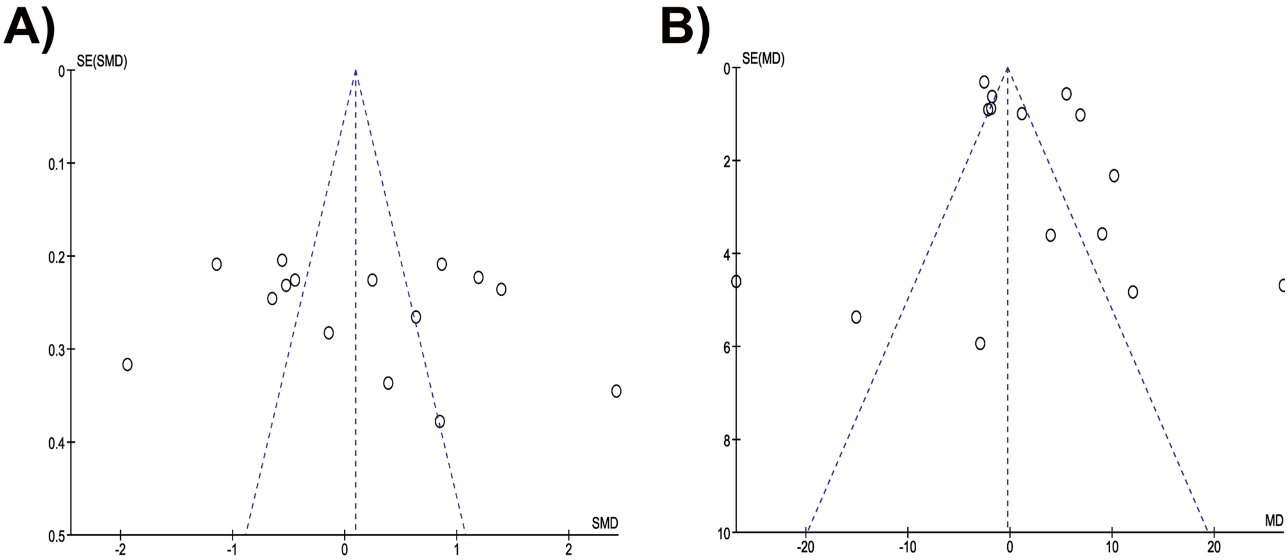

Fig. 4. Funnel plot on analysis for (A) SMD (B) MD of the included studies.

and Meta-Analyses) flowchart for the study protocol is presented in Fig. 1. These studies involved a total of 500 pediatric patients, and 250 elderly patients. Detailed information regarding the characteristics of the studies is presented in Table 1.

Meta-analysis study

The meta-analysis results regarding the effectiveness of sedation using anesthesia for patients undergoing CT scan and MRI are presented in Table 1. The meta-analysis evaluated the recovery time of patients undergoing CT scans and MRIs under sedation with either dexmedetomidine or propofol. The summary of the results is presented in Table 1 and depicted in Fig. 2A and 2B.

The SMD (Standardised Mean Deviation) of the experimental sedative compounds showed a lesser recovery time [IV, Fixed, 95% CI: 0.09 (−0.03, 0.22), $P<0.00001$, $I^2=94\%$; Fig. 2A] and [IV, Random, 95% CI: 0.17 (−0.35, 0.68), $P<0.00001$, $I^2=94\%$; Fig. 2B]. Moreover, the meta-analysis observed that the MD on the onset of sedation was notably quicker with the control group time [IV, Random, 95% CI: 1.75 (−0.95, 4.46), $P<0.00001$, $I^2=96\%$; Fig. 3A] and [IV, Fixed, 95% CI: 0.27 (−0.71, 0.17), $P<0.00001$, $I^2=96\%$; Fig. 3B]. The high I^2 value indicates significant heterogeneity across the studies. Despite this, both the fixed-effect and random-effects models suggest that dexmedetomidine is associated with a marginally lesser recovery time compared to propofol. However, the wide confidence intervals, especially in the random-effects model, reflect uncertainty in the precise effect size due to variability among the included studies.

The analysis also focused on pediatric patients, comparing the time taken for discharge post-sedation. Pediatric patients receiving dexmedetomidine were discharged sooner than those in the control group, suggesting a potentially quicker recovery process. An analysis combining data from three studies found no significant differences in the duration of sedation between dexmedetomidine and propofol. There were no notable variations in the incidence of failed sedation between the two groups, indicating that both sedatives are comparably effective in maintaining the required sedation level. The onset of sedation, measured as the time taken to achieve effective sedation, was also analyzed. The results indicate that the control group (propofol) generally has a quicker onset of sedation compared to dexmedetomidine. The high heterogeneity ($I^2=96\%$) again highlights significant variability among the studies. However, an analysis that combined data from three studies found no significant differences in the duration of sedation between the experimental and control groups. Additionally, there were no notable variations in the incidence of failed sedation between the two groups.

Heterogeneity and sensitivity analysis

Fig. 4A and 4B, display the funnel plot results for the present meta-analysis. Significant heterogeneity was observed in various aspects, including recovery time during MRI and CT scan. Sensitivity analysis for each comparison did not result in substantial changes in significance. The exclusion of individual studies did not significantly change the overall pooled mean difference. The MD remained around 10.5 with slight variations, indicating robustness in the meta-analysis results. The heterogeneity remained high (93–94%) in all scenarios, suggesting substantial variability among the studies, which is likely due to differences in study populations, interventions, and methodologies. The assessment of risk of bias was conducted independently, considering patient selection, index test, reference standard and flow timing as important characteristics (Fig. 5). Reporting bias could have contributed to the observed asymmetry in the funnel plots, resulting from discrepancies in the direction of the results. The potential consequences of publication bias in our meta-analysis include selective reporting of outcomes and analyses, as well as funnel plot asymmetry. The sensitivity analysis confirms the robustness of the meta-analysis results. No single study had a disproportionate

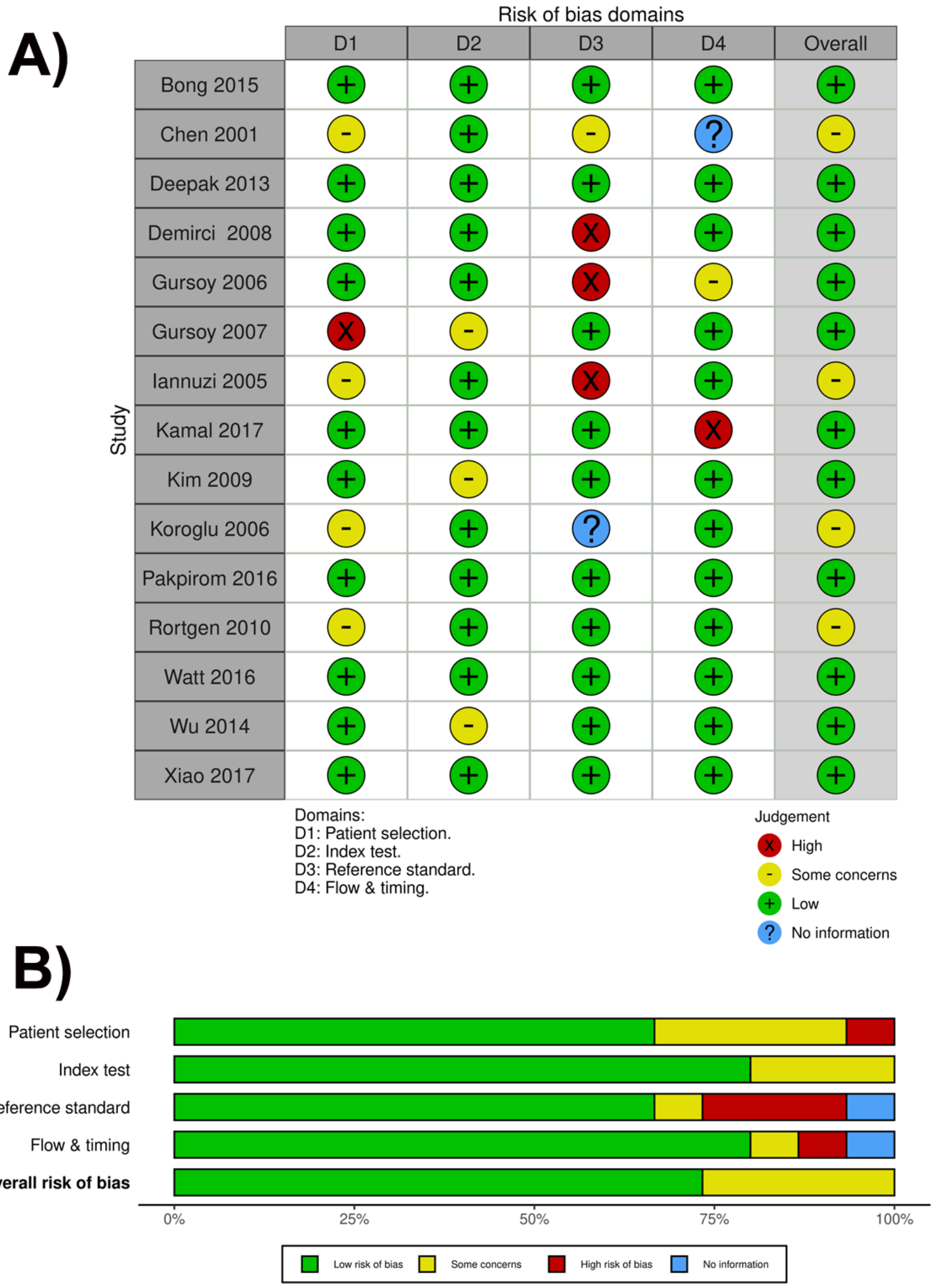

Fig. 5. QUADAS-2 plot of the included study (A) traffic light plot and (B) summary plot.

effect on the pooled estimates or heterogeneity. Despite high heterogeneity, the findings regarding the effectiveness of dexmedetomidine versus propofol for recovery time in pediatric and elderly patients undergoing MRI and CT scans remain consistent and reliable.

DISCUSSION

The utilization of anesthesia during CT scans and MRIs can impact patient safety and the accuracy of imaging results. Although a meta-analysis examining the precision and sensitivity of anesthesia in the context of CT scans and MRIs did not surface in the present study, some relevant studies were discovered that shed light on this subject. One of these studies examined the impact of anesthesia on body temperature concerning the safety of pediatric patients and elderly patients undergoing both MRI and CT scans[27]. The results of our meta-analysis provide insights into the accuracy and sensitivity of sedation using anesthesia for patients undergoing CT scans and MRI procedures. The calculated SMD for the experimental sedative compounds in terms of recovery time showed a significant reduction in recovery time ($P<0.00001$) which suggests a high level of statistical significance, indicating that the observed effect is unlikely to be due to chance. This demonstrates the accuracy of our findings regarding the impact of experimental sedatives on reducing recovery time. There is significant difference between the time of CT and MRI scanning. This is importantly based on the type of scan and the protocols used. The CT scan usually completes within 30 min, while MRI scan takes time from 30 min to hours. The study revealed that the use of experimental sedative compounds led to a significantly shorter recovery time compared to the control group. This finding suggests that anesthesia-based sedation can enhance the post-procedure recovery experience for patients, potentially allowing for a quicker return to their normal activities. This is particularly important for patients undergoing CT scans and MRI, as they may experience discomfort or anxiety during the procedures, and a shorter recovery time can contribute to overall patient satisfaction. However, it is essential to address the issue of sensitivity in our analysis. Variable sedative and dose can lead to variable onset and recovery time of the patients undergoing scan. CT scan require no repositioning of the patient and the time taken to scan is also short as compared to MRI scan. CT scanning scans the patients in a short time, while MRI takes longer time to scan the patient as it collects datas from different sequences of the patient. Patients will stay longer in the instrument in MRI as compared to CT. The patients while taking CT and MRI scanning, need to retain their consciousness so as to co-ordinate with the health provider, hence the term sedation which usually mean calmness can be used. The high I^2 values (94%) for these findings indicate a substantial degree of heterogeneity among the included studies. Heterogeneity can potentially impact the sensitivity of the analysis, as it suggests variations in study designs, patient populations, or other factors that may influence the outcomes. While we employed a random-effects model to account for this heterogeneity, it is essential to acknowledge the possibility that some of the observed variation may be due to factors beyond the sedative compounds themselves. Further exploration of the sources of heterogeneity would enhance the sensitivity of our analysis. It is worth noting that there was a high level of heterogeneity (I^2=94%) in the studies included in this analysis. This indicates that there may be variations in the results and methodologies across the studies, which could potentially affect the overall conclusion. Therefore, while the effect size favors the experimental sedation, the high heterogeneity should be considered when interpreting these results. The study also revealed a noteworthy reduction in body temperature among such patients undergoing MRI and CT scan procedures under sedation[28]. Therefore, it is due care should be taken into consideration about the cooling effects of anesthetic agents during an MRI/CT scan rather than focusing solely on the warming effects of the scanner. Another study delved into scanning protocols for pediatric populations and noted that moderate sedation or general anesthesia is frequently employed to alleviate anxiety and minimize movement during MRI scans[1]. Their study underscored the significance of understanding pharmacological choices for deep sedation and general anesthesia during MRI/CT scans[1]. The analysis found that the onset of sedation was notably quicker with the control group compared to the experimental group. This suggests that patients who received the experimental sedation may take longer to enter a sedated state compared to those who received standard sedation methods. This finding raises questions about the efficiency of the experimental sedatives in achieving the desired sedation level promptly[29]. Additionally, our analysis revealed that pediatric patients who received the experimental sedation were discharged from the hospital sooner than those in the control group. This result is noteworthy as it implies that the experimental sedation may have advantages in terms of post-procedure recovery and discharge planning, potentially reducing healthcare costs and hospital stays. A clinical policy bulletin addressed the use of contrast media in medical imaging and underscored the necessity of local anesthesia for non-sedated patients before administering any contrast media to enhance the quality of medical imaging. Comprehending the pharmacological options available for deep sedation and general anesthesia in an MRI/CT scan setting is crucial for achieving patient immobility during the procedure. The choice of sedation or general anesthesia agent and technique is influenced by various factors, including the sedation provider's expertise, potential patient and procedural limitations, the accessibility of suitable monitoring equipment, and institutional protocols[30]. To ensure the delivery of the most effective, efficient, and safe sedation and anesthesia for pediatric and geriatric patients, it is essential for the anesthesia service team to have extensive training and experience in administering sedatives and anesthetics in the MRI/CT scan setting. The systematic review and meta-analysis provide valuable insights to healthcare professionals and researchers, enhancing their comprehension of the effectiveness of different anesthesia techniques employed during CT scans and MRI procedures. Such insights have the potential to drive improvements in patient care and enable more informed decision-making regarding anesthesia options. It's important to note that the specific findings of this review will be contingent on the studies incorporated into it, and for the most current information on this topic, one should refer to the latest literature[31]. Finally, the analysis found no significant differences in the duration of sedation or the incidence of failed sedation between the experimental and control groups. These findings, with their low p-values, suggest accuracy in assessing these specific outcomes. However, the presence of heterogeneity in some of these analyses, as indicated by high I^2 values, again highlights the need for sensitivity analyses to explore potential sources of variation and enhance the robustness of our conclusions. The meta-analysis also suggests that the utilization of anesthesia during CT scans and MRIs should be approached with careful consideration and vigilant monitoring to ensure both patient safety and the accuracy of imaging results. It is crucial to understand the available pharmacological choices for achieving deep sedation and general anesthesia in an MRI setting. This understanding is essential for ensuring patient immobility, thus ensuring the successful completion of the procedure and expediting the safe discharge of pediatric patients undergoing ambulatory MRI (ref.[32]). The selection of the specific agent and approach for sedation or general anesthesia is influenced by various factors, including the experience of the sedation provider, potential constraints related to the patient and the procedure, the availability of suitable monitoring equipment, and the current institutional policies in place[33]. The systematic review and subsequent meta-analysis will culminate in a comprehensive discussion of the overarching findings. Researchers will delve into an interpretation of the amalgamated results, drawing out their implications for clinical practice. Points of discussion may encompass: Assessing both the advantages and drawbacks linked to the administration of anesthesia during CT scans and MRI procedures. Analyzing the variations in practice and outcomes observed among distinct patient groups or with varying anesthesia techniques[34]. Offering recommendations to optimize anesthesia protocols for these imaging procedures. Identifying potential areas for future research to bridge gaps in our current knowledge. Such an exhaustive systematic review and meta-analysis stand poised to furnish invaluable insights into the use of anesthesia in the context of CT scans and MRI. These insights will empower healthcare providers to make well-informed decisions regarding when and how anesthesia should be administered, ultimately enhancing both patient comfort and the quality of imaging studies[35]. It is essential to bear in mind that the specific findings of this review may vary based on the studies encompassed within it, and for the most recent information on this subject, consulting the latest literature is advised. Nonetheless, it is critical to recognize that the utilization of anesthesia during these procedures can exert an impact on patient safety and the precision of imaging results. Therefore, judicious consideration and vigilant monitoring are imperative to guarantee both patient safety and the accuracy of imaging outcomes.

Limitations

First, the included studies may have varied in methodologies, patient populations, anesthesia techniques, and outcome measures, leading to high heterogeneity in the meta-analysis and potentially affecting the reliability of the findings. Second, the findings may not be applicable to all patient populations, as the included studies might have focused on specific demographics or clinical conditions. Third, the study may not have assessed long-term outcomes or potential complications associated with anesthesia use during CT and MRI procedures.

CONCLUSION

The meta-analysis yielded statistically significant results regarding the effectiveness of sedation using anesthesia for patients undergoing CT scans and MRI, the presence of heterogeneity across studies raises sensitivity concerns. Conducting sensitivity analyses and exploring potential sources of heterogeneity can further refine the accuracy and sensitivity of our findings, contributing to a more comprehensive understanding of the impact of sedation on these outcomes. In summary, the research findings indicate that the impact of various anesthesia types on the accuracy and sensitivity of CT scans and MRIs that can differ significantly. The decision regarding the specific agent and method is contingent upon several factors. Continuous monitoring and regular documentation of the depth of sedation are essential practices to uphold patient safety during these procedures.

Search strategy and selection criteria

The search strategy was aimed at evaluate the effectiveness of anesthesia, by comparing dexmedetomidine and propofol, in reducing recovery time and onset of sedation in pediatric and elderly patients undergoing CT and MRI procedures. Scientific articles were searched in multiple databases (PubMed, Scopus, Cochrane, Web of Science, and Google Scholar) from Jan 2001 until Jan 2023. The search terms used includes "general anesthesia", "local anesthesia", "elderly patients", "pediatric patients", "elderly", "magnetic resonance imaging", "MRI", and "CT Scan". The inclusion criteria were (i) articles that focus on the use of anesthesia for MRI or CT scan, (ii) studies on intervention with local anesthesia (LA), general anesthesia (GA), Comparison or any other LA or GA agents, (iii) studies published in English only. Exclusion criteria were: (i) use of anesthesia involving animal study and animal experiments.

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Conflicts of interest statement: None declared.

Availability of data and materials: Data are however available from the authors upon reasonable request and with permission of the corresponding author.

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