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Does Route Matter? A Randomized Double-Blind Trial Comparing Intravenous and Intrathecal Dexmedetomidine for Prevention of Post-spinal Shivering in Cesarean Delivery

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Abstract

Background: Shivering is a common adverse effect of spinal anesthesia during cesarean section. Dexmedetomidine, a selective α_2-agonist, has been administered via various routes to mitigate this adverse effect.

Objectives: This study aimed to compare the efficacy and hemodynamic safety of intravenous (IV) versus intrathecal (IT) dexmedetomidine for preventing post-spinal anesthesia shivering (PSAS).

Methods: In this randomized, double-blind, parallel-group controlled trial, parturient women scheduled for elective cesarean section under spinal anesthesia were consecutively screened for eligibility. Eligible participants were randomly assigned in a 1:1:1 ratio to receive IV dexmedetomidine, IT dexmedetomidine, or placebo, using computer-generated block randomization. Allocation concealment was ensured using sealed, opaque envelopes. Patients, anesthesiologists, surgeons, and outcome assessors were blinded to group allocation. The primary outcome was the incidence of PSAS. Secondary outcomes included shivering onset time and intensity, hemodynamic variables, temperature changes, and adverse events.

Results: The incidence of shivering was 35.3% in the IV group, 40.0% in the IT group, and 49.0% in the control group ($P = 0.373$). The IT-DEX group showed a significantly delayed onset of shivering ($P < 0.0001$) and higher peri-shivering body temperatures ($P < 0.0001$) compared with the other groups. Mean arterial pressure (MAP) was lower in the IT group at 45 minutes ($P = 0.038$) and 60 minutes ($P = 0.021$) after the block.

Conclusions: At a fixed dose of 10 μg, neither IV nor IT dexmedetomidine significantly reduced the overall incidence of shivering compared with placebo. However, IT administration significantly delayed the onset of shivering and preserved body temperature. Trial Registration and Funding: Trial Registration: IRCT20240524061880N1 (Iranian Clinical Trial Registry). Funding: This study was funded by the Medical University of Isfahan.

Keywords: Cesarean Section, Spinal Anesthesia, Prevention, Intravenous Injection, Intrathecal Injection, Dexmedetomidine

1. Background

Post-spinal anesthesia shivering (PSAS) remains a common and uncomfortable complication during cesarean delivery, with reported incidences ranging from 30% to 80% (1, 2). Shivering increases maternal oxygen consumption, impairs monitoring accuracy, and may exacerbate patient distress (3, 4).

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Dexmedetomidine, a highly selective α_2-adrenergic receptor agonist, has been investigated for its anti-shivering properties through central thermoregulatory modulation, lowering vasoconstriction and shivering thresholds (5, 6). Both intravenous (IV) and intrathecal (IT) routes have shown promise; however, evidence remains inconsistent regarding comparative efficacy (7, 8).

Most IV dexmedetomidine studies demonstrating benefit have used weight-based boluses of 0.3 - 0.5 μg·kg^{-1} or continuous infusions initiated after spinal block or cord clamping (8, 11). Intrathecal dexmedetomidine, typically 5 - 10 μg co-administered with hyperbaric bupivacaine, has been associated with prolonged sensory block and a reduced incidence of shivering; however, direct head-to-head trials comparing it with IV administration are scarce (7, 12, 13).

2. Objectives

Given the variability in reported findings and the lack of adequately powered trials comparing these two routes at equivalent microgram doses, we designed a randomized controlled trial to evaluate the prophylactic efficacy and safety of 10 μg IT dexmedetomidine, 10 μg IV dexmedetomidine, and placebo in preventing PSAS during elective cesarean delivery under spinal anesthesia.

3. Methods

3.1. Study Design and Setting

This randomized, double-blind, parallel-group, controlled trial was conducted at Shahid Beheshti Hospital, Isfahan, Iran. The study protocol was approved by the Ethics Committee of Isfahan University of Medical Sciences (IR.MUI.MED.REC.1403.062) and registered in the Iranian Registry of Clinical Trials (IRCT20240524061880N1). The trial was conducted in accordance with the Declaration of Helsinki and the CONSORT guidelines for randomized controlled trials.

3.2. Participants and Sampling Process

During the study period, all parturient women scheduled for elective cesarean section under spinal anesthesia were consecutively screened for eligibility during the preanesthetic evaluation. Consecutive sampling was used to minimize selection bias and to ensure that all eligible patients presenting during the recruitment period had an equal opportunity to participate.

Women aged 18 - 40 years with American Society of Anesthesiologists (ASA) physical status II who met the inclusion criteria and had none of the predefined exclusion criteria were considered eligible. After a detailed explanation of the study protocol, written informed consent was obtained from all participants before enrollment.

A total of 155 patients were assessed for eligibility. Thirteen patients were excluded after randomization because of surgical cancellation, withdrawal of consent, or protocol violations. Ultimately, data from 142 participants were included in the final analysis, as shown in the CONSORT flow diagram.

3.3. Inclusion and Exclusion Criteria

Eligible participants were healthy parturient women aged 18 - 40 years with ASA physical status II who were scheduled for elective cesarean delivery under spinal anesthesia.

Patients were excluded before enrollment if they had contraindications to neuraxial anesthesia, known hypersensitivity to dexmedetomidine, pre-existing cardiovascular instability, thyroid dysfunction, baseline hypothermia (< 36°C) or fever (> 38°C), chronic use of sedatives or analgesics, Body Mass Index (BMI) ≥ 35 kg/m^2, or high-risk pregnancy conditions.

Participants were excluded after randomization if spinal anesthesia failed or was converted to general anesthesia, surgery was canceled, study drug administration was interrupted or incorrectly administered, data collection was incomplete, or the patient withdrew consent at any stage of the study.

3.4. Randomization and Blinding

Eligible participants were randomly allocated in a 1:1:1 ratio to the IV dexmedetomidine group, IT dexmedetomidine group, or control group. Randomization was performed using a computer-generated random sequence with permuted blocks of 6 to ensure balanced group sizes throughout the study.

Allocation concealment was maintained using sealed, opaque, sequentially numbered envelopes prepared by an independent statistician who was not involved in patient recruitment, anesthesia management, or outcome assessment. Upon enrollment, the next envelope in sequence was opened by an anesthesia nurse who was not involved in data collection.

The study was double-blinded; participants, attending anesthesiologists, surgeons, and outcome assessors remained unaware of group assignments

throughout the perioperative and postoperative periods.

3.5. Intervention Protocol

All patients received standardized spinal anesthesia in the sitting position using hyperbaric bupivacaine. In the IV dexmedetomidine group, patients received 10 μg of dexmedetomidine intravenously after establishment of spinal anesthesia. In the IT dexmedetomidine group, 10 μg of dexmedetomidine was added to the intrathecal local anesthetic solution. Patients in the control group received spinal anesthesia without dexmedetomidine. Perioperative management, ambient operating room temperature, intravenous fluids, and warming strategies were standardized across all groups.

3.6. Outcome Measures

The primary outcome was the incidence of PSAS. Secondary outcomes included time to onset of shivering, shivering intensity, perioperative temperature changes, hemodynamic variables, including MAP and heart rate (HR), and the incidence of adverse events such as hypotension, bradycardia, nausea, vomiting, and the need for rescue medications.

3.7. Statistical Analysis

Data were analyzed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using one-way analysis of variance or the Kruskal-Wallis test, as appropriate. Categorical variables were analyzed using the chi-square test or Fisher exact test. Repeated-measures analysis of variance was used to evaluate changes in hemodynamic variables over time. Multivariable logistic regression was performed to assess factors associated with shivering occurrence. A two-tailed P value of < 0.05 was considered statistically significant.

4. Results

4.1. Demographic Characteristics

A total of 149 women participated in this study and were divided into 3 groups: dexmedetomidine IV (35.9%), dexmedetomidine IT (28.2%), and control (35.9%). The CONSORT flow diagram detailing enrollment, allocation, and follow-up is presented in Figure 1. The mean ± SD age of the total study population was 32.43 ± 6.17 years (range, 18 to 44 years). The mean age did not differ significantly among the 3 groups (P = 0.271). In addition, there were no significant differences in height (P = 0.974), weight (P = 0.709), BMI (P = 0.832), or pregnancy week (P = 0.524) among the 3 groups (Table 1).

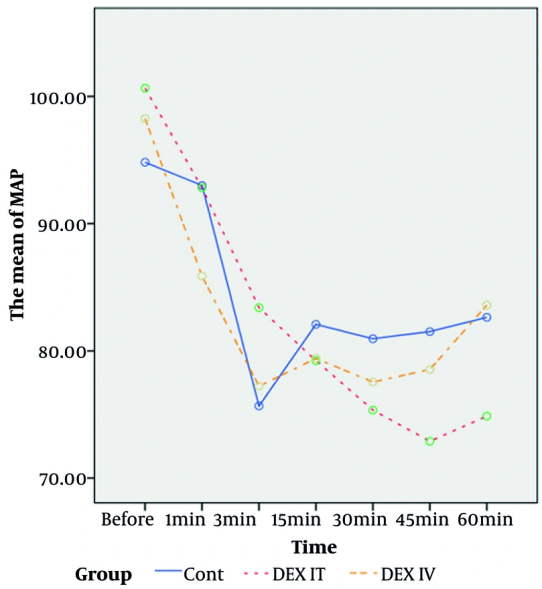

Figure 1. The process of the study according to the CONSORT flow diagram

However, mean gravid differed significantly among the 3 groups (P < 0.0001). Post hoc testing showed that the control group had significantly lower gravid than the other 2 groups (P < 0.0001), whereas the dexmedetomidine IV and IT groups did not differ from each other (P = 0.457) (Table 1).

4.2. Hemodynamic Variables

The patients' vital signs, including MAP and HR, were monitored at multiple time points: before the intervention and at 1, 3, 15, 30, 45, and 60 minutes after the intervention. MAP before the intervention did not differ significantly among the 3 groups (P = 0.071). However, at 45 and 60 minutes after the intervention, MAP in the dexmedetomidine IT group was significantly lower than that in the other 2 groups. No difference was found between the dexmedetomidine IV group and the control group. As shown in Figure 2, mean MAP decreased significantly over time from 1 to 60 minutes after the intervention in all 3 treatment groups; however, MAP changes over time did not differ significantly among the 3 groups (P = 0.616) (Table 2).

Table 1. Comparison of Demographic Characteristics Between the Three Study Groups [a]

Variables	Dexmedetomidine IV (n = 51)	Dexmedetomidine IT (n = 40)	Control (n = 51)	P-Value
Age (y)	31.73 ± 6.35	33.13 ± 6.03	33.1 ± 5.84	0.271
Height (cm)	162.1 ± 6.12	167.9 ± 47.7	160.2 ± 14.7	0.974
Weight (kg)	77.64 ± 12.56	80.5 ± 13.61	78.43 ± 13.37	0.709
BMI	29.61 ± 4.96	31.27 ± 10.43	33.22 ± 25.4	0.832
Gravid	2.62 ± 1.83	2.92 ± 1.34	1.76 ± 0.71	< 0.0001
Pregnancy (wk)	36.84 ± 2.12	36.55 ± 2.48	37.51 ± 1.15	0.524

[a] Values are expressed as mean ± SD.

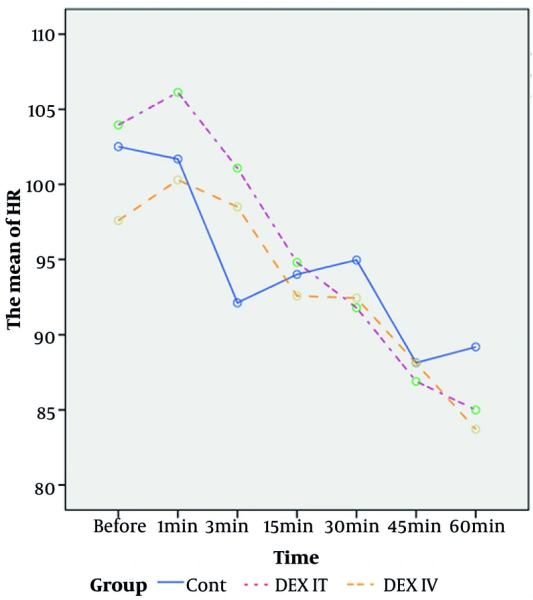

Figure 2. Changes in mean MAP over time by the three groups

Mean HR did not differ significantly among the 3 treatment groups before the intervention or over time, with one exception: at minute 3, HR in the control group was significantly lower than that in the dexmedetomidine IT group (P = 0.047). In addition, mean HR decreased significantly over time across all 3 groups (P < 0.0001) (Figure 3), with no significant differences in HR changes among the groups (P = 0.609).

4.3. Clinical Characteristics Related to Shivering

The clinical characteristics related to shivering are shown in Table 3. The incidence of shivering was lower in the dexmedetomidine IV group (35.3%) and higher in the control group than in the other 2 groups (49%). However, no significant difference was found among the 3 groups (P = 0.373).

The clinical characteristics related to shivering are shown in Table 3. The incidence of shivering was lower in the dexmedetomidine IV group (35.3%) and higher in the control group than in the other 2 groups (49%). However, no significant difference was found among the 3 groups (P = 0.373). The risk ratio (95% CI) for shivering incidence was 0.72 (0.47, 1.10) for IV-DEX versus control and 0.81 (0.52, 1.27) for IT-DEX versus control. Control (37.03 ± 0.19°C) and Dex IV (36.94 ± 0.14°C) differed significantly from Dex IT (P < 0.0001). During shivering, Dex IT maintained the highest temperature (37.13 ± 0.15°C), whereas Dex IV recorded the lowest temperature (36.85 ± 0.18°C), with significant differences for Dex IT versus control (P < 0.0001) and Dex IT versus Dex IV (P = 0.015) (Table 3).

In contrast, shivering intensity (no to mild shivering vs. moderate to very severe shivering) did not differ significantly among the 3 groups (P = 0.445). The time to shivering was significantly longer in the dexmedetomidine IT group than in the other 2 groups (P < 0.0001), with no difference between the dexmedetomidine IV and control groups (P = 0.256). The effect size for the delay in shivering onset in the IT-DEX group compared with the control group was moderate (Cohen d = 0.46). Pethidine administration (P = 0.711) and ephedrine administration (P = 0.263) did not differ significantly among the 3 groups.

5. Discussion

In this randomized, double-blind, parallel-group trial, we found no significant differences in overall shivering incidence or severity among a fixed 10-μg dose of IV dexmedetomidine, a fixed 10-μg dose of IT dexmedetomidine, and placebo, despite distinct physiological trends: lower MAP at 45 - 60 minutes in the IT group, similar HR reductions over time across all

Table 2. Changes in MAP and HR Between the Three Groups Over Time [a]

Variables	Dex IV	Dex IT	Control	P-Value			
				Three groups	Dex IV and Dex IT	Dex IV and Control	Dex IT and Control
Mean arterial pressure							
Before	98.25 ± 16.8	100.6 ± 11.5	94.81 ± 12.7	0.071	0.691	0.418	0.129
min 1	85.86 ± 19.05	92.8 ± 15.1	93 ± 13.2	0.090	0.097	0.060	0.998
min 3	77.2 ± 16.7	83.4 ± 37.6	75.7 ± 16.3	0.820	0.426	0.939	0.283
min 15	79.4 ± 13.7	79.2 ± 11.8	82.1 ± 11.3	0.235	0.997	0.503	0.523
min 30	77.55 ± 11.9	75.35 ± 12.5	80.96 ± 13.7	0.085	0.675	0.346	0.095
min 45	78.54 ± 11.7	72.9 ± 11.9	81.52 ± 12.8	0.007 [b]	0.047 [b]	0.367	0.001 [b]
min 60	83.6 ± 11.3	74.87 ± 11.5	82.64 ± 12	0.001 [b]	0.001 [b]	0.905	0.005 [b]
P value (comparison over time)	P < 0.0001 [b]	P < 0.0001 [b]	P < 0.0001 [b]	0.616 [c]	0.930 [c]	0.370 [c]	0.383 [c]
Before and min 1	-12.39 (-17.16, -7.62) [b]	-7.84 (-12.84, -2.84) [b]	-1.82 (-3.67, 0.031)				
Before and min 3	-21.02 (-26.72, -15.33) [b]	-17.24 (-29.32, -5.15) [b]	-19.14 (-23.55, -14.73) [b]				
Before and min 15	-18.84 (-24.22, -13.46) [b]	-21.41 (-25.77, -17.05) [b]	-12.72 (-17.71, -7.73) [b]				
Before and min 30	-20.7 (-25.87, -15.52) [b]	-25.3 (-29.7, -20.9) [b]	-13.85 (-18.79, -8.91) [b]				
Heart rate							
Before	97.59 ± 18.35	103.95 ± 19.4	102.5 ± 16.1	0.076	0.199	0.328	0.923
min 1	100.29 ± 20.8	106.13 ± 19.8	101.69 ± 17	0.191	0.309	0.925	0.524
min 3	98.5 ± 20.5	101.08 ± 21.4	92.12 ± 26.42	0.048 [b]	0.849	0.318	0.047 [b]
min 15	92.57 ± 17.6	94.8 ± 19.7	94.0 ± 19.7	0.759	0.834	0.918	0.978
min 30	91.76 ± 12.14	91.8 ± 17.12	94.96 ± 17.8	0.764	0.998	0.593	0.656
min 45	88.1 ± 14.22	86.9 ± 12.36	88.14 ± 13.1	0.871	0.900	1.000	0.900
min 60	83.71 ± 12.9	85.0 ± 11	89.2 ± 12.3	0.055	0.865	0.054	0.240
P value (comparison over time)	P < 0.0001 [b]	P < 0.0001 [b]	P < 0.0001 [b]	0.609 [c]	0.339 [c]	0.527 [c]	0.703 [c]
Before and min 1	2.7 (-3.29, 8.71)	2.17 (-3.24, 7.59)	-0.82 (-4.17, 2.52)				
Before and min 3	0.91 (-4.91, 6.74)	-2.87 (-9.17, 3.41)	-10.39 (-18.5, -2.27) [b]				
Before and min 15	-5.01 (-10.76, 0.73)	-9.15 (-16.6, -1.7) [b]	-8.51 (-13.84, -3.18) [b]				
Before and min 30	-5.82 (-11.6, -0.05) [b]	-12.15 (-19.3, -4.99) [b]	-7.54 (-12.42, -2.67) [b]				

[a] Values are expressed as mean ± SD or Mean difference (95% CI).

[b] Significant at the 0.05 level.

[c] Comparison over time between groups.

groups, and higher peri-shivering temperatures in the IT group (1 - 3).

5.1. Comparison With the Literature and Dose Explanation

Our results contrast with prior randomized controlled trials in which IV dexmedetomidine reduced shivering incidence during cesarean delivery, often using larger weight-based doses (2, 4-7). For example, another study reported significant prevention of shivering with 0.5 μg·kg^{-1} IV dexmedetomidine after cord clamping, without major hemodynamic compromise (2). Given that our fixed 10-μg dose corresponds to approximately 0.14 μg·kg^{-1} in an average 70-kg parturient, this relatively low fixed dose is the most likely explanation for the neutral finding regarding shivering incidence. This interpretation is reinforced by a 2023 ED_50/ED_95 study of IV dexmedetomidine for treating established shivering, which suggested an ED_95 of 0.39 μg·kg^{-1}, indicating that higher prophylactic doses may be necessary (6).

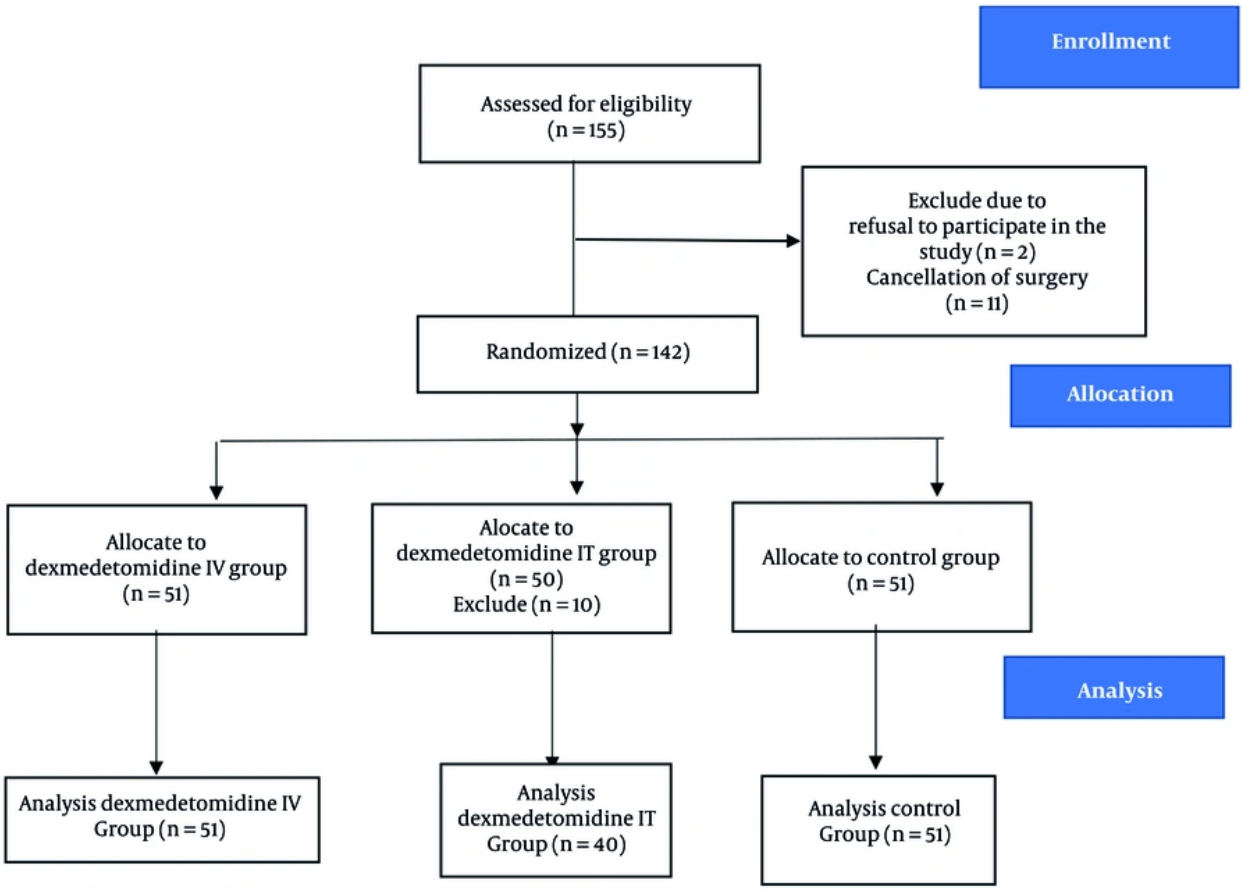

Figure 3. Changes in mean HR over time by the three groups

Recent network meta-analyses confirm the efficacy of IV dexmedetomidine but highlight dose-timing interplay as critical (4, 5).

The literature on IT dexmedetomidine in cesarean anesthesia more consistently demonstrates shivering reduction and block prolongation (3, 8-10, 15). However, most studies compare IT dexmedetomidine with IT placebo rather than directly with IV administration and often use local anesthetic combinations that may synergize with the anti-shivering effects of IT dexmedetomidine. Our head-to-head design found no superiority with equal microgram dosing.

5.2. Benefits Versus Harms

Although the IT group showed lower late-time MAP, there was no significant increase in the incidence of hypotension (MAP < 65 mmHg) or bradycardia (HR < 50 bpm) between groups (Table 3), indicating an acceptable safety profile at this dose. The primary benefit of IT administration was a significant delay in shivering onset and preservation of peri-shivering temperature, a distinct physiological effect likely mediated at the spinal level that may improve patient comfort even without reducing overall incidence. This finding aligns with previous studies reporting segmental modulation of shivering thresholds (7, 11, 12). Dexmedetomidine centrally lowers vasoconstriction and shivering thresholds through α_2-adrenoceptor activation, potentially contributing to temperature-shivering dissociation.

5.3. Limitations

Table 3. Clinical Characteristics Related to Shivering in Patients in the Three Treatment Groups [a]

Variables	Dex IV	Dex IT	Control	P-Value			
				Three Groups	Dex IV and Dex IT	Dex IV and Control	Dex IT and Control
Shivering				0.373	0.836	0.230	0.672
Yes	18 (35.3)	17 (42.5)	25 (49)	0.373	0.836	0.230	0.672
No	33 (64.7)	23 (57.5)	26 (51)	0.373	0.836	0.230	0.672
Shivering intensity				0.445	0.671	0.535	0.263
No to mild shivering (grade 0 - 1)	35 (68.6)	24 (60)	37 (72.5)	0.445	0.671	0.535	0.263
Moderate to very severe shivering (grade 2 - 4)	16 (31.4)	16 (40)	14 (27.5)	0.445	0.671	0.535	0.263
Time of shivering	48.33 ± 15.9	105 ± 21.21	43.75 ± 9.8	< 0.0001	< 0.0001	0.256	< 0.0001
Pethidine prescription	15 (25.9)	13 (32.5)	13 (25.5)	0.711	0.502	0.965	0.445
Ephedrine prescription	39 (67.2)	22 (55)	27 (52.9)	0.263	0.289	0.365	0.957
Temperature before intervention	37.03 ± 0.19	37.26 ± 0.18	36.94 ± 0.14	< 0.0001	< 0.0001	0.052	< 0.0001
Temperature during shivering	36.95 ± 0.21	37.13 ± 0.15	36.85 ± 0.18	< 0.0001	0.015	0.291	< 0.0001

[a] Values are expressed as mean ± SD or No (%).

Limitations include the single-center setting, fixed low-dose regimen, lack of core temperature monitoring, and modest sample size, which limited the power to detect smaller intergroup differences. Moreover, potential confounders such as baseline anxiety, operating room temperature, and transfer origin, which are known shivering risk factors, were not stratified (13-15). The observed difference in mean gravida among groups, although not found to be a significant confounder for shivering incidence, remains a potential limitation in baseline comparability. In interventional studies in our country, obtaining consent is very difficult. Many individuals have an unfavorable view of medications; therefore, we lost a number of patients because they did not consent. In addition, coordinating operating room schedules and patients is difficult. Some patients received the medication, but the effective timing of administration was disrupted, and the patient was excluded from the study. However, we attempted to meet all necessary ethical requirements, and sample collection took about 3 years. Future trials should use dose-finding methods to establish equivalent effective doses for IV and IT dexmedetomidine, use standardized core temperature measurement, and incorporate broader shivering risk stratification.

5.4. Conclusions

At the doses tested, neither IV nor IT dexmedetomidine significantly reduced shivering incidence compared with placebo during elective cesarean spinal anesthesia. Intrathecal dexmedetomidine produced lower late-time MAP and higher peri-shivering temperatures. Optimizing dose and timing is likely essential to realize anti-shivering benefits without compromising maternal hemodynamics.

Footnotes

AI Use Disclosure: The authors declare that no generative AI tools were used in the creation of this article.

Authors' Contribution: Study concept/design: M. M.; Data acquisition: M. S. K. S.; Data analysis/interpretation and statistical analysis: S. S.; Manuscript drafting: T. F.; Critical revision for important intellectual content: M. M.; Administrative/technical/material support and study supervision: M. M.

Clinical Trial Registration Code: IRCT20240524061880N1.

Conflict of Interests Statement: The authors do not declare any conflicts of interests for this study.

Data Availability: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: IR.MUI.MED.REC.1403.062.

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Informed Consent: Informed consent was obtained from all participants.

References

1. Sng BL, Carvalho B. Intrathecal dexmedetomidine for cesarean delivery: a scoping review. *Int J Obstet Anesth*. 2025;**Epub**(6):Online. [PubMed ID: 38215432]. https://doi.org/10.1016/j.ijoa.2024.103980.
2. Nesioonpour S, Bayat S, Ghomeishi A, Behaeen K, Savaie M, Ahmadzadeh A. Effect of Intravenous Dexmedetomidine on Shivering in Cesarean Section under Intrathecal Anesthesia: Randomized Clinical Trial. *Anesth Pain Med*. 2022;**12**(3). [PubMed ID: 36818484]. [PubMed Central ID: PMC9923329]. https://doi.org/10.5812/aapm-122735.
3. Sharma A, Varghese N, Venkateswaran R. Effect of intrathecal dexmedetomidine versus intravenous dexmedetomidine on subarachnoid anesthesia with hyperbaric bupivacaine. *J Anaesthesiol Clin Pharmacol*. 2020;**36**(3):381-385. [PubMed ID: 33487907]. [PubMed Central ID: PMC7812950]. https://doi.org/10.4103/joacp.JOACP_323_17.
4. Ferrea G, Monks DT, Singh PM, Fedoruk K, Singh NP, Blake L, et al. Comparative efficacy of intravenous treatments for perioperative shivering in patients undergoing caesarean delivery under neuraxial anaesthesia: A systematic review and Bayesian network meta-analysis of randomised-controlled trials. *J Clin Anesth*. 2025;**100**. 111680. [PubMed ID: 39608094]. https://doi.org/10.1016/j.jclinane.2024.111680.
5. Shokri M, Bakhtiari Z, Kargar B, Hajialigol A. The Effect of Intravenous Dexmedetomidine During Surgery in the Prevention of Shivering After General Anesthesia in Patients Undergoing Spinal Surgery: A Randomized Clinical Trial. *Anesth Pain Med*. 2025;**15**(2). [PubMed ID: 40717905]. [PubMed Central ID: PMC12297032]. https://doi.org/10.5812/aapm-159077.
6. Yang M, Li S, Drzymalski D, Chen X. Intravenous Bolus of Dexmedetomidine for Treatment of Severe Shivering After Caesarean Delivery Under Combined Spinal-Epidural Anaesthesia: A Randomized Dose-Response Study. *Drug Des Devel Ther*. 2024;**Volume 18**:2393-2402. [PubMed ID: 38911029]. [PubMed Central ID: PMC11193989]. https://doi.org/10.2147/DDDT.S456289.
7. Kim SH, Sul Y, Ye JB, Lee JY, Lee JS. Dexmedetomidine-associated hypothermia in critical trauma: A case report and literature analysis. *Medicine (Baltimore)*. 2025;**104**(3):e41349. [PubMed ID: 39833034]. [PubMed Central ID: PMC11749715]. https://doi.org/10.1097/MD.0000000000041349.
8. Giaccari LG, Coppolino F, Aurilio C, Pace MC, Passavanti MB, Pota V, et al. Is intrathecal bupivacaine plus dexmedetomidine superior to bupivacaine in spinal anesthesia for a cesarean section? A systematic review and meta-analysis. *Eur Rev Med Pharmacol Sci*. 2024;**28**(15):4067-4079. [PubMed ID: 39194198]. https://doi.org/10.26355/eurrev_202408_36638.
9. Zhang Q, Xia LY, Liang WD, Rao DY, Zhu PP, Huang KN, et al. Intrathecal Dexmedetomidine Combined With Ropivacaine in Cesarean Section: A Prospective Randomized Double-Blind Controlled Study. *Front Med (Lausanne)*. 2022;**9**. 922611. [PubMed ID: 35872755]. [PubMed Central ID: PMC9301008]. https://doi.org/10.3389/fmed.2022.922611.
10. Medeiros H, Amaral S, Lombardi RA, Korn E, Mueller A, Trevisan LP, et al. Effects of combined intrathecal dexmedetomidine and local anaesthetic on analgesia duration of spinal anaesthesia: a systematic review and meta-analysis of randomised controlled trials. *Br J Anaesth*. 2025;**134**(5):1580-1587. [PubMed ID: 40113480]. https://doi.org/10.1016/j.bja.2025.02.022.
11. Doufas AG, Lin CM, Suleman MI, Liem EB, Lenhardt R, Morioka N, et al. Dexmedetomidine and meperidine additively reduce the shivering threshold in humans. *Stroke*. 2003;**34**(5):1218-1223. [PubMed ID: 12690216]. https://doi.org/10.1161/01.STR.0000068787.76670.A4.
12. Omar H, Aboella WA, Hassan MM, Hassan A, Hassan P, Elshall A, et al. Comparative study between intrathecal dexmedetomidine and intrathecal magnesium sulfate for the prevention of post-spinal anaesthesia shivering in uroscopic surgery; (RCT). *BMC Anesthesiol*. 2019;**19**(1). 190. [PubMed ID: 31651246]. [PubMed Central ID: PMC6814123]. https://doi.org/10.1186/s12871-019-0853-0.
13. Qi X, Chen D, Li G, Cao J, Yan Y, Li Z, et al. Risk factors associated with intraoperative shivering during caesarean section: a prospective nested case-control study. *BMC Anesthesiol*. 2022;**22**(1). 56. [PubMed ID: 35227213]. [PubMed Central ID: PMC8883627]. https://doi.org/10.1186/s12871-022-01596-7.
14. Neaton K, Voldanova L, Kiely T, Nagle C. Non-pharmacological treatments for shivering post neuraxial anaesthesia for caesarean section: a scoping review. *Contemp Nurse*. 2024;**60**(1):42-53. [PubMed ID: 38300736]. https://doi.org/10.1080/10376178.2024.2310256.
15. Ahsan B, Majedi MA, Sin Darreh S, Masaeli M. Is Dexmedetomidine Effective on Postoperative Shivering in Patients Undergoing General Anesthesia for an Appendectomy? A Double-Blind, Randomized Clinical Trial. *Interv Pain Med Neuromod*. 2023;**In Press**(In Press). https://doi.org/10.5812/ipmn-140583.