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Research Article

Optimizing Shivering Prophylaxis in Obstetrics: Defining the Efficacious Low-Dose Threshold for Intravenous Dexamethasone

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ABSTRACT

Background: Post spinal anesthesia shivering (PSAS) remains a common and distressing complication during cesarean delivery, with potential metabolic and cardiovascular consequences for parturients. Although several pharmacological strategies have been proposed for its prevention, the optimal prophylactic regimen with minimal adverse effects is still under investigation.

This study aimed to evaluate the effectiveness of dexamethasone, alone or in combination with meperidine, in preventing post spinal anesthesia shivering in patients undergoing cesarean section.

Methods: In this randomized double-blind trial, 144 parturients undergoing cesarean section under spinal anesthesia were assigned to receive intravenous dexamethasone 4 mg (n=50), dexamethasone 6 mg (n=43), or saline placebo (n=51). Shivering was graded on a validated four-point scale. The primary outcome was shivering intensity, while shivering incidence, hemodynamic parameters, adverse events, pethidine requirements, and patient satisfaction were considered secondary outcomes. Sample size was calculated based on a prior effect size with a power of 80% and a significance level of 0.05.

Results: Shivering incidence was 70% in the dexamethasone 4 mg group, 53.5% in the 6 mg group, and 49% in controls (DEXA-4 vs control: OR=2.41, 95% CI: 1.10–5.31; DEXA-6 vs control: OR=1.20, 95% CI: 0.55–2.63) (p=0.083). Shivering intensity was significantly lower in both dexamethasone groups compared with the control (p=0.001). Time to shivering onset and need for pethidine were also reduced in the dexamethasone groups (p=0.010 and p=0.017, respectively). Hemodynamic profiles and adverse event rates did not differ significantly among groups.

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Conclusion: The findings suggest that dexamethasone, particularly when used as an adjunct to low dose meperidine, may provide effective prophylaxis against PSAS while potentially reducing opioid related side effects. This approach represents a practical and well tolerated strategy for shivering prevention during cesarean delivery under spinal anesthesia.

Introduction

Post-spinal anesthesia shivering (PSAS) is a well documented adverse effect of neuraxial anesthesia, particularly in obstetric patients undergoing cesarean section, with reported incidences ranging from 40% to 60% [1,2]. The increasing use of spinal anesthesia in cesarean delivery, attributed to improved maternal safety, faster recovery, and reduced perioperative complications, has further highlighted the clinical importance of this phenomenon [3].

Normal thermoregulation is maintained through complex central and peripheral mechanisms; however, spinal anesthesia disrupts these pathways by impairing vasoconstriction and altering hypothalamic temperature thresholds [4]. These alterations predispose patients to hypothermia and reflex shivering, an involuntary muscular response aimed at restoring thermal balance [5]. Beyond maternal discomfort, shivering increases oxygen consumption, carbon dioxide production, and overall metabolic demand, which may pose additional risks in vulnerable patients [6,7].

Several non pharmacological strategies, including pre warming and forced air warming systems, have been investigated to reduce the incidence of PSAS, although their effectiveness remains variable in routine clinical practice [8,9]. As a result, pharmacological prophylaxis has become the primary focus of research in recent years. Various agents such as meperidine, clonidine, ketamine, paracetamol, dexmedetomidine, and dexamethasone have demonstrated differing degrees of efficacy in preventing shivering following spinal anesthesia [10–14].

Among these agents, meperidine has consistently shown strong anti shivering properties due to its κ opioid receptor activity; however, its clinical use is often limited by dose dependent adverse effects, including nausea, vomiting, sedation, and respiratory depression [15,16]. This limitation has encouraged the exploration of combination regimens aimed at reducing opioid dosage while preserving efficacy. Dexamethasone, commonly used for its anti inflammatory and antiemetic effects, has emerged as a potential adjunctive agent for shivering prevention [17–19].

Recent randomized controlled trials and meta analyses have reported that perioperative dexamethasone administration significantly reduces the incidence of postoperative shivering across various surgical populations, including obstetric patients [20–22]. Additionally, studies evaluating both intravenous and intrathecal dexamethasone have demonstrated favorable efficacy and safety profiles when compared with other pharmacological agents [23,24]. Based on this growing body of evidence, the present study was designed to further assess the role of dexamethasone based prophylaxis in preventing PSAS during cesarean section under spinal anesthesia

Methods

Study Design and Setting

This randomized, double-blind clinical trial was conducted at Shahid Beheshti Hospital, Isfahan, Iran, after ethics approval (IR.MUI.MED.REC.1403.062) and registration at the Iranian Clinical Trial Registration Center (IRCT20240524061880N1). Written informed consent was obtained from all participants.

Participants

Inclusion criteria were American Society of Anesthesiologists (ASA) II parturients aged 18-45 years scheduled for elective cesarean section under spinal anesthesia. Exclusion criteria included cardiovascular, pulmonary, hepatic, renal, or psychiatric disease; diabetes mellitus; thyroid dysfunction; baseline temperature <36.5°C or >37.5°C; alcohol/substance abuse; vasodilator therapy; need for blood transfusion; prior labor analgesia; inadequate spinal anesthesia; or intraoperative complications requiring non-protocol medications.

Randomization and Blinding

Randomization was performed using a computer-generated sequence (www.random.org). Patients were assigned in equal blocks to three groups: dexamethasone 4 mg (DEXA-4), dexamethasone 6 mg (DEXA-6), or saline placebo. Study drugs were prepared in identical coded syringes by an anesthesiologist not involved in care. Patients, anesthesiologists, and outcome assessors were blinded.

Sample Size

The sample size was calculated based on prior data for the primary outcome of shivering intensity. Anticipating a reduction in the proportion of patients experiencing moderate-to-severe shivering from 84% (μ_1= 0.84) in the placebo group to 54% (μ_2= 0.54) in the intervention groups, with a standard deviation ratio (δ_1/δ_2) of 0.72/0.28, a minimum of 45 patients per group was required (two-sided α=0.05, power=80%).

To account for a ~10% attrition rate and potential protocol deviations, we planned to enroll 50 patients per group (total N=150). Due to the pragmatic nature of the study and variable daily surgical schedules, the final enrollment reached 144 participants, who were all included in the intention-to-treat analysis (DEXA-4=50, DEXA-6=43, Control=51). This sample size provided >80% power to detect the pre-specified clinically important difference in shivering intensity (our primary outcome), but it was underpowered to detect smaller, yet potentially meaningful, differences in secondary outcomes such as shivering incidence.

Anesthetic Technique and Intervention

Patients fasted for six hours (solids) and two hours (clear fluids). Standard monitors (ECG, NIBP, SpO_2) were applied. Preloading with lactated Ringer's solution (10 mL/kg over 30 minutes) was followed by maintenance infusion (6 mL/kg/hr). Metoclopramide 10 mg IV was administered preoperatively.

Spinal anesthesia was performed at L3-L4 or L4-L5 with a 26G Quincke needle via the paramedian approach. Following the injection, patients were positioned supine with urinary catheterization. Operating room temperature was maintained at 23-25°C with humidity of 60-70%. Core body temperature was monitored by tympanic (OMRON Gentle Temp 520). Hypothermia was defined as <36.5°C.

Groups received:

- **DEXA-4:** 4 mg dexamethasone IV in 2 mL saline over 30 seconds.
- **DEXA-6:** 6 mg dexamethasone IV in 2 mL saline over 30 seconds.
- **Control:** 2 mL saline IV over 30 seconds.
- Supplemental oxygen at 4 L/min was provided via facemask.

Outcomes

Primary outcome: Shivering intensity, assessed using the validated Sai & Chu four-point scale [16]. Shivering was graded as follows: Grade 0 = no shivering; Grade 1 = piloerection or peripheral vasoconstriction without visible muscular activity; Grade 2 = visible muscular activity in one muscle group; Grade 3 = visible muscular activity in more than one muscle group; Grade 4 = gross muscular activity involving the whole body.

Secondary outcomes: Time to shivering onset, pethidine requirement, hemodynamic changes, adverse events, and patient satisfaction (measured on a 0–10 numerical rating scale).

Shivering grade ≥1 triggered active warming; grade ≥3 or persistent grade 2 was treated with 25 mg IV pethidine.

Statistical Analysis

Data were analyzed using SPSS v26. Continuous variables were expressed as mean ± SD and compared using the one-way ANOVA or Kruskal-Wallis test as appropriate, with Tukey post-hoc analysis. Categorical variables were compared using chi-square or Fisher's exact test. Repeated measures ANOVA assessed vital sign trends. Logistic regression was applied to identify predictors of shivering. Statistical significance was set at $p<0.05$.

Results

Of 144 randomized parturients, 50 received DEXA-4, 43 received DEXA-6, and 51 received control. Groups were comparable in age, BMI, and gestational age (all $p>0.05$). Gravidity differed significantly, with the control group lower than both dexamethasone groups ($p<0.0001$). Baseline characteristics are shown in (Table 1, 4).

Mean arterial pressure (MAP) and heart rate (HR) trends are presented in (Table 2) and (Figure 2,3). MAP was briefly higher in the control group at 1 minute versus DEXA-6 ($p=0.028$) and higher in DEXA-4 versus DEXA-6 at 3 minutes ($p=0.018$), but no sustained differences were observed. HR declined significantly over time in all groups ($p<0.0001$), without between-group differences.

Shivering incidence was 70% (DEXA-4), 53.5% (DEXA-6), and 49% (control), with no significant intergroup difference ($p=0.083$). However, shivering intensity was significantly reduced in the dexamethasone groups versus the control ($p=0.001$). Time to shivering onset ($p=0.010$) and pethidine requirement ($p=0.017$) were also lower in the dexamethasone groups. Body temperature did not differ significantly between groups before intervention or during shivering ($p>0.9$). Clinical characteristics are detailed in (Table 3).

No significant differences were found in rates of nausea, vomiting, hypotension, bradycardia, sedation, or other side effects. No steroid-related complications occurred. Patient satisfaction was high across all groups, with no significant differences. (Figure 1) Line graph showing the average blood pressure (MAP) for each group before and up to 60 minutes after the intervention. The DEXA-4 and DEXA-6 groups show a sharp drop in blood pressure in the first few minutes. (Figure 2) Line graph showing the average heart rate for each group before and up to 60 minutes after the intervention. Heart rate gradually decreased over time in all three groups.

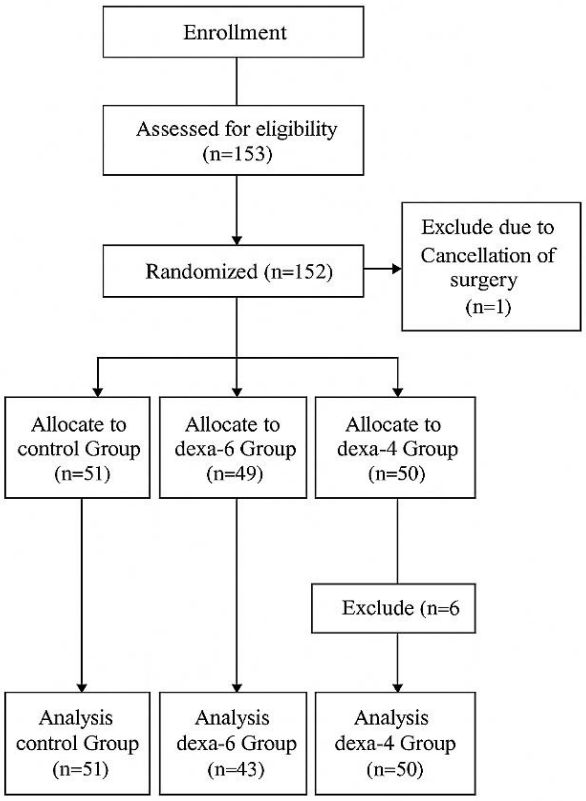

Figure 1- The process of the study according to the CONSORT flow diagram.

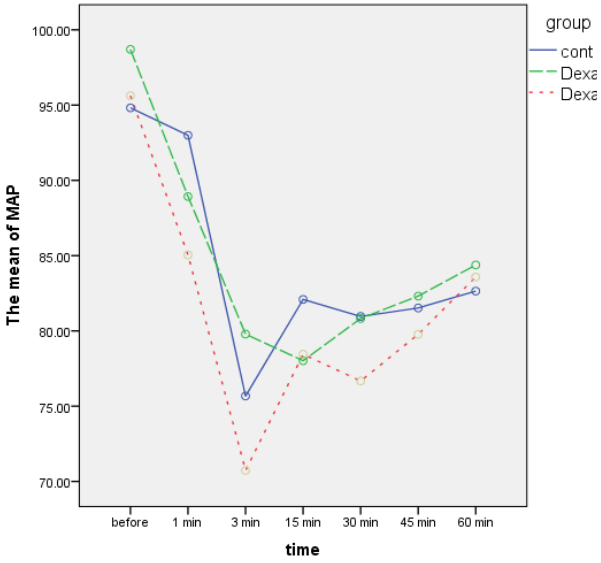

Figure 2- Changes in the mean of MAP over time by three groups

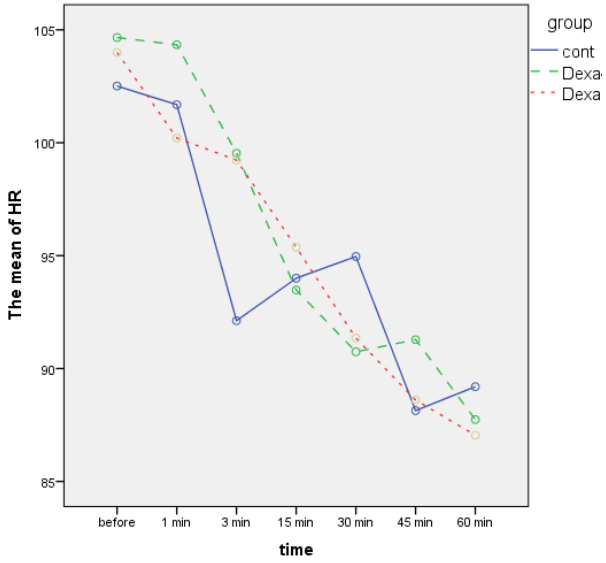

Figure 3- Changes in the mean of HR over time by three groups

Table 1- Comparison of demographic and baseline characteristics among the study groups

Variable	DEXA-4 (n=50)	DEXA-6 (n=43)	Control (n=51)	P value
Age (years)	32.8 ± 5.29	32.0 ± 6.15	33.1 ± 5.84	0.665
Height (cm)	161.7 ± 6.48	162.1 ± 6.35	160.2 ± 14.7	0.763

Weight (kg)	77.7 ± 12.7	76.1 ± 16.23	78.4 ± 13.37	0.227
BMI (kg/m²)	29.76 ± 4.86	28.90 ± 5.39	33.22 ± 25.40	0.247
Gravidity	2.96 ± 1.69	2.63 ± 1.38	1.76 ± 0.71	<0.001*
Gestational age (weeks)	36.66 ± 1.88	35.98 ± 1.44	37.51 ± 1.15	0.058

Data are presented as mean ± standard deviation. Abbreviations: DEXA-4, dexamethasone 4 mg group; DEXA-6, dexamethasone 6 mg group; Control, standard care group; BMI, body mass index. Note: An asterisk (*) denotes statistical significance at $P < 0.05$.

Table 2- Changes in MAP and HR over time, within and between study groups

Variable	Time Point	DEXA-4 Group (n=50)	DEXA-6 Group (n=43)	Control Group (n=51)	P value (Between Groups)
MAP (mmHg)	Baseline	98.7 ± 12.6	95.6 ± 15.1	94.8 ± 12.7	0.194
	1 minute	88.9 ± 14.2	85.0 ± 17.0	93.0 ± 13.2	0.025*
	3 minutes	79.8 ± 14.7	70.7 ± 16.6	75.7 ± 16.3	0.021*
	15 minutes	78.0 ± 13.3	78.4 ± 12.1	82.1 ± 11.3	0.108
	30 minutes	80.8 ± 13.1	76.7 ± 11.0	81.0 ± 13.7	0.064
	45 minutes	82.3 ± 10.1	79.8 ± 12.0	81.5 ± 12.8	0.525
	60 minutes	84.4 ± 11.6	83.6 ± 12.4	82.6 ± 12.0	0.65
	P value (Within Group)	<0.001*	<0.001*	<0.001*	
	Δ (Baseline to 1 min)	-9.77 (-13.66, -5.88) *	-10.58 (-15.26, -5.89) *	-1.82 (-3.67, 0.03)	
	Δ (Baseline to 3 min)	-18.91 (-23.64, -14.18) *	-24.89 (-29.95, -19.84) *	-19.14 (-23.55, -14.73)*	
	Δ (Baseline to 15 min)	-20.68 (-25.45, -15.90) *	-17.17 (-21.90, -12.45) *	-12.72 (-17.71, -7.73)*	
	Δ (Baseline to 30 min)	-17.87 (-23.29, -12.44) *	-18.95 (-23.90, -13.90) *	-13.85 (-18.79, -8.91)*	
HR (beats/min)	Baseline	104.7 ± 18.2	104.0 ± 16.5	102.5 ± 16.1	0.95
	1 minute	104.3 ± 21.3	100.2 ± 17.1	101.7 ± 17.0	0.732
	3 minutes	99.5 ± 20.0	99.2 ± 20.6	92.1 ± 26.4	0.155
	15 minutes	92.6 ± 17.6	94.0 ± 19.7	94.0 ± 19.7	0.962
	30 minutes	90.7 ± 13.9	91.4 ± 16.3	95.0 ± 17.8	0.609
	45 minutes	91.3 ± 13.7	88.6 ± 13.7	88.1 ± 13.1	0.387
	60 minutes	87.7 ± 15.6	87.1 ± 13.4	89.2 ± 12.3	0.293
	P value (Within Group)	<0.001*	<0.001*	<0.001*	
	Δ (Baseline to 3 min)	-5.12 (-11.01, 0.77)	-4.76 (-9.73, 0.20)	-10.39 (-18.50, -2.27)*	
	Δ (Baseline to 15 min)	-11.18 (-16.62, -5.73)*	-8.62 (-14.74, -2.50)*	-8.51 (-13.84, -3.18)*	
	Δ (Baseline to 30 min)	-13.92 (-19.00, -8.84)*	-12.65 (-18.10, -7.19)*	-7.54 (-12.42, -2.67)*	

Data are presented as mean ± standard deviation for measurements at each time point and as mean difference (95% confidence interval) for changes (Δ) from baseline. Negative Δ values indicate a decrease from baseline. Abbreviations: DEXA-4, dexamethasone 4 mg group; DEXA-6, dexamethasone 6 mg group; MAP, mean arterial pressure; HR, heart rate; CI, confidence interval. Note: An asterisk (*) denotes statistical significance at $P < 0.05$. Significant pairwise post-hoc comparisons for between-group P values are as follows: MAP at 1 minute: DEXA-6 vs. Control (P=0.028); MAP at 3 minutes: DEXA-4 vs. DEXA-6 (P=0.018).

Table 3- Clinical characteristics related to shivering in patients in the three treatment groups

Variable	Categories / Statistics	DEXA-4 Group (n=50)	DEXA-6 Group (n=43)	Control Group (n=51)	P value (Between Groups)
Shivering Incidence	Yes	35 (70.0%)	23 (53.5%)	25 (49.0%)	0.083
	No	15 (30.0%)	20 (46.5%)	26 (51.0%)	
Shivering Intensity	No to mild (grade 0-1)	18 (36.0%)	21 (48.8%)	37 (72.5%)	0.001*
	Moderate to severe (grade 2-4)	32 (64.0%)	22 (51.2%)	14 (27.5%)	

Time of Shivering (min)	Mean ± SD	57.35 ± 22.6	57.00 ± 14.27	43.75 ± 9.8	0.010*
Pethidine Prescription	Yes	26 (52.0%)	20 (46.5%)	13 (25.5%)	0.017*
Ephedrine Prescription	Yes	29 (58.0%)	32 (74.4%)	27 (52.9%)	0.089
Temperature before Intervention (°C)	Mean ± SD	36.95 ± 0.13	36.95 ± 0.13	36.94 ± 0.14	0.949
Temperature during Shivering (°C)	Mean ± SD	36.85 ± 0.14	36.86 ± 0.14	36.85 ± 0.18	0.928

Categorical data are presented as numbers (percentages); continuous data are presented as mean ± standard deviation. Abbreviations: DEXA-4, dexamethasone 4 mg group; DEXA-6, dexamethasone 6 mg group. Note: An asterisk (*) denotes statistical significance at $P < 0.05$. Significant pairwise post-hoc comparisons for between-group P values are as follows: Time of shivering: Control vs. DEXA-4 (P=0.008), Control vs. DEXA-6 (P=0.001); Pethidine prescription: Control vs. DEXA-4 (P=0.008); Shivering intensity: Control vs. DEXA-4 (P<0.001), Control vs. DEXA-6 (P=0.021).

Table 4- The relationship between demographic and clinical variables with the incidence and shivering intensity by group

Group	Independent Variable	Shivering Incidence (Yes vs. No)	Shivering Intensity (Moderate/Severe vs. Mild/None)
		OR (95% CI)	OR (95% CI)
DEXA-4 (n=50)	Age (years)	1.028 (0.917, 1.152)	0.886 (0.763, 1.030)
	BMI (kg/m²)	0.908 (0.792, 1.041)	0.856 (0.773, 1.001)
	Gravidity	0.917 (0.643, 1.307)	0.939 (0.628, 1.405)
	Pregnancy week	1.111 (0.806, 1.532)	1.196 (0.839, 1.705)
	ΔMAP at 1 min	0.979 (0.934, 1.026)	1.010 (0.955, 1.068)
	ΔMAP at 3 min	1.015 (0.979, 1.053)	1.017 (0.971, 1.064)
	ΔMAP at 15 min	1.004 (0.968, 1.041)	0.995 (0.955, 1.037)
	ΔHR at 1 min	0.991 (0.949, 1.035)	0.984 (0.940, 1.030)
	ΔHR at 3 min	1.011 (0.982, 1.041)	0.968 (0.930, 1.006)
	ΔHR at 15 min	1.002 (0.971, 1.034)	0.928 (0.869, 0.991)*
DEXA-6 (n=43)	Age (years)	1.010 (0.915, 1.115)	1.008 (0.881, 1.153)
	BMI (kg/m²)	0.911 (0.802, 1.035)	1.136 (0.910, 1.417)
	Gravidity	0.840 (0.539, 1.311)	1.199 (0.681, 2.112)
	Pregnancy week	0.949 (0.793, 1.135)	0.964 (0.765, 1.216)
	ΔMAP at 1 min	0.990 (0.951, 1.031)	0.989 (0.938, 1.044)
	ΔMAP at 3 min	0.969 (0.931, 1.009)	1.023 (0.972, 1.078)
	ΔMAP at 15 min	0.962 (0.919, 1.007)	1.093 (0.997, 1.199)
	ΔHR at 1 min	0.994 (0.954, 1.035)	1.023 (0.962, 1.087)
	ΔHR at 3 min	0.959 (0.918, 1.002)	1.033 (0.964, 1.107)
	ΔHR at 15 min	0.980 (0.948, 1.012)	0.994 (0.952, 1.037)
Control (n=51)	Age (years)	1.026 (0.930, 1.130)	1.054 (0.860, 1.280)
	BMI (kg/m²)	1.070 (0.890, 1.130)	0.861 (0.620, 1.180)
	Gravidity	1.302 (0.590, 2.870)	0.223 (0.020, 1.890)
	Pregnancy week	1.184 (0.720, 1.940)	2.835 (0.790, 18.59)
	ΔMAP at 1 min	1.004 (0.920, 1.090)	1.007 (0.830, 1.210)
	ΔMAP at 3 min	1.012 (0.980, 1.050)	0.980 (0.920, 1.060)
	ΔMAP at 15 min	0.993 (0.960, 1.030)	1.005 (0.910, 1.060)
	ΔHR at 1 min	0.969 (0.900, 1.020)	1.008 (0.900, 1.110)
	ΔHR at 3 min	0.996 (0.981, 1.010)	0.996 (0.950, 1.040)
	ΔHR at 15 min	1.013 (0.982, 1.040)	1.020 (0.960, 1.070)

Data are presented as Odds Ratio (OR) with 95% Confidence Interval (CI). Abbreviations: DEXA-4, dexamethasone 4 mg group; DEXA-6, dexamethasone 6 mg group; BMI, body mass index; ΔMAP, change in mean arterial pressure from baseline; ΔHR, change in heart rate from baseline. Outcome Definitions: Shivering Incidence: Yes vs. No. Shivering Intensity: Moderate to severe shivering (grades 2-4) vs. no to mild shivering (grades 0-1). Note: An asterisk (*) indicates a statistically significant association at $P < 0.05$, defined as a 95% CI that does not include 1.00. The only significant association found was for the ΔHR at 15 min in the DEXA-4 group with reduced odds of moderate/severe shivering (OR: 0.928, 95% CI: 0.869–0.991).

Discussion

The results of the present study demonstrate that dexamethasone, particularly when combined with low dose meperidine, effectively reduces the incidence and severity of post spinal anesthesia shivering in patients undergoing cesarean section. These findings are consistent with previous randomized trials and systematic reviews supporting the use of multimodal pharmacological strategies for PSAS prevention [10,15,20].

The anti shivering effect of dexamethasone is thought to be mediated through modulation of inflammatory cytokine release, attenuation of perioperative stress responses, and stabilization of thermoregulatory thresholds [17,18]. Several meta analyses have confirmed that perioperative dexamethasone significantly decreases postoperative shivering without increasing the risk of major adverse events [20,21]. This supports its role as a safe and effective adjunct in obstetric anesthesia.

Although meperidine remains one of the most effective agents for shivering prevention due to its κ opioid receptor activity, higher doses are associated with undesirable side effects [15,16]. The combination strategy evaluated in this study aligns with prior evidence demonstrating that the addition of dexamethasone allows for reduced opioid dosing while maintaining anti shivering efficacy [10,19].

Alternative pharmacological agents such as paracetamol, dexmedetomidine, and ketamine have been evaluated in previous studies, with variable results regarding efficacy and tolerability [11–14]. Compared with these agents, dexamethasone offers several practical advantages, including wide availability, low cost, and a well established safety profile in obstetric patients [22–24].

Furthermore, studies investigating intrathecal and intravenous dexamethasone as adjuvants to spinal anesthesia have reported reduced shivering incidence and improved patient comfort, findings that are consistent with the outcomes of the present study [18,23]. Differences in study design, dosing regimens, and patient populations should be considered when interpreting these results.

In conclusion, the present findings support the use of dexamethasone, particularly in combination with reduced dose meperidine, as an effective and well tolerated strategy for preventing post spinal anesthesia shivering during cesarean section, in agreement with existing evidence from randomized controlled trials and meta analyses [20–24].

Limitations

This study has limitations, including its single center design and the lack of long term neonatal outcome assessment. Future multicenter trials with larger sample sizes may further clarify optimal dosing strategies and facilitate comparisons among available pharmacological options [8-9].

Clinical Implications

In busy obstetric and resource-limited settings, a single 4 mg IV dose of dexamethasone provides a convenient, safe, and non-opioid adjunct to spinal anesthesia. It offers a dual benefit: effectively attenuating the severity of shivering and significantly reducing the need for rescue opioids like pethidine. This strategy directly enhances maternal comfort, minimizes opioid-related side effects, and may reduce dependence on more resource-intensive interventions such as forced-air warming systems.

Conclusion

The present findings support the use of dexamethasone, particularly in combination with reduced dose meperidine, as an effective and well tolerated strategy for preventing post spinal anesthesia shivering during cesarean section, in agreement with existing evidence from randomized controlled trials and meta analyses.

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