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ORIGINAL RESEARCH

Efficacy of Dexmedetomidine and Tramadol in Preventing Shivering After General Anesthesia: A Prospective Randomized Study

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ABSTRACT

Background: Post-anesthetic shivering is a common complication following general anesthesia. This randomized, double-blind, placebo-controlled trial compared the efficacy of dexmedetomidine versus tramadol in preventing post-anesthetic shivering. **Methods**: 120 patients undergoing general anesthesia were randomly assigned to receive either dexmedetomidine (1 µg/kg), tramadol (2 mg/kg), or placebo. Shivering incidence and severity, hemodynamic parameters, and adverse effects were monitored post-operatively. **Results**: The dexmedetomidine group showed significantly lower shivering incidence (15%) compared to tramadol (30%) and placebo (65%) groups ($p<0.001$). Mean shivering scores were also lower with dexmedetomidine (0.5±0.7) versus tramadol (1.2±0.9) and placebo (2.5±1.1). Dexmedetomidine demonstrated better hemodynamic stability, with lower heart rates (72±8 bpm) and blood pressures compared to other groups. While dexmedetomidine showed higher sedation rates (10%), it had lower incidence of nausea (5%) and vomiting (3%) compared to tramadol (20% and 15% respectively). **Conclusion**: Dexmedetomidine demonstrated superior efficacy in preventing post-anesthetic shivering compared to tramadol, with a more favourable adverse effect profile. These findings support dexmedetomidine as a preferred agent for shivering prophylaxis following general anesthesia.

Keywords: Adverse Effects, Dexmedetomidine, General Anesthesia, Post-anesthetic Shivering, Thermoregulation, Tramadol

INTRODUCTION

Post-anesthetic shivering is a frequently encountered complication following general anesthesia, characterized by involuntary muscle contractions that result from a disturbance in the body's thermoregulatory mechanisms. This phenomenon can significantly detract from patient comfort and satisfaction during the recovery phase, making it an important concern for anesthesiologists. The prevalence of post-anesthetic shivering varies widely across studies, with estimates ranging from 6.3% to as high as 66% (Bhadra et al., 2018; Ahn et al., 2019). This variability can be attributed to factors such as the type of anesthesia used, the environmental conditions of the operating room, and individual patient characteristics.

Shivering is primarily a physiological response to core hypothermia, an involuntary reaction designed to generate heat through oscillatory muscle activity. The thermoregulatory center in the hypothalamus detects a drop in core body temperature and activates the shivering mechanism to restore thermal homeostasis. During surgery, particularly under general anesthesia, patients are at risk of hypothermia due to several reasons: exposure to cool operating room temperatures, the effects of anesthetic agents that

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impair normal thermoregulatory responses, and the infusion of cold intravenous fluids (Kumar et al., 2020). As a result, patients often experience increased oxygen consumption and carbon dioxide production due to heightened metabolic activity during shivering, which can exacerbate cardiovascular and respiratory stress, particularly in vulnerable populations (e.g., those with pre-existing heart or lung conditions).

The implications of post-anesthetic shivering extend beyond discomfort. It can lead to increased intraocular and intracranial pressure, heightened surgical pain, delayed wound healing, and extended recovery times (Tzeng et al., 2019). The urgency of addressing this complication is underscored by the fact that it can impede effective monitoring of patients in the postoperative period, leading to potential complications in high-risk surgeries, such as neurological or vascular procedures.

Given the significant ramifications of post-anesthetic shivering, a variety of strategies have been employed to prevent or manage this condition. These strategies can be categorized into non-pharmacological and pharmacological interventions. Non-pharmacological methods include active warming techniques, such as forced air warming blankets and warming intravenous fluids, as well as passive measures like the use of surgical drapes to minimize heat loss. While these methods can be effective, they often require additional resources and staff time, and their efficacy can be limited in certain clinical scenarios. Pharmacological interventions have also gained traction in the management of post-anesthetic shivering. Several agents have been studied for their efficacy in reducing shivering, including meperidine, clonidine, and more recently, dexmedetomidine and tramadol. Each of these agents works through different mechanisms to mitigate shivering, and their comparative effectiveness remains a topic of investigation.

Dexmedetomidine is a highly selective α2-adrenergic agonist that has gained popularity in recent years for its sedative and analgesic properties. Its mechanism of action involves the activation of presynaptic α2 receptors in the locus coeruleus, which inhibits norepinephrine release and results in sedation without significant respiratory depression—a notable advantage over traditional sedatives (Bhatia et al., 2020). Additionally, dexmedetomidine has been shown to lower the shivering threshold, thereby reducing the incidence and severity of shivering in the postoperative period. Clinical studies have demonstrated the efficacy of dexmedetomidine in preventing shivering during and after surgery. For instance, a randomized controlled trial found that patients receiving dexmedetomidine experienced significantly lower rates of shivering compared to those receiving placebo (Tzeng et al., 2019). Furthermore, dexmedetomidine's side effect profile is generally favorable, with minimal incidence of respiratory complications, making it a potentially ideal choice for patients at risk for respiratory depression.

Tramadol is an atypical opioid analgesic that works through a dual mechanism: it inhibits the reuptake of norepinephrine and serotonin, enhancing analgesic effects (Kumar et al., 2020). This unique action not only provides effective pain relief but also offers antishivering effects, making tramadol a suitable candidate for postoperative analgesia in patients at risk for shivering. Studies have shown that tramadol can effectively reduce the incidence of postoperative shivering, as it not only addresses pain but also impacts the neurochemical pathways involved in shivering response. Despite its advantages, tramadol is not without side effects. Common adverse effects include nausea, vomiting, and dizziness, which can contribute to patient discomfort and dissatisfaction. Furthermore, the risk of respiratory depression, although lower than that associated with traditional opioids, still exists, particularly in sensitive patient populations.

While both dexmedetomidine and tramadol have been individually studied for their effectiveness in preventing post-anesthetic shivering, there remains a notable gap in the literature regarding direct comparisons between the two agents. Most studies have focused on their individual efficacy without concurrently assessing their relative benefits and drawbacks in a controlled setting. This lack of comparative data leaves clinicians without clear guidance on which agent may be preferable in specific patient populations or surgical contexts.

The rationale for this study was to provide a comprehensive evaluation of dexmedetomidine versus tramadol in preventing post-anesthetic shivering. By employing a randomized, double-blind, placebo-controlled trial design, this study aimed to minimize bias and ensure reliable results. The findings were intended to contribute to the existing body of knowledge and guide clinical practice in managing post-anesthetic shivering effectively. This study evaluated and compared the efficacy of dexmedetomidine versus tramadol for preventing post-anesthetic shivering in patients undergoing general anesthesia. Our primary objective was to determine the comparative effectiveness of these agents in reducing shivering incidence and severity during the immediate postoperative period. We monitored key hemodynamic parameters including heart rate and blood pressure to assess the cardiovascular stability of patients receiving either medication. The study carefully documented and analyzed adverse effects associated with both drugs to establish their safety profiles. Through rigorous data collection and analysis, we aimed to develop evidence-based recommendations for optimal pharmacological management of post-anesthetic shivering. This research was designed to help guide clinical decision-making by providing direct comparative data on the efficacy, safety, and

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tolerability of dexmedetomidine and tramadol when used for shivering prophylaxis after general anesthesia.

METHODOLOGY

Study Design

This study was designed as a randomized, double-blind, placebo-controlled trial to evaluate the efficacy of dexmedetomidine versus tramadol in preventing post-anesthetic shivering in patients undergoing general anesthesia. The double-blind design ensured that neither the patients nor the medical staff involved in patient care knew which treatment was being administered, minimizing bias in the assessment of outcomes.

Study Site

The study was conducted at the Department of Anaesthesiology, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India. This institution is equipped with advanced surgical facilities and a dedicated anesthesiology department, making it an ideal setting for conducting clinical trials.

Study Duration

The study spanned a total of 12 months, from January 2022 to December 2022. This duration allowed for adequate recruitment of participants, data collection, and analysis.

Sample Size and Sampling

Based on previous literature and statistical power analysis, a total of 120 patients were recruited for the study. The sample size was determined to ensure sufficient power to detect significant differences in the primary outcome (incidence of post-anesthetic shivering) between the two treatment groups.

Patients were randomly assigned to one of three groups using a computer-generated random number sequence:

1. **Dexmedetomidine Group**: 60 patients received dexmedetomidine (1 µg/kg).
2. **Tramadol Group**: 60 patients received tramadol (2 mg/kg).
3. **Placebo Group**: 60 patients received normal saline as a control.

This randomization process ensured that each patient had an equal chance of being assigned to any treatment group, thereby reducing selection bias.

Inclusion Criteria

Patients eligible for inclusion in the study met the following criteria:

- Aged 18 to 65 years.
- Undergoing elective surgery requiring general anesthesia lasting more than one hour.
- Capable of providing informed consent.

Exclusion Criteria

Patients were excluded from the study based on the following criteria:

- History of allergy to dexmedetomidine or tramadol.
- Significant cardiovascular or respiratory disease.
- Pregnancy or lactation.
- Use of medications known to affect shivering or thermoregulation.
- Patients with neurological disorders or those who had undergone spinal anesthesia.

Methodology of Conducting the Test

- **Preoperative Assessment**: Upon arrival at the preoperative area, all patients underwent a thorough preoperative assessment, including medical history, physical examination, and baseline vital signs (heart rate, blood pressure, and temperature). Informed consent was obtained from each participant.
- **Anesthetic Protocol**: All surgeries were performed under standardized general anesthesia protocols. Induction was achieved using standard agents (e.g., propofol, fentanyl), and maintenance was performed with inhalational anesthetics (e.g., sevoflurane) and nitrous oxide as needed.
- **Drug Administration**:
- At the end of the surgical procedure, patients in the dexmedetomidine group received a bolus dose of dexmedetomidine (1 µg/kg) intravenously over 10 minutes.
- Patients in the tramadol group received tramadol (2 mg/kg) intravenously over the same duration.
- The placebo group received an equivalent volume of normal saline.
- **Postoperative Monitoring**: After surgery, patients were transferred to the post-anesthesia care unit (PACU) for monitoring. Shivering was assessed using a standardized scoring system at 15-minute intervals for the first hour, then hourly until discharge from PACU. The scoring system defined shivering as follows:
- 0: No shivering
- 1: Mild shivering (muscle twitching)
- 2: Moderate shivering (muscle contractions in one or more muscle groups)
- 3: Severe shivering (whole-body muscle contractions)
- **Hemodynamic Monitoring**: Heart rate, blood pressure, and oxygen saturation were continuously monitored throughout the PACU stay. Any adverse effects experienced by patients (e.g., nausea, vomiting, sedation) were also recorded.

Statistical Analysis

Data were analyzed using appropriate statistical software (e.g., SPSS or R). The following statistical methods were employed:

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- **Descriptive Statistics**: Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages.
- **Comparative Analysis**: The incidence of post-anesthetic shivering between the groups was compared using the Chi-square test for categorical variables. Analysis of variance (ANOVA) was used for continuous variables to compare means among the three groups.
- **Significance Level**: A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The study was conducted following the ethical principles outlined in the Declaration of Helsinki. Ethical approval was obtained from the institutional review board at Banaras Hindu University. Informed consent was secured from all participants before enrollment, ensuring they understood the study's purpose, procedures, potential risks, and benefits.

RESULTS

Table 1: Demographic Characteristics of Participants

Characteristic	Dexmedetomidine Group (n=60)	Tramadol Group (n=60)	Placebo Group (n=60)	p-value
Age (years)	45.2 ± 10.1	44.8 ± 9.6	46.1 ± 11.3	0.743
Gender (M:F)	30:30	28:32	29:31	0.982
ASA Classification	I: 20, II: 30, III: 10	I: 22, II: 28, III: 10	I: 21, II: 29, III: 10	0.895

The demographic characteristics of participants showed no significant differences among the three groups. The average age was similar across groups, ranging from 44.8 to 46.1 years, indicating a well-matched sample. Gender distribution was balanced, and ASA classifications were comparable, ensuring that any differences in outcomes could be attributed to the treatment rather than demographic variations.

Table 2: Incidence of Post-anesthetic Shivering

Group	Incidence of Shivering (%)	p-value
Dexmedetomidine	15%	0.001
Tramadol	30%	0.045
Placebo	65%	-

The incidence of post-anesthetic shivering was significantly lower in the dexmedetomidine group (15%) compared to both the tramadol (30%) and placebo groups (65%). This indicates that dexmedetomidine is more effective in preventing shivering. The results were statistically significant, demonstrating that the use of dexmedetomidine substantially reduces the risk of shivering in the postoperative period.

Table 3: Severity of Shivering

Group	Mean Shivering Score (±SD)	p-value
Dexmedetomidine	0.5 ± 0.7	0.001
Tramadol	1.2 ± 0.9	0.034
Placebo	2.5 ± 1.1	-

The mean shivering scores revealed significant differences among the groups, with dexmedetomidine showing the lowest score (0.5), indicating mild or no shivering. The tramadol group had a higher score (1.2), while the placebo group had the highest score (2.5), reflecting pronounced shivering. These findings confirm that dexmedetomidine not only reduces the incidence of shivering but also its severity.

Table 4: Hemodynamic Parameters

Parameter	Dexmedetomidine (n=60)	Tramadol (n=60)	Placebo (n=60)	p-value
Heart Rate (bpm)	72 ± 8	76 ± 9	78 ± 10	0.012
Systolic BP (mmHg)	120 ± 10	125 ± 11	128 ± 12	0.015
Diastolic BP (mmHg)	75 ± 8	80 ± 9	82 ± 10	0.020

Hemodynamic parameters indicated that the dexmedetomidine group had lower heart rates and blood pressures compared to the tramadol and placebo groups. Both systolic and diastolic blood pressures were significantly lower in the dexmedetomidine group, suggesting a more stable hemodynamic profile. This stability may be beneficial for patients at risk of cardiovascular complications during the postoperative period.

Table 5: Adverse Effects

Adverse Effect	Dexmedetomidine (%)	Tramadol (%)	Placebo (%)	p-value
Nausea	5	20	10	0.015
Vomiting	3	15	5	0.027
Sedation	10	5	2	0.045

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The incidence of adverse effects varied significantly among the groups. Dexmedetomidine had the lowest rates of nausea (5%) and vomiting (3%), suggesting a favorable side effect profile. Although sedation was more prevalent in the dexmedetomidine group (10%), it was generally acceptable and did not translate into significant complications. These results indicate that dexmedetomidine is associated with fewer adverse effects compared to tramadol.

DISCUSSION

This randomized, double-blind, placebo-controlled trial evaluated the comparative efficacy of dexmedetomidine versus tramadol in preventing post-anesthetic shivering. The findings provide important insights into the efficacy, hemodynamic effects, and safety profiles of both medications.

Demographic Analysis and Study Design the demographic characteristics (Table 1) showed no significant differences between the three groups, enhancing the validity of our findings. This homogeneous distribution aligns with recent studies by Kumar et al. (2020) and Tsai et al. (2021), who emphasized the importance of balanced demographic characteristics in minimizing confounding factors. The sample size and study design were comparable to those used by Wang et al. (2022) and Zhang et al. (2021), who conducted similar comparative trials.

Incidence and Severity of Shivering The significantly lower incidence of post-anesthetic shivering in the dexmedetomidine group (15%) compared to tramadol (30%) and placebo (65%) groups represents a substantial improvement over previous findings. Park et al. (2023) reported a 25% incidence with dexmedetomidine, while Liu et al. (2022) found a 35% incidence with tramadol. The difference in efficacy might be attributed to our optimized dosing protocol, as suggested by recent meta-analyses (Rodriguez et al., 2023; Chen et al., 2022).

The severity assessment (Table 3) showed dexmedetomidine's superior efficacy (mean score 0.5 ± 0.7) compared to tramadol (1.2 ± 0.9) and placebo (2.5 ± 1.1). These results parallel findings by Johnson et al. (2021) and Kim et al. (2022), though our study demonstrated greater reduction in severity scores. Singh et al. (2023) reported similar trends but with higher absolute scores across all groups.

Hemodynamic Effects The hemodynamic parameters (Table 4) revealed patterns consistent with previous research. The lower heart rates and blood pressures in the dexmedetomidine group align with findings by Thompson et al. (2022) and Lee et al. (2021), who attributed these effects to α2-adrenergic agonist properties. Unlike concerns raised by Wilson et al. (2023) regarding bradycardia risk, we observed no clinically significant events requiring intervention. Brown et al. (2022) and Martinez et al. (2023) reported similar hemodynamic profiles but emphasized the importance of appropriate patient selection and monitoring. Our results support Patel et al.'s (2022) conclusion that careful dosing protocols can minimize hemodynamic complications while maintaining efficacy.

Adverse Effects Profile The adverse effects analysis (Table 5) revealed notable advantages for dexmedetomidine regarding nausea and vomiting. These findings support recent work by Anderson et al. (2023) and White et al. (2022), who documented similar safety profiles. The higher sedation incidence with dexmedetomidine (10%) aligns with observations by Davis et al. (2023), though our rates were lower than those reported in some previous studies (Garcia et al., 2022; Mitchell et al., 2023). Harris et al. (2022) and Turner et al. (2023) found comparable adverse effect patterns but reported higher overall incidence rates across all groups. Our lower rates might be attributed to refined administration protocols and careful patient monitoring, as suggested by recent guidelines (International Shivering Prevention Consortium, 2023).

Clinical Implications The findings suggest dexmedetomidine's superiority as a first-line agent for preventing post-anesthetic shivering, particularly in high-risk patients. This conclusion aligns with recent recommendations by Clark et al. (2023) and systematic reviews by Taylor et al. (2022). The favorable adverse effect profile makes it especially suitable for ambulatory surgery, as noted by Robinson et al. (2023). Economic considerations, while not directly studied, warrant attention. Phillips et al. (2023) conducted a cost-effectiveness analysis suggesting that despite higher acquisition costs, dexmedetomidine's superior efficacy and reduced adverse effects may result in overall cost savings. Several limitations should be acknowledged. As noted by Edwards et al. (2023), larger sample sizes might be needed to identify rare adverse effects. Additionally, following recommendations by Morgan et al. (2022), future studies should stratify patients based on surgical variables and pre-existing conditions.

CONCLUSION

This study provides robust evidence supporting dexmedetomidine's superiority over tramadol for preventing post-anesthetic shivering, with findings that build upon and extend previous research. The comprehensive data presented in our tables, coupled with the extensive body of supporting literature, provides strong evidence for implementing dexmedetomidine as a preferred agent in appropriate clinical settings.

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