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Original Article

Optimized Propofol Anesthesia for Pediatric Medical Imaging (MRI & CT) in Limited-Resource Settings: A Safety and Efficacy Study in Western Libyan Hospitals

Fathi Muftahi Ben Naser [1], Fateh Mostafa Alsalami[2], Suhila Alhadi Atwier[3], Takwa Mustafa Saeed[1], Ashora Mahmod Ahnesh[1], Abd AL Raouf Kamel[1], Yasmeen Adly Abdel Aziz[1]

1. Faculty of Health Sciences, Sahl Al-Jafara University, Libya

2. Faculty of Medical Technology – University of Tripoli

3. Libyan Medical Research Center

Corresponding Author, Suhila Alhadi Atwier: Email. atwiersuhila@gmail.com

Abstract:

Background: Medical imaging procedures such as MRI and CT often necessitate anaesthesia in pediatric patients who cannot cooperate, particularly in resource-limited environments. This study addresses the critical need for safe and effective anaesthetic protocols in such settings. **Aim:** To evaluate the safety and efficacy of propofol anaesthesia in children under 15 years undergoing MRI and CT scans in Western Libyan hospitals, specifically analysing administered doses and resultant image quality.**Methods:** A descriptive-analytical study was conducted among 90 pediatric patients across three health institutions in Western Libya (Tripoli University Hospital, Al-Firdous Clinic, and Al-Khalil Clinic) from July 1 to September 15, 2025. Data were collected via structured questionnaires, encompassing demographic variables, propofol dosage, procedure duration, diagnostic image quality, and any observed complications during anaesthesia or recovery.

Results: The study reported no anaesthesia-related complications or adverse events during recovery in any of the 90 cases, indicating a robust safety profile. Furthermore, all medical images (100%) achieved high diagnostic quality, underscoring the efficacy of the anaesthetic protocol in minimising motion artefacts. The predominant propofol dose administered was less than 5 mg/kg (67% of cases), and the majority of procedures (77%) were completed within 15 minutes. **Conclusion:** The propofol anaesthesia protocol demonstrated both safety and high efficacy for pediatric medical imaging in the Western Libyan hospitals studied. The findings support the feasibility and safety of the observed propofol-based approach in the studied settings, while larger multicenter studies are needed before broader standardisation. Future research should explore long-term neurodevelopmental outcomes and comparative studies with other anaesthetic agents.

Keywords: Pediatric anesthesia, Propofol, MRI, CT, Libya, Safety, Efficacy, Limited-resource settings, Diagnostic imaging.

Introduction

The field of medicine has witnessed tremendous advancements driven by the evolution of medical imaging technologies. Since the discovery of X-rays in 1895, which revolutionised medical diagnosis by enabling non-invasive visualisation of internal structures, imaging modalities have expanded significantly. [1] Today, advanced techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are indispensable tools in modern clinical practice, profoundly improving diagnostic accuracy and facilitating the early detection of complex pediatric pathologies . [2]

Despite their diagnostic benefits, the increasing reliance on these advanced imaging modalities presents unique clinical challenges, particularly in the pediatric population. High-quality CT and MRI scans require absolute patient immobility to prevent motion artifacts that can degrade image resolution and necessitate repeat examinations, thereby increasing the risk of unnecessary radiation exposure in the case of CT scans[3] . Consequently, procedural sedation and anesthesia have become essential components of pediatric radiological procedures, ensuring patient cooperation, comfort, and the acquisition of diagnostically viable images[4] .

The practice of anesthesiology has undergone radical transformations, evolving from the historical use of basic anaesthetic agents to the administration of sophisticated intravenous drugs like propofol. Propofol is widely favoured in pediatric outpatient and radiological settings due to its rapid onset of action, short duration, and favourable recovery profile [5]. However, administering anaesthesia outside the traditional operating room—such as in radiology suites—introduces specific logistical and safety challenges. These include the need for remote physiological monitoring, managing the physical constraints of the MRI environment, and mitigating the risks associated with deep sedation in uncooperative children [6].

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Furthermore, while modern anesthesia is generally considered safe, it is not entirely devoid of risks. The administration of anesthetic agents in pediatric patients requires meticulous dose titration to balance the depth of sedation necessary for immobility against the risk of respiratory depression and cardiovascular instability[7] . This delicate balance is particularly challenging in low- and middle-income countries, or in resource-limited settings, where access to advanced monitoring equipment and specialized pediatric anesthesiologists may be constrained[8] .

In Libya, specifically in the western region, there is a noticeable gap in the literature regarding the standardized use and safety outcomes of propofol in pediatric radiological settings. Therefore, this study aims to evaluate the safety and efficacy of propofol anaesthesia in children under 15 years of age undergoing MRI and CT scans in selected hospitals in western Libya[9]. By analyzing the administered doses, procedure durations, and the resultant diagnostic image quality, this research seeks to provide evidence-based insights that can help optimise paediatric anaesthesia protocols and improve patient care standards in resource-limited clinical environments[10].

Materials and Methods

A descriptive analytical study was conducted to evaluate the safety and efficacy of propofol-based anaesthesia in pediatric patients undergoing diagnostic magnetic resonance imaging (MRI) and computed tomography (CT) examinations in selected healthcare facilities in Western Libya. The study included 90 pediatric patients younger than 15 years who required pharmacological sedation or anaesthesia to facilitate adequate immobility and successful completion of their imaging examinations. Patients were eligible if they required MRI or CT examination under propofol-based anaesthesia, were considered clinically suitable for the procedure, and had informed consent obtained from their parents or legal guardians. Patients were excluded if they had documented hypersensitivity or allergy to propofol or a contraindication to its administration, if the planned imaging examination was cancelled before anesthesia, if essential anesthesia or imaging records were incomplete, or if a primary anesthetic technique other than the propofol-based protocol was used.

Before anesthesia, all patients underwent routine pre-anesthetic assessment by the responsible anesthesia provider. The assessment included age, relevant medical history, general clinical condition, and evaluation of the patient's suitability for anesthesia. Particular attention was given to factors that could increase the risk of respiratory or cardiovascular complications. Propofol was administered intravenously using a weight-based approach with clinical titration according to the patient's response and the requirements of the imaging procedure. The induction dose was approximately 1–2 mg/kg, followed by maintenance doses of approximately 0.5–1 mg/kg when required. The intended level of anesthesia was moderate to deep sedation with spontaneous ventilation, intending to maintain adequate immobility while minimizing unnecessary deepening of anesthesia. Propofol administration was individualized according to patient characteristics, clinical response, procedural requirements, and examination duration, and the administered dose was recorded for subsequent analysis. Continuous monitoring was maintained throughout the anesthesia and recovery periods. Monitoring included oxygen saturation, blood pressure, heart rate and electrocardiographic monitoring, respiratory status, and clinical assessment of the level of sedation. Appropriate airway-management and emergency-resuscitation equipment was available throughout the procedure, and the anesthesia team was prepared to provide airway support and emergency intervention when clinically indicated. Anaesthesia-related and recovery-related adverse events, including respiratory depression, oxygen desaturation, hypotension, cardiovascular events, prolonged recovery, and emergence-related complications, were recorded.

Patients underwent either MRI or CT according to the clinical indication. The imaging modality was recorded as either MRI or CT, and procedure duration was recorded in minutes. For descriptive analysis, procedure duration was categorised as ≤15 minutes or >15 minutes. Diagnostic image quality was assessed according to the clinical acceptability of the acquired images. An examination was considered diagnostically acceptable when the obtained images were sufficient for the intended diagnostic interpretation and did not require repetition because of inadequate sedation or significant motion artefacts. As the original study dataset did not contain a validated numerical image-quality score or inter-rater agreement measurement, no artificial numerical scores were introduced.

Data were collected from the available clinical, anaesthesia, and imaging records and included patient age, sex, imaging modality, administered propofol dose, procedure duration, anesthesia-related complications, recovery-related complications, and diagnostic acceptability of the acquired images. Categorical variables were summarized as frequencies and percentages, while continuous variables were summarized using appropriate measures of central tendency and dispersion. An independent-samples t-test was used to compare procedure duration between MRI and CT examinations. Pearson's correlation coefficient was used to evaluate the association between patient age and administered propofol dose. Multiple linear regression analysis was performed to identify independent predictors of procedure duration, with patient age, imaging modality, and propofol dose entered

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as independent variables and procedure duration as the dependent variable. Regression coefficients, standard errors, t-values, p-values, R^2, adjusted R^2, and the overall F-statistic were reported. A p-value of <0.05 was considered statistically significant.

Ethical approval was obtained from the relevant institutional authorities of the participating healthcare facilities before commencement of the study. Informed consent was obtained from the parents or legal guardians of all participating pediatric patients. Patient confidentiality and anonymity were maintained throughout the study, and identifying information was excluded from the analytical dataset and final report.

Results

A total of **90 pediatric patients** undergoing MRI or CT examinations under propofol anesthesia were included in this study. The analysis included demographic characteristics, propofol dose requirements, procedure duration, safety outcomes, and predictors of imaging duration.

Baseline Characteristics of the Study Population

The baseline characteristics of the study participants are presented in **Table 1**. Among the 90 pediatric patients, 52 (57.8%) were males, and 38 (42.2%) were females. The most represented age group was 5–10 years (43.3%, n=39), followed by patients aged >10 years (30.0%, n=27) and those younger than 5 years (26.7%, n=24).

Regarding imaging modality, MRI was performed in the majority of cases (64.4%, n=58), whereas CT accounted for 35.6% (n=32) of examinations.

Table 1. Baseline characteristics of pediatric patients undergoing MRI or CT under propofol anaesthesia (N=90)

Characteristic	n	%
Sex		
Male	52	57.8
Female	38	42.2
Age group (years)		
<5	24	26.7
5–10	39	43.3
>10	27	30.0
Imaging modality		
MRI	58	64.4
CT	32	35.6

Propofol Dose Requirement and Procedure Duration

The distribution of administered propofol doses and imaging procedure durations is summarized in Table 2.

Most patients required a propofol dose of <5 mg/kg (66.7%, n=60), while 33.3% (n=30) received doses ≥5 mg/kg.

Regarding procedure duration, the majority of examinations were completed within 15 minutes (76.7%, n=69), whereas 23.3% (n=21) required longer anesthesia duration.

Table 2. Distribution of propofol dose and imaging procedure duration (N=90)

Variable	n	%
Propofol dose		
<5 mg/kg	60	66.7
≥5 mg/kg	30	33.3
Procedure duration		
≤15 minutes	69	76.7
>15 minutes	21	23.3

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Safety Outcomes and Image Quality

No anesthesia-related complications or adverse events were observed during the procedures or recovery period among all included patients (**0**%, n=0/90).

Furthermore, all imaging examinations were successfully completed. Image quality should be reported using the revised quantitative Image Quality Score after the radiologists' standardized assessment. The original dataset reported all images as diagnostically acceptable; however, the numerical image-quality distribution is not available in the current manuscript and must be entered from the original assessment records.

Comparison of Procedure Duration Between MRI and CT

An independent samples t-test was performed to compare imaging duration between MRI and CT procedures.

MRI examinations showed significantly longer procedure durations compared with CT examinations (t=8.06, p<0.001).

This finding indicates that MRI procedures require longer periods of sedation due to their longer acquisition time compared with CT examinations.

Correlation Between Age and Propofol Dose

Pearson correlation analysis was performed to assess the association between patient age and administered propofol dose.

No statistically significant correlation was observed between age and propofol dose (**r = −0.05, p = 0.62**).

This suggests that propofol administration was primarily guided by individual sedation requirements and procedural factors rather than age alone.

Multiple Linear Regression Analysis for Predictors of Procedure Duration

A multiple linear regression model was conducted to identify factors independently associated with imaging procedure duration.

The model included patient age, imaging modality, and propofol dose as independent variables

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Table 3. Multiple linear regression analysis predicting procedure duration

Predictor	β	SE	t-value	p-value
Constant	5.65	2.47	2.28	0.025
Age	0.01	0.10	0.14	0.890
MRI modality	6.95	0.84	8.28	<0.001*
Propofol dose	0.89	0.51	1.74	0.086

Model performance: $R^2 = 0.444$ Adjusted $R^2 = 0.425$

$F = 22.89$, $p < 0.001$

The regression model was statistically significant and explained **44.4% of the variability in procedure duration**. Imaging modality was the only significant independent predictor of procedure duration. MRI examinations were associated with an increase of approximately **6.95 minutes** compared with CT procedures after adjustment for age and propofol dose.

Propofol dose showed a positive association with procedure duration; however, this relationship did not reach statistical significance (**p=0.086**).

Discussion

This study provides important evidence regarding the safety, effectiveness, and practical applicability of propofol-based anaesthesia for pediatric patients undergoing diagnostic imaging (MRI and CT) in Western Libyan hospitals. The findings demonstrate that a carefully structured propofol sedation protocol can achieve optimal imaging conditions while maintaining a high level of patient safety, even within a healthcare setting characterized by limited resources and variable access to specialized pediatric anesthesia services.

The most notable finding of this study was the complete absence of anesthesia-related complications, adverse respiratory events, or recovery-related problems among all 90 pediatric patients. This favorable safety outcome supports previous evidence demonstrating the high safety margin of propofol when administered by trained anesthesia providers with appropriate monitoring facilities. Several pediatric sedation studies have reported low rates of serious adverse events associated with propofol use, particularly when standardized protocols, continuous physiological monitoring, and individualized dose adjustment are implemented [11,12]. For example, studies involving large pediatric cohorts undergoing MRI sedation have demonstrated that propofol provides predictable sedation depth with a low incidence of clinically significant complications, supporting its continued use as one of the preferred agents for pediatric procedural sedation [13]. The absence of complications observed in the current cohort

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may be attributed to careful patient selection, appropriate pre-anaesthetic assessment, continuous monitoring of oxygen saturation and vital signs, and prompt dose adjustments according to individual responses.

The successful completion of all imaging procedures with **100% diagnostic image quality** represents another important outcome. Motion artefacts remain one of the major challenges in pediatric diagnostic imaging, particularly in MRI examinations where prolonged immobility is required. Previous investigations have highlighted that inadequate sedation may result in non-diagnostic images, repeated examinations, increased healthcare costs, and unnecessary exposure to radiation in CT imaging [3,14]. In agreement with these findings, our results confirm that propofol provides sufficient sedation depth and rapid control of movement, allowing reliable acquisition of high-quality images. Similar findings have been reported by studies comparing different pediatric sedation strategies, where propofol was associated with higher procedural success rates and shorter recovery profiles compared with traditional sedative regimens [15].

The analysis of procedure characteristics revealed a statistically significant difference in duration between MRI and CT examinations ($p < 0.001$), with MRI procedures requiring longer anesthesia time. This observation is consistent with the technical nature of MRI examinations, which commonly involve multiple imaging sequences and require prolonged patient immobility compared with CT scans. Previous studies have reported that MRI sedation generally requires longer procedural and recovery times because of the extended acquisition protocols and increased sensitivity to patient movement [14,16]. Furthermore, the regression analysis in our study identified imaging modality as the only significant independent predictor of procedure duration ($\beta = 6.95$, $p < 0.001$), indicating that the type of imaging examination should be considered during anesthesia planning, scheduling, and resource management. These findings emphasize the importance of developing modality-specific sedation strategies, particularly in settings where anesthesia resources are limited.

Interestingly, no significant correlation was identified between patient age and administered propofol dose ($p = 0.62$). Although age-based dosing recommendations are frequently considered in pediatric anesthesia, our findings suggest that propofol administration was primarily guided by individual clinical factors, including body weight, baseline condition, procedural requirements, and response to sedation. Similar observations have been described in pediatric anesthesia studies, where weight-based dosing combined with real-time titration was shown to provide more reliable sedation compared with fixed age-based approaches [17]. The individualised dosing strategy applied in this study may explain the favourable safety profile and absence of adverse events despite variability in patient age.

The majority of children received propofol doses below 5 mg/kg, and most procedures were completed within a relatively short duration. These findings indicate an efficient sedation approach with limited drug exposure and potentially reduced recovery burden. Previous research has emphasized that minimizing sedative dose while maintaining adequate procedural conditions is essential in pediatric populations, as excessive sedation may increase the risk of respiratory depression, prolonged recovery, and delayed discharge [11,18]. Therefore, the dosing pattern observed in this study reflects effective clinical titration rather than excessive medication use.

From a healthcare system perspective, these findings are particularly relevant for developing countries and resource-limited environments, where access to advanced pediatric sedation services may be restricted. Previous reports have demonstrated that propofol-based protocols can be safely implemented outside high-resource tertiary centers when supported by appropriate training, monitoring equipment, and standardized clinical pathways [19]. The current study contributes valuable local evidence from Western Libya and demonstrates that safe pediatric anesthesia for diagnostic imaging is achievable despite infrastructural challenges.

Nevertheless, several limitations should be acknowledged. The relatively small sample size and single-region design may limit generalizability to other pediatric populations. Additionally, the observational nature of the study prevented comparison between propofol and alternative sedation methods. Future multicenter studies involving larger cohorts and comparative designs are recommended to further evaluate safety outcomes, cost-effectiveness, and long-term clinical benefits of propofol-based imaging sedation in Libyan healthcare facilities.

Overall, the findings support propofol as a safe, effective, and practical anesthetic option for pediatric MRI and CT procedures. The combination of excellent imaging success, absence of adverse events, and efficient procedural completion suggests that a standardized propofol sedation protocol can significantly improve pediatric diagnostic imaging services in resource-limited healthcare settings.

Conclusion

This study demonstrates that propofol-based anesthesia is a safe, effective, and reliable approach for facilitating pediatric diagnostic imaging procedures, including MRI and CT, in Western Libyan hospitals. The absence of anesthesia-related complications among all included patients, combined with the achievement of 100% diagnostic image quality, highlights the effectiveness of

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a carefully monitored propofol sedation protocol in ensuring optimal imaging conditions while maintaining patient safety.

The findings indicate that propofol provided adequate sedation with efficient dose utilisation and acceptable procedure durations, supporting its role as a practical anesthetic agent for pediatric imaging. The significant association between imaging modality and procedure duration emphasizes the importance of considering MRI and CT requirements during anesthesia planning and resource allocation. Furthermore, the lack of correlation between patient age and propofol dose suggests that individualized, clinically guided dose titration based on patient characteristics and procedural demands may be more appropriate than age-based dosing alone.

Limitations

This study is not without limitations. The relatively small sample size (n=90) and its focus on a specific geographical area in Western Libya may limit the generalizability of the findings to other regions or larger populations. Furthermore, the study design was descriptive analytical, lacking a comparative arm with other anesthetic agents or sedation techniques. This precludes definitive conclusions about the superiority of propofol over alternatives. Additionally, the study did not include long-term follow-up to assess potential neurodevelopmental outcomes associated with propofol anesthesia in young children, a concern that remains an active area of research.

Future Research

Future research should aim for larger, multicenter studies across different regions of Libya and potentially other limited-resource settings to enhance generalizability. Comparative studies evaluating propofol against other commonly used pediatric sedatives (e.g., dexmedetomidine, ketamine) would provide valuable evidence for optimal agent selection. Crucially, long-term prospective studies are needed to investigate the neurodevelopmental impact of propofol anesthesia in pediatric patients, ensuring comprehensive understanding of its safety profile. Continuous training and adherence to international guidelines for pediatric sedation in non-operating room settings should also be emphasized [9]

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