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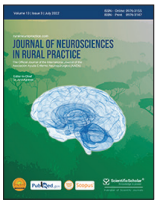
Journal of Neurosciences in Rural Practice

Article in Press



Original Article

Adverse events and sedation characteristics of propofol and dexmedetomidine during magnetic resonance imaging: An observational study in neuropsychiatric population

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ABSTRACT

Objectives: Propofol and dexmedetomidine are the most commonly used sedative drugs during magnetic resonance imaging (MRI) studies. However, data regarding peri-procedural adverse events, and the profile of these drugs concerning the quality of sedation, imaging, and recovery is limited in neurological and psychiatric populations. This study aimed to compare adverse events and sedation characteristics of propofol and dexmedetomidine during MRI studies in patients with neurological and psychiatric illnesses.

Materials and Methods: This prospective observational study was conducted between March 2020 and September 2021 after the Ethics Committee's approval and informed consent. Patients of all ages and genders undergoing elective MRI studies for neurological, neurosurgical, or psychiatric illness under sedation with either dexmedetomidine or propofol infusion were included in the study.

Results: The patients in the dexmedetomidine group were older, had higher body mass index, and had more pre-procedure risk factors than the propofol group. Pre-medication use (midazolam or ketamine) was more in the propofol group. There was no difference in respiratory adverse events, but cardiovascular events (bradycardia and hypotension) were more with dexmedetomidine. There was no difference in the quality of sedation (patient movement, image quality, and need for repeating the imaging sequence). Recovery time from anesthesia was faster, and Aldrete score and Observer Assessment of Alertness/Sedation Scale scores in the post-anesthesia care unit were higher with propofol.

Conclusion: Cardiovascular but not respiratory adverse events were more with dexmedetomidine, recovery profile was better with propofol, and both the drugs were similar regarding the quality of sedation and images in neurological and psychiatric patients undergoing MRI study.

Keywords: Adverse events, Dexmedetomidine, Magnetic resonance imaging, Propofol, Recovery, Sedation

INTRODUCTION

A substantial proportion of patients undergoing magnetic resonance imaging (MRI) studies require sedation or anesthesia for successful completion. The reasons mostly are poor tolerance to noisy and claustrophobic MRI environment, cognitive impairment from neurological pathologies or psychiatric illness, inability to lie still due to discomfort or pain, and uncooperativeness in children and adults.[1] Adequate depth of sedation is needed to facilitate the completion of MRI sequences without patient movement, distortion of image quality, need for repeat imaging, wastage of time and resources, and to ensure patient safety during the procedure. Various sedative and anesthetic drugs are used in clinical practice for MRI study, either as intermittent boluses or continuous infusion, alone or as a combination, while preserving spontaneous respiration without an artificial airway. Among the different drugs, propofol and dexmedetomidine are the two most common sedative agents used for this purpose.[2,3] These drugs can lead to cardiorespiratory adverse events such as bradycardia, hypotension, arrhythmia, apnea, respiratory depression, airway obstruction, desaturation, and the need for the placement of an artificial airway.[4] It is currently not established in large prospective studies if a particular anesthetic technique increases the risk of adverse events in the neuropsychiatric population.[5,6] Moreover, ambiguity exists regarding which of the two is better with regard to the quality of sedation and recovery profile, appropriate for MRI study in this vulnerable population. Hence, there is a need

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Received: 17 January 2024 **Accepted:** 14 May 2024 **Epub ahead of print:** 28 June 2024 **Published:** XXXX **DOI:** 10.25259/JNRP_20_2024

to conduct a comparative analysis between propofol and dexmedetomidine regarding safety and effectiveness.

The primary objective of this study was to evaluate the incidence of adverse events during an MRI study with propofol and dexmedetomidine sedation in patients with neurological, neurosurgical, and psychiatric diseases. Our secondary objectives were to compare the quality of sedation and images and the impact of dexmedetomidine versus propofol sedation on the recovery profile after an MRI study.

MATERIALS AND METHODS

This prospective observational study was conducted at an academic neurosciences and psychiatry hospital after obtaining approval from the Institute Ethics Committee (NO. NIMHANS/DO/IEC (BS and NS DIV)/2019–2020, dated January 27, 2020) and written informed consent. We included patients of all ages and genders scheduled for elective MRI study under sedation or general anesthesia for their neurological, neurosurgical, or psychiatric illness between March 2020 and September 2021. We excluded patients if no consent was available, if the artificial airway was *in situ* with or without mechanical ventilation before the MRI study, or if the MRI was performed without sedation or anesthesia.

The following data were collected: age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status grade, admitting specialty (neurology, neurosurgery, or psychiatry), clinical diagnosis, body part scanned during MRI study (brain, spine, or both), drugs used for pre-medication, bolus and maintenance drugs used for sedation during MRI study, Observer's Assessment of Alertness/Sedation scale (OAAS) score after induction of and recovery from sedation, duration of sedation for MRI study, and any drug-related adverse events. We also extracted data regarding the number of pre-anesthetic risk factors documented in the anesthesia records, which included extremes of age, history of obstructive sleep apnea, presence of hyper- or hypotension, diabetes mellitus, congenital heart disease, abnormal electrocardiogram, respiratory tract infection, asthma, chronic obstructive pulmonary disease, fever, drug allergy, electrolyte imbalance, altered liver and renal function tests, and abnormal consciousness. The choice of sedation or anesthesia technique was at the discretion of the attending anesthesiologist.

The adverse events were pre-defined for this study as follows:

- Bradycardia – decrease in heart rate <20% of baseline value
- Hypotension – systolic blood pressure <20% of baseline value
- Cardiac arrest – asystole on multi-parameter patient monitor
- Arrhythmia – new-onset rhythm changes on electrocardiogram on multi-parameter monitor
- Desaturation – decrease in peripheral oxygen saturation >10% of baseline
- Apnea – cessation of breathing for >15 s
- Airway obstruction – abnormal chest movement with decreased airflow necessitating airway maneuver (head repositioning or artificial airway placement)
- Aspiration – the presence of gastric contents in the airway with desaturation
- Laryngospasm – reduced chest movement with decreased airflow and inspiratory stridor
- Bronchospasm – decreased chest movement and airflow with expiratory rhonchi
- Allergic reaction – redness or swelling at the injection site, anaphylaxis (hemodynamic instability, bronchospasm, and generalized rashes after drug administration)
- Significant change in temperature – temperature change of >1% on either side of the baseline value after completion of MRI study
- Delayed recovery – time taken for sensorium to attain pre-sedation state is >30 min.

The details regarding the quality of sedation, images, and recovery were also obtained. The quality of sedation was assessed by patient movement and the need for repeating the MRI sequence. An independent radiologist assessed the quality of MRI images obtained using a Likert score (1 = very low quality to 5 = excellent quality). The recovery characteristics were assessed using the time to awakening (minutes), OAAS score at recovery, duration of stay in post-anesthesia care unit (PACU) in minutes, and PACU discharge Aldrete score.

Based on a previous study that compared airway adverse events between propofol and dexmedetomidine,[2] the sample size for this study was determined to be 733. This sample was based on the incidence of airway obstruction of 8% in the propofol group and 5% in the dexmedetomidine group. With an expected response rate of 50% and after applying continuity correction, we calculated that our study would require a sample size of at least 333 for the dexmedetomidine group and 400 for the propofol group (i.e., a total sample size of 733; to ensure that the reference group is 1.2 times larger than the test group) to achieve a power of 80% and a level of significance of 5%, for declaring that the one drug is superior to other at a −10% margin of superiority. Since we planned to assess other adverse events and to cater to our secondary outcomes, we inflated the sample size by 20%. We thus planned to recruit at least 880 patients during the 18-month study period.

The interval and ordinal scale variables are represented as median (interquartile range) or mean and standard deviation, while nominal variables are presented as frequencies and percentages. The data was analyzed using the Mann–Whitney

U-test for ordinal or interval scale variables and the Chi-square test for nominal variables. $P < 0.05$ was taken as the level of statistical significance. The statistical analysis was performed using R software version 4.1.2.

RESULTS

A total of 888 patients underwent an MRI study during the study period with dexmedetomidine (n = 398) and propofol (n = 490) as the primary drug for providing sedation. The patients in the propofol group were younger, with lower BMI, and had fewer risk factors (0.6 ± 0.8 vs. 0.9 ± 0.9) than those in the dexmedetomidine group. There was no difference concerning ASA physical status grade, gender, diagnosis or body part scanned during the MRI study [Table 1]. More patients in the propofol group received pre-medication 273 (55.71%) versus 172 (43.22%) with either midazolam or ketamine bolus as compared to the dexmedetomidine group in the pre-procedure holding area. Patients in both groups received a bolus dose of their respective drug before starting the continuous infusion with a compatible syringe pump in the MRI gantry. However, a few patients in both groups also received ketamine bolus before starting either dexmedetomidine or propofol infusion for the MRI study. There was no difference in OAAS score after induction of sedation (median 2 in all patients in both the groups) or duration of MRI study (median 50 min) [Table 2]. The details regarding adverse events in both groups are shown in Table 3. The respiratory adverse events (number of oxygen desaturation episodes, duration of oxygen desaturation episodes, number of apnea episodes, need for airway intervention, and number of airway interventions needed) were similar in both groups. The cardiovascular adverse

Table 1: Demographic characteristics of patients in both groups. Values are expressed as median (interquartile range) or as number (percentage).

Variable	Levels	Dexmedetomidine (n=398)	Propofol (n=490)	P-value
Age (years)	-	22.5 (5–47)	6 (2.8–14)	<0.001
BMI (kg/m^2)	-	19.4 (13.5–22.1)	15.1 (11.7–19.2)	<0.001
ASA physical status grade	-	2 (2–2)	2 (2–2)	0.063
Number of risk factors	-	1 (0–1)	1 (0–1)	<0.001
Female gender (%)	-	164 (41.21)	189 (38.57)	0.466
Admitting department (%)	Neurology	283 (71.11)	319 (65.1)	0.128
	Neurosurgery	91 (22.86)	141 (28.78)	
	Psychiatry	24 (6.03)	30 (6.12)	
Body part scanned during MRI study (%)	Both	64 (16.08)	76 (15.51)	0.271
	Brain	326 (81.91)	395 (80.61)	
	Spine	8 (2.01)	19 (3.88)	

BMI: Body mass index, ASA: American Society of Anesthesiologists; MRI: Magnetic resonance imaging

Table 2: Comparison between two groups with regard to pre-medication and sedation characteristics during MRI study. Values are expressed as median (interquartile range) or as number (percentage).

Variable	Levels	Dexmedetomidine (n=398)	Propofol (n=490)	P-value
Use of pre-medication (%)	No	226 (56.78)	217 (44.29)	<0.001
	Yes	172 (43.22)	273 (55.71)	
Midazolam pre-medication (%)	No	246 (61.81)	267 (54.49)	<0.001
	Yes	152 (38.19)	223 (45.51)	
Ketamine pre-medication (%)	No	366 (91.96)	415 (84.69)	0.001
	Yes	32 (8.04)	75 (15.31)	
Triclofos pre-medication (%)	No	398 (100)	487 (99.39)	0.326
	Yes	0 (0)	3 (0.61)	
Bolus sedation used (%)	None	16 (4.02)	16 (3.27)	<0.001
	Dexmedetomidine	268 (67.34)	2 (0.41)	
	Ketamine	25 (6.28)	28 (5.71)	
	Propofol	89 (22.36)	444 (90.61)	
OAAS score after induction	-	2 (2–2)	2 (2–2)	0.454
Duration of sedation (minutes)	-	50 (45–60)	50 (45–60)	0.574

OAAS: Observer's assessment of alertness/sedation scale, MRI: Magnetic resonance imaging

Table 3: Comparison of adverse events in both groups. Values are expressed as median (interquartile range) or as number (percentage).

Variable	Levels	Dexmedetomidine (*n*=398)	Propofol (*n*=490)	*P*-value
Adverse respiratory event (%)	No	371 (93.22)	455 (92.86)	0.939
	Yes	27 (6.78)	35 (7.14)	
Type of respiratory event (%)	Airway obstruction	17 (4.27)	29 (5.92)	0.516
	Airway obstruction, desaturation	6 (1.51)	3 (0.61)	
	Airway obstruction, desaturation, apnea	0 (0)	1 (0.2)	
	Airway obstruction, desaturation, inadequate depth	1 (0.25)	0 (0)	
	Desaturation	1 (0.25)	1 (0.2)	
	desaturation, bronchospasm/ laryngospasm	1 (0.25)	0 (0)	
	Inadequate depth	1 (0.25)	1 (0.2)	
	None	371 (93.22)	455 (92.86)	
Number of oxygen desaturation episodes	-	0 (0–0)	0 (0–0)	0.355
Duration of oxygen desaturation episodes (min)	-	0 (0–0)	0 (0–0)	0.352
Number of apnea episodes	-	0 (0–0)	0 (0–0)	0.369
Need for airway intervention (%)	No	359 (90.2)	432 (88.16)	0.390
	Yes	39 (9.8)	58 (11.84)	
Number of airway interventions	-	0 (0–0)	0 (0–0)	0.854
Adverse cardiovascular event (%)	No	364 (91.46)	490 (100)	<0.001
	Yes	34 (8.54)	0 (0)	
Type of cardiovascular event (%)	Bradycardia	27 (6.78)	0 (0)	<0.001
	Bradycardia and hypotension	6 (1.51)	0 (0)	
	Hypotension	1 (0.25)	0 (0)	
	None	364 (91.46)	489 (99.8)	
	Wide QRS on electrocardiogram	0 (0)	1 (0.2)	
Presence of hypotension episode (%)	No	391 (98.24)	490 (100)	0.01
	Yes	7 (1.76)	0 (0)	
Presence of bradycardia episode (%)	No	365 (91.71)	490 (100)	<0.001
	Yes	33 (8.29)	0 (0)	
Hypotension requiring intervention (%)	No	391 (98.24)	490 (100)	0.010
	Yes	7 (1.76)	0 (0)	
Bradycardia requiring intervention (%)	No	397 (99.75)	490 (100)	0.917
	Yes	1 (0.25)	0 (0)	
Post-procedure skin temperature (°F)	-	97.8 (97.3–98.2)	97.5 (96.8–98)	<0.001
A significant change in skin temperature (by 1%) from baseline (%)	Increase	3 (0.75)	7 (1.43)	0.482
	Decrease	26 (6.53)	26 (5.31)	
	No change	369 (92.71)	457 (93.27)	

events were more in the dexmedetomidine group when compared to the propofol group. Bradycardia, hypotension, and hypotension requiring intervention were significantly more likely with dexmedetomidine. The post-MRI temperature was significantly lower (statistically but not clinically) with propofol compared to dexmedetomidine. However, there was no difference between the two groups regarding significant (>1%) change in skin temperature on either side of the baseline (increase or decrease after MRI study). The quality of sedation assessed by movement during MRI, number of movements, number of sequences repeated, and image quality score were similar with both drugs [Table 4]. The recovery profile after sedation was better with propofol compared to dexmedetomidine based on time to recovery, OAAS score at recovery (4.9 ± 0.3 vs. 4.8 ± 0.4), and PACU discharge Aldrete score (9.8 ± 0.5 vs. 9.7 ± 0.7) while the duration of PACU stay was similar between both the groups [Table 5].

Table 4: Comparison of quality of sedation between the two groups. Values are expressed as median (interquartile range) or as number (percentage).

Variable	Levels	Dexmedetomidine (*n*=398)	Propofol (*n*=490)	*P*-value
Movement during MRI (%)	No	315 (79.15)	387 (78.98)	1.000
	Yes	83 (20.85)	103 (21.02)	
Number of movements	-	0 (0–0)	0 (0–0)	0.810
Number of sequences repeated	-	0 (0–0)	0 (0–0)	0.348
Image quality score	-	4 (4–5)	4 (4–5)	0.438

MRI: Magnetic resonance imaging

Table 5: Comparison of post-sedation recovery characteristics between the two groups. Values are expressed as median (interquartile range).

Variable	Dexmedetomidine (*n*=398)	Propofol (*n*=490)	*P*-value
Time to recovery (minutes)	15 (10–16)	12 (10–15)	<0.001
OAAS score at recovery	5 (5–5)	5 (5–5)	0.001
Duration of PACU stay (minutes)	40 (35–45)	40 (35–45)	0.262
PACU discharge Aldrete score	10 (10–10)	10 (10–10)	<0.001

OASS: Observer's assessment of alertness/sedation scale, PACU: Post-anesthesia care unit

DISCUSSION

The recovery from sedation/anesthesia for an MRI study is critical as often this procedure is performed as a daycare diagnostic procedure. Neurological and psychiatric patients are likely to have disturbances in consciousness or are sensitive to the sedative effects of these drugs. Therefore, the effect of sedative drugs on induction and recovery after MRI in this population can be exaggerated or unpredictable. We observed a faster recovery and higher OAAS and Aldrete scores at PACU discharge with propofol compared to dexmedetomidine with a comparable duration of sedation and PACU stay. Earlier studies have also documented shorter sedation onset and faster recovery with propofol compared to dexmedetomidine.[7-10] Comparable duration of sedation in both dexmedetomidine and propofol groups similar to our findings was observed in earlier studies as well.[7,10] Unlike our study, previous studies noted faster discharge with propofol.[8,10] A recent study observed that emergence delirium (ED) was less when dexmedetomidine was used as compared to propofol.[11] In contrast, a meta-analysis of five trials involving 337 children observed a higher incidence of ED and delayed recovery with dexmedetomidine than propofol.[12] Another recent meta-analysis (six studies, 368 patients) also observed reduced ED and shorter induction and recovery times with propofol than dexmedetomidine but similar study duration in children undergoing MRI.[13] These findings were reiterated in another meta-analysis of six trials involving 415 children.[10] The ED scores were not assessed in our study.

The quality of sedation is important in spontaneously breathing patients undergoing MRI study. Good-quality sedation prevents patient movement, reduces the need for repeating MRI sequences, and minimizes the occurrence of poor image quality. Patient movement necessitating rescue sedation supplementation was less with dexmedetomidine than with propofol sedation.[11] The patient movement necessitated the repetition of MRI sequences to overcome motion-induced image degradation and the overall quality of MRI images was similar between dexmedetomidine and propofol in our study. This finding was observed in an earlier study as well.[13]

Dexmedetomidine is known to cause bradycardia and hypotension in clinical doses. We observed more bradycardia and hypotension with dexmedetomidine compared to propofol. Similar to our observation, a decrease in heart rate was documented with dexmedetomidine in an earlier study.[14] Still, in contrast to our findings, a significant decrease in blood pressure occurred with propofol. Unlike our observations, hypotension (59% vs. 4%) and bradycardia (2.9% vs. 0.6%) were more with propofol than dexmedetomidine in a retrospective study.[9] Another study also noted lower blood pressure during sedation with propofol compared to dexmedetomidine.[8] This variability could be due to the differences in the dosage of both the drugs and the type of pre-medication used in different studies. Most patients in our study population received dexmedetomidine at 1–2 μg/kg/h and propofol at 2–3 mg/kg/h, though this varied as per the needs of individual patients.

Dexmedetomidine is known to preserve spontaneous respiration better than propofol. In our study, we observed similar incidences of respiratory adverse events with propofol and dexmedetomidine. An earlier study[2] documented similar airway dimensions during sedation with dexmedetomidine and propofol at most measured places, which may explain the lack of difference in adverse respiratory events of airway obstruction between the two

groups in our study. In contrast, increased respiratory adverse events, including the requirement of an artificial airway and additional airway maneuvers, were documented with propofol in other studies.[8,10,14] The difference in the findings could be due to the dissimilarity in the doses of the sedative agents used, primary pathology, speed of drug administration, and susceptibility of patients to sedative drug effects.

A decrease in temperature is expected in patients undergoing MRI study due to cold environment, use of sedation, and inability to warm the patients actively. However, about 0.24°C–0.5°C mean increase in core temperature was noted in previous studies due to the offsetting of heat loss by absorption of radiofrequency radiation generated from the MRI scanner.[15,16] In contrast, other studies observed a decrease in core temperature by about 0.28°C–1°C and a significant correlation between the duration of the MRI study and the decrease in temperature.[17,18] We did not observe a significant change in temperature before and after MRI in both groups in the majority of the patients, though both increases and decreases in temperature were noted in a few patients in both groups. No previous studies compared temperature changes with dexmedetomidine and propofol in patients undergoing MRI.

The strengths of our study include the prospective nature of data collection and large sample size, which is necessary when observing low incidence rates of adverse events. Furthermore, this is the only large study to evaluate two commonly used sedation techniques in neurological and psychiatric populations. The study, however, has significant limitations. First, being an observational study, there was no control over the dose, rate, and timing of administration of the two study drugs, all of which can influence the outcome parameters that we studied. Second, the single institutional study nature may restrict extrapolating our findings to other settings. Third, different drugs were used for pre-medication before dexmedetomidine or propofol infusion for the MRI study. These could have influenced the adverse events, recovery, and quality of sedation. Fourth, unlike previous studies involving only children, our study population included patients of all ages who required sedation for MRI study. A more homogeneous study population would have helped identify age-specific adverse events of these drugs. Finally, many other sedation techniques are adopted by anesthesiologists for MRI studies. The findings of our study involving two drugs may not be generalizable when other drugs for sedation/anesthesia are used.

CONCLUSION

This study provides valuable evidence for the safety and efficacy of both propofol and dexmedetomidine for sedation during MRI in neurological and psychiatric patients. Propofol appears to have advantages in terms of fewer cardiovascular adverse events and faster recovery, while dexmedetomidine may be preferable for patients with a higher risk of respiratory complications. The choice of drug should be individualized based on the patient.

Ethical approval

The research/study approved by the Institutional Review Board at the National Institute of Mental Health and Neurosciences, number NO. NIMHANS/DO/IEC (BS and NS DIV)/2019-2020, dated January 27, 2020.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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How to cite this article: Narayanan S, Kamath S, Chakrabarti D. Adverse events and sedation characteristics of propofol and dexmedetomidine during magnetic resonance imaging: An observational study in neuropsychiatric population. J Neurosci Rural Pract. doi: 10.25259/JNRP_20_2024