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Research Article

Dose-Dependent Preventive Analgesic Effects of Intravenous Dexamethasone versus Paracetamol after Cesarean Section under Spinal Anesthesia: A Randomized Triple-Blind Controlled Trial

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ABSTRACT

Background: Effective management of post-cesarean pain remains an important clinical challenge. Both glucocorticoids and paracetamol are used as preventive analgesics, but the optimal dose of dexamethasone and its comparative efficacy versus paracetamol are not well established. This study evaluated the preventive analgesic effects of three intravenous dexamethasone doses (2, 4, and 6 mg) compared with intravenous paracetamol and placebo on somatic and visceral pain after elective cesarean section under spinal anesthesia.

Methods: In this randomized triple-blind controlled trial, 235 women (ASA II, aged 18–45 years) undergoing elective cesarean section were allocated to five groups: dexamethasone 2 mg (Dexa 2, n=42), dexamethasone 4 mg (Dexa 4, n=50), dexamethasone 6 mg (Dexa 6, n=43), paracetamol 1 g (PARA, n=49), and control (Control, n=51). All patients received spinal anesthesia with 2.5 mL hyperbaric bupivacaine 0.5%. Somatic pain (VAS 0–10) was assessed at 2, 4, and 6 hours postoperatively, and visceral pain (during uterine massage) at 2 and 6 hours. Rescue analgesia (meperidine 25 mg) was administered when VAS exceeded 3. Analgesic requirement, spinal block onset time, and peak sensory level were recorded. Multiple linear regression was performed to identify predictors of pain at 6 hours.

Results: Baseline characteristics were comparable between groups except for gravidity (p=0.002). At 2 hours, somatic pain was lowest in the Dexa 4 (2.32±0.62) and Dexa 6 (2.20±0.63) groups, both significantly lower than control (3.86±0.93), paracetamol (3.36±0.56), and Dexa 2 (2.80±0.80) (all p<0.001). At 4 hours, Dexa 4 showed higher somatic pain (5.14±0.80) than Dexa 2 (4.02±0.81), Dexa 6 (4.09±0.92), and paracetamol (3.95±1.05) (all p<0.001) and was comparable to control (4.86±0.89). No significant differences were observed at 6 hours (p=0.251). Visceral pain at 2 hours was lowest in the Dexa 2 group (5.0±0.93), significantly lower than Dexa 4 (5.74±0.75) and paracetamol (6.0±0.81), while the control group

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had the highest scores (8.23±0.61) (all p<0.001). By 6 hours, visceral pain scores were similar across groups (p=0.995). Rescue analgesia at 2 hours was required in 0% (Dexa 6), 2% (Dexa 4), 23.8% (Dexa 2), 32.7% (paracetamol), and 68.6% (control). At 4 hours, the proportions were 90.5%, 70.0%, 93.0%, 69.4%, and 90.2%, respectively. Dexa 4 demonstrated the fastest spinal block onset (24.06±1.05 s, p<0.001). Regression analysis showed that in the Dexa 2 group, higher gestational age predicted lower visceral pain at 6 hours (β=−0.10, p=0.044), while in the Dexa 4 group, higher maternal age (β=0.061, p=0.005) and BMI (β=0.064, p=0.008) predicted higher visceral pain.

Conclusion: Preoperative dexamethasone and paracetamol both improved early postoperative analgesia after cesarean section under spinal anesthesia. Dexamethasone 6 mg provided the greatest reduction in early somatic pain and analgesic requirement, whereas dexamethasone 2 mg showed a more favorable effect on early visceral pain. The observed variability in analgesic response across doses suggests a complex dose and time-dependent effect of dexamethasone, warranting further investigation.

Introduction

Cesarean section is one of the most commonly performed surgical procedures worldwide, and spinal anesthesia is widely considered the preferred anesthetic technique because of its rapid onset, dense neural blockade, and favorable maternal and neonatal safety profile [1-2]. Despite advances in obstetric anesthesia, postoperative pain following cesarean section remains a significant clinical concern that may interfere with early ambulation, breastfeeding, maternal–infant bonding, and overall recovery [1–4]. Inadequate postoperative analgesia has also been associated with delayed functional recovery and increased risk of persistent postoperative pain [5]. Current recommendations emphasize the use of multimodal and opioid sparing analgesic strategies for cesarean delivery. Procedure specific postoperative pain management guidelines, including the PROSPECT recommendations, advocate combining neuraxial anesthesia with systemic non opioid analgesics to improve analgesia while minimizing opioid related adverse effects [6-7].

Among these agents, intravenous dexamethasone has attracted increasing attention because of its anti inflammatory, antiemetic, and potential analgesic properties. Previous studies and meta analyses suggest that perioperative dexamethasone may reduce postoperative pain intensity and opioid requirements in various surgical procedures, including cesarean section [6-7].

The analgesic effect of dexamethasone is believed to be mediated through inhibition of inflammatory mediators, suppression of cytokine release, and modulation of central sensitization pathways involved in pain processing [8-13] [10–13].

However, the optimal dose of intravenous dexamethasone for preventive analgesia in cesarean section remains unclear. Previous studies have used varying doses, and dose response data in obstetric anesthesia are limited. In a recent study from our group, we investigated the lowest effective dose of intravenous dexamethasone for shivering prophylaxis during obstetric spinal anesthesia, highlighting the importance of dose selection in this population [14]. Intravenous paracetamol is another commonly used non opioid analgesic with a well established safety profile in obstetric patients and breastfeeding mothers. It has been shown to reduce postoperative pain and opioid consumption after cesarean delivery and is frequently included in multimodal analgesic protocols [8,15]. Importantly, pain after cesarean section includes both somatic pain from the abdominal incision and visceral pain related to uterine manipulation and contraction, which may respond differently to pharmacological interventions [16-17]. Therefore, the present randomized triple blind controlled trial was designed to compare the preventive analgesic effects of three doses of intravenous dexamethasone (2, 4, and 6 mg) with intravenous paracetamol (1 g) and a placebo on postoperative pain after an elective cesarean section under spinal anesthesia.

Methods

Study design and setting

This prospective, randomized, triple-blind controlled clinical trial was conducted at Beheshti Hospital, affiliated with Isfahan University of Medical Sciences, Isfahan, Iran, between October 2025 and January 2026. The study protocol received approval from the institutional ethics committee (IR.ARI.MUI.REC.1404.197) and was prospectively registered in the Iranian Registry of Clinical Trials (IRCT20240221061070N11). All procedures were performed in accordance with the ethical standards outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants before enrollment in the study.

Participants

Parturients aged 18–45 years with American Society of Anesthesiologists (ASA) physical status II who were scheduled for elective cesarean section under spinal anesthesia were considered eligible for participation. Patients were excluded if they had a history of neurological disease, contraindications to neuraxial anesthesia, known allergy or hypersensitivity to any of the study medications, chronic use of analgesic drugs, or if emergency cesarean delivery was required. Procedures lasting longer than 90 minutes were excluded from the final analysis because the study protocol was designed for surgeries expected to be completed within this time frame.

Sample size calculation

Based on a previous study with mean pain scores of 0.84±0.72 and 0.54±0.28 in two groups, a two-sided α of 0.05, and power of 80%, the calculated sample size was 15 per group. To account for dropouts and protocol violations, we enrolled 40 to 50 per group, yielding a total of 235 patients.

Randomization and blinding

Participants were randomly allocated into five groups using computer-generated randomization with sealed opaque envelopes. The study groups included:

- Dexamethasone 2 mg
- Dexamethasone 4 mg
- Dexamethasone 6 mg
- Intravenous paracetamol 1 g
- Placebo (normal saline)

The preparation of the intravenous study medications was performed by an anesthesiologist who was not involved in patient management or data collection. Patients, anesthesiologists administering anesthesia, surgeons, and outcome assessors were all blinded to group allocation.

Anesthesia and interventions

Upon arrival in the operating room, standard monitoring, including electrocardiography, noninvasive blood pressure, and pulse oximetry, was applied. Two 18-gauge intravenous cannulas were inserted. Patients received preloading with warmed Ringer's lactate solution (10 mL/kg) over approximately 30 minutes.

Spinal anesthesia was performed at the L4–L5 interspace using a 26-gauge Quincke needle in the sitting position and paramedian approach. Hyperbaric bupivacaine 0.5% (2.5 mL; 12.5 mg) was injected intrathecally.

Immediately after the establishment of spinal anesthesia, patients received the allocated intravenous study medication. Dexamethasone or a placebo was administered intravenously over approximately one minute. Intravenous paracetamol (1 g) was infused over 10 minutes. Hypotension, defined as a decrease in systolic blood pressure greater than 20% from baseline, was treated with intravenous ephedrine 10 mg. Bradycardia (heart rate <50 beats/min) was treated with atropine 0.5 mg intravenously. All patients received metoclopramide 10 mg intravenously as prophylaxis for nausea and vomiting.

Outcome measures

The primary outcome of the study was the need for rescue analgesia within the first six hours after surgery.

Secondary outcomes included postoperative pain intensity assessed using the visual analog scale (VAS) at 0, 2, 4, and 6 hours after surgery and visceral pain. Uterine massage is routinely performed in the early postpartum period to assess uterine tone and to detect possible uterine atony.

In our institution, this procedure is carried out when the patient is transferred from the recovery room to the ward and again several hours after discharge from the operating room (approximately 4 hours after admission to the ward).

Although clinically necessary, uterine massage is commonly associated with significant discomfort and pain for postpartum patients. Therefore, this study was designed to evaluate the effects of different drug dosages administered in various intervention groups on patients' responses to uterine massage. Rescue analgesia was administered when the VAS pain score exceeded 4**.**

Statistical analysis

Data are summarized using mean ± standard deviation for continuous measures and number (percentage) for categorical variables. Intergroup differences in baseline parameters and postoperative pain scores were evaluated via one-way ANOVA, followed by Tukey's test for post-hoc pairwise comparisons. Categorical outcomes were analyzed with the Chi-square test or Fisher's exact test, as appropriate. Changes in pain scores within each group across time points were examined using repeated-measures ANOVA.

To identify predictors of pain at 6 hours postoperatively, multiple linear regression was employed, incorporating age, BMI, gravidity, and gestational age as independent variables; results are reported as standardized beta coefficients with 95% confidence intervals. All statistical analyses were performed using SPSS software (version 27), with a two-tailed P value < 0.05 considered statistically significant.

Results

A total of 235 participants were enrolled and allocated to five groups: Dexa-2 (n=42), Dexa-4 (n=50), Dexa-6 (n=43), paracetamol (PARA, n=49), and control (n=51)

(Figure 1). As shown in (Table 1), the groups were well-balanced for age, height, weight, BMI (with the corrected value for control: 33.22 ± 5.1 kg/m²), gestational week, and preoperative systolic/diastolic blood pressure, mean arterial pressure, and heart rate (all $p > 0.05$). Gravidity differed significantly ($p = 0.002$), with the Dexa-4 and Dexa-6 groups having higher mean gravidity compared to the control and Dexa-2.

Somatic pain ((Table 2), Appendix 1)

A statistically significant difference between groups was present at 2 hours ($p < 0.001$) and 4 hours ($p < 0.001$) but not at 6 hours ($p = 0.251$). Somatic pain increased significantly over time within each group (repeated-measures ANOVA, $p < 0.001$ for all) (Table 2).

At 2 hours postoperatively, all dexamethasone groups had significantly lower somatic pain scores compared to the control group (all $p < 0.001$) and compared to the paracetamol group ($p = 0.003$ for Dexa-2, $p < 0.001$ for Dexa-4 and Dexa-6). Dexa-4 and Dexa-6 also showed significantly lower pain than Dexa-2 ($p = 0.015$ and $p = 0.002$, respectively).

At 4 hours, a striking shift occurred. The Dexa-4 group's somatic pain score became the highest among all active treatments (5.14 ± 0.8), significantly greater than Dexa-2 (4.02 ± 0.81), Dexa-6 (4.09 ± 0.92), and paracetamol (3.95 ± 1.05), with all $p < 0.001$. The Dexa-4 group was comparable to the control group (4.86 ± 0.89, $p = 1.000$). Dexa-2, Dexa-6, and paracetamol showed similarly lower pain levels at this time point ($p = 1.000$ for pairwise comparisons between them).

At 6 hours, no significant differences were found between any groups (all $p > 0.05$), indicating convergence of pain intensity to a higher level (all means 6.69-7.04).

Visceral pain (Table 2)

Significant intergroup differences were present at 2 hours ($p < 0.001$) but not at 6 hours ($p = 0.995$). Visceral pain increased over time in all groups except the control, where it remained high throughout ($p = 0.097$ for control) (Table 2).

At 2 hours, the control group reported the highest visceral pain (8.23 ± 0.61), significantly greater than all other groups ($p < 0.001$ for each). Among the intervention groups, the Dexa-2 group provided the lowest visceral pain score (5.0 ± 0.93), which was significantly better than Dexa-4 (5.74 ± 0.75, $p < 0.001$) and paracetamol (6.0 ± 0.81, $p < 0.001$) and similar to Dexa-6 (5.3 ± 1.05, $p = 0.980$). The paracetamol group had higher visceral pain than the Dexa-6 group ($p = 0.001$).

At 6 hours, all groups, including control, reported similarly high visceral pain scores (range 7.95-8.02, overall $p = 0.995$), with all pairwise comparisons yielding $p > 0.975$.

Analgesic requirements and spinal block characteristics ((Table 3), Appendix 2)

The need for supplemental rescue analgesia varied markedly between groups at 2 hours ($p < 0.001$) and 4 hours ($p < 0.001$). At 6 hours, all patients in every group had received rescue analgesia (100% in all groups, no statistical comparison performed).

At 2 hours, no patient in the Dexa-6 group (0%) required rescue analgesia, and only 2% of those in the Dexa-4 group did so. The Dexa-2 group had a requirement of 23.8%, paracetamol 32.7%, and control 68.6%. Pairwise comparisons (Appendix 2) showed that the Dexa-2 group was not significantly different from the paracetamol group ($P = 0.352$), whereas both Dexa-4 and Dexa-6 were significantly superior to paracetamol ($p < 0.001$). All active treatments were superior to control.

At 4 hours, using the corrected data derived from raw patient counts, the numbers requiring rescue analgesia were: Dexa-2, 38 out of 42 (90.5%); Dexa-4, 35 out of 50 (70.0%); Dexa-6, 40 out of 43 (93.0%); paracetamol, 34 out of 49 (69.4%); and control, 46 out of 51 (90.2%). Consequently, the Dexa-4 and paracetamol groups had the lowest analgesic requirement at this time point, significantly lower than Dexa-2, Dexa-6, and control (all $p < 0.001$ to $p = 0.002$). The difference between Dexa-4 and paracetamol was not significant ($p = 0.990$).

Regarding spinal block characteristics, onset time differed significantly across groups ($p < 0.001$), with the Dexa 4 group showing the fastest onset (24.06 ± 1.05 seconds).

However, most pairwise differences were small (1–1.5 seconds) and of questionable clinical relevance. The peak sensory block level did not differ among the five groups ($p = 0.750$), with all groups achieving a mean level around T4 (range 4.23–4.50).

In group-specific multiple linear regression models using age, BMI, gravidity, and gestational week as independent predictors of total pain score and visceral pain score at 6 hours, only three associations reached statistical significance ($p < 0.05$). In the Dexa 2 group, greater gestational age was significantly associated with lower visceral pain scores ($\beta = -0.10$, 95% CI: -0.20 to -0.002; $p = 0.044$). In the Dexa 4 group, both older maternal age ($\beta = 0.061$, 95% CI: 0.019 to 0.100; $p = 0.005$) and higher BMI ($\beta = 0.064$, 95% CI: 0.017 to 0.110; $p = 0.008$) were significantly associated with higher visceral pain scores. No other demographic or clinical variables showed a statistically significant relationship with either total pain or visceral pain in any of the other groups (Dexa 6, paracetamol, or control) (Table 4).

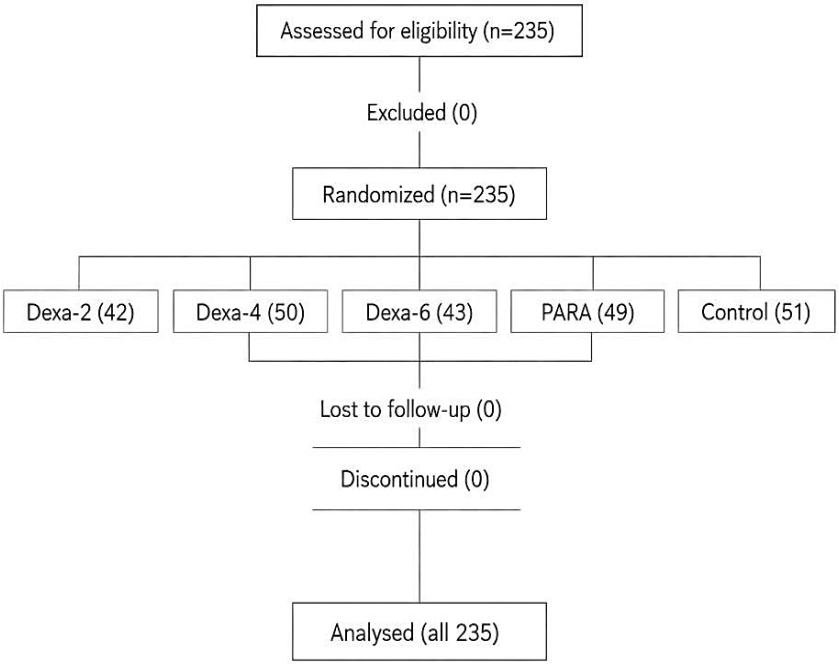

Figure 1- CONSORT flow diagram of participant enrollment and allocation.

Table 1- Baseline demographic and clinical characteristics.

Variable	Dexa-2 (n=42)	Dexa-4 (n=50)	Dexa-6 (n=43)	PARA (n=49)	Control (n=51)	P value
Age (years)	30.11 ± 6.73	32.8 ± 5.29	32.0 ± 6.15	31.97 ± 5.66	33.1 ± 5.84	0.249
Height (cm)	160.43 ± 5.81	161.72 ± 6.48	162.12 ± 6.35	160.86 ± 9.94	160.2 ± 14.7	0.885
Weight (kg)	75.26 ± 13.6	77.74 ± 12.7	76.14 ± 16.23	80.59 ± 13.25	78.43 ± 13.37	0.928
BMI (kg/m²)	29.31 ± 5.69	29.76 ± 4.86	28.9 ± 5.39	31.19 ± 5.1	33.22 ± 5.4	0.286
Gravidity	1.96 ± 0.95	2.96 ± 1.69	2.63 ± 1.38	2.37 ± 1.23	1.76 ± 0.71	0.002
Pregnancy week	36.86 ± 2.71	36.66 ± 1.88	35.98 ± 1.44	36.22 ± 2.55	37.51 ± 1.15	0.388
Systolic BP (mmHg)	131.33 ± 15.6	132.9 ± 15.0	130.23 ± 16.91	128.59 ± 17.42	125.86 ± 14.8	0.481
Diastolic BP (mmHg)	84.59 ± 16.65	81.6 ± 13.73	78.32 ± 15.93	82.42 ± 14.85	79.29 ± 13.56	0.562
MAP (mmHg)	100.17 ± 15.17	98.7 ± 12.59	95.62 ± 15.12	97.81 ± 14.87	94.81 ± 12.7	0.087
HR (bpm)	104.97 ± 12.8	104.66 ± 18.17	104.0 ± 16.5	99.36 ± 16.86	102.5 ± 16.1	0.113

Data are presented as mean ± SD. P values were calculated using one-way ANOVA. BMI, body mass index; BP, blood pressure; MAP, mean arterial pressure; HR, heart rate. Preoperative values are shown for all vital signs.

Table 2- Postoperative somatic and visceral pain scores over time.

Variable	Time	Dexa-2	Dexa-4	Dexa-6	PARA	Control	P value (between groups)
Somatic pain	2h	2.8 ± 0.8	2.32 ± 0.62	2.2 ± 0.63	3.36 ± 0.56	3.86 ± 0.93	<0.001
	4h	4.02 ± 0.81	5.14 ± 0.8	4.09 ± 0.92	3.95 ± 1.05	4.86 ± 0.89	<0.001
	6h	6.97 ± 0.84	7.0 ± 0.83	7.04 ± 0.81	6.69 ± 0.82	6.96 ± 0.82	0.251
P (over time)		<0.001	<0.001	<0.001	<0.001	<0.001	
Visceral pain	2h	5.0 ± 0.93	5.74 ± 0.75	5.3 ± 1.05	6.0 ± 0.81	8.23 ± 0.61	<0.001
	6h	7.97 ± 0.86	7.96 ± 0.83	8.02 ± 0.83	7.95 ± 0.81	8.0 ± 0.82	0.995
P (over time)		<0.001	<0.001	<0.001	<0.001	0.097	

Values are mean ± SD on a 0-10 VAS. Between-group comparisons at each time point were made with one-way ANOVA; within-group changes over time were assessed using repeated-measures ANOVA. Detailed pairwise comparisons are provided in Appendix 1.

Table 3- Analgesic use, spinal block onset time, and peak sensory level.

Time / Variable	Dexa-2 (n=42)	Dexa-4 (n=50)	Dexa-6 (n=43)	PARA (n=49)	Control (n=51)	P value
Analgesic use, n (%)						
2h	10 (23.8%)	1 (2.0%)	0 (0%)	16 (32.7%)	35 (68.6%)	<0.001
4h	38 (90.5%)	35 (70.0%)	40 (93.0%)	34 (69.4%)	46 (90.2%)	<0.001
6h	42 (100%)	50 (100%)	43 (100%)	49 (100%)	51 (100%)	–
Onset time (sec)	25.11 ± 1.46	24.06 ± 1.05	25.55 ± 1.22	24.85 ± 1.22	24.68 ± 1.48	<0.001
Block level (peak)	4.38 ± 1.18	4.50 ± 1.12	4.23 ± 0.81	4.32 ± 0.92	4.43 ± 0.92	0.75

Analgesic use is shown as n (%). Onset time and block level are mean ± SD. P values from chi-square test (analgesic use) or one-way ANOVA (onset time, block level). Corrected 4-hour numbers are derived from raw patient counts. Detailed pairwise comparisons are in Appendix 2.

Table 4- Regression analysis: predictors of pain at 6 hours.

Group	Independent variable	Dependent: total pain		Dependent: visceral pain	
		β (95% CI)	P	β (95% CI)	P
Dexa-2	Age	0.014 (-0.02, 0.05)	0.478	-0.019 (-0.06, 0.02)	0.345
	BMI	0.001 (-0.05, 0.05)	0.966	-0.002 (-0.05, 0.05)	0.919
	Gravidity	0.107 (-0.17, 0.39)	0.443	0.053 (-0.23, 0.34)	0.713
	Pregnancy week	0.009 (-0.09, 0.10)	0.848	-0.10 (-0.20, -0.002)	0.044
Dexa-4	Age	0.009 (-0.03, 0.05)	0.678	0.061 (0.019, 0.10)	0.005
	BMI	0.03 (-0.02, 0.08)	0.222	0.064 (0.017, 0.11)	0.008
	Gravidity	0.014 (-0.12, 0.15)	0.842	0.035 (-0.11, 0.18)	0.622
	Pregnancy week	-0.046 (-0.17, 0.08)	0.471	-0.119 (-0.24, 0.004)	0.058
Dexa-6	Age	0.02 (-0.02, 0.06)	0.331	-0.002 (-0.04, 0.04)	0.906
	BMI	0.044 (-0.003, 0.092)	0.067	-0.009 (-0.056, 0.04)	0.697
	Gravidity	0.121 (-0.06, 0.30)	0.185	0.130 (-0.05, 0.31)	0.165
	Pregnancy week	-0.048 (-0.12, 0.02)	0.192	-0.046 (-0.12, 0.02)	0.22
PARA	Age	-0.006 (-0.04, 0.03)	0.762	-0.031 (-0.07, 0.01)	0.135
	BMI	0.014 (-0.03, 0.06)	0.528	0.039 (-0.01, 0.09)	0.115
	Gravidity	-0.006 (-0.20, 0.19)	0.945	-0.167 (-0.35, 0.02)	0.079
	Pregnancy week	-0.062 (-0.15, 0.03)	0.179	-0.056 (-0.15, 0.03)	0.227
Control	Age	0.009 (-0.039, 0.042)	0.949	-0.087 (-0.05, -0.03)	0.543
	BMI	0.103 (-0.033, 0.070)	0.473	-0.074 (-0.07, 0.04)	0.606
	Gravidity	-0.016 (-0.352, 0.314)	0.911	-0.068 (-0.20, 0.37)	0.634
	Pregnancy week	-0.084 (-0.264, 0.144)	0.559	0.063 (-0.16, 0.25)	0.661

Independent variables: age, BMI, gravidity, and gestational week entered simultaneously. β = standardized beta coefficient; CI = confidence interval.

Discussion

The present randomized triple-blind controlled trial evaluated the preventive analgesic effects of three different doses of intravenous dexamethasone (2, 4, and 6 mg) compared with intravenous paracetamol (1 g) and placebo in women undergoing elective cesarean section under spinal anesthesia. The main findings of this study were that all active treatments reduced early postoperative pain compared with placebo, but the magnitude and temporal pattern of analgesia varied between the interventions. Higher doses of dexamethasone were more effective in reducing early somatic pain and the need for rescue analgesia, whereas the lowest dexamethasone dose showed the most favorable effect on visceral pain during the early postoperative period. By six hours after surgery, pain scores converged across all groups, suggesting that the analgesic benefit of a single preoperative dose is primarily limited to the early postoperative phase.

Postoperative pain after cesarean delivery remains a clinically important problem despite advances in obstetric anesthesia. Effective analgesia facilitates early mobilization, improves maternal comfort, and supports breastfeeding and maternal–infant bonding [1–3]. Consequently, contemporary guidelines emphasize the use of multimodal analgesia to reduce reliance on opioids and minimize opioid-related adverse effects such as nausea, vomiting, and sedation [5]. Non-opioid agents, including paracetamol and corticosteroids, play an important role within these multimodal strategies.

Our findings regarding dexamethasone are consistent with previous studies demonstrating that perioperative corticosteroids can reduce postoperative pain and opioid consumption. Meta-analyses have shown that dexamethasone administered before or during surgery significantly decreases postoperative pain intensity and analgesic requirements across a range of surgical procedures, including cesarean delivery [6-7]. The analgesic effect of dexamethasone is thought to result

from its anti-inflammatory properties, including inhibition of phospholipase A2 activity, reduction of prostaglandin synthesis, and suppression of pro-inflammatory cytokine release [10-11]. In addition, experimental studies suggest that glucocorticoids may modulate nociceptive processing at the level of the spinal cord and central nervous system, thereby attenuating central sensitization after surgical injury [12-13].

In the present study, dexamethasone at doses of 4 mg and 6 mg provided superior control of somatic pain during the first two postoperative hours compared with both paracetamol and placebo. This observation aligns with previous clinical trials suggesting that moderate doses of dexamethasone (commonly 4–8 mg) are associated with improved early postoperative analgesia [6-7]. Interestingly, however, the analgesic profile observed in our study did not follow a strictly linear dose–response pattern. At four hours after surgery, the group receiving 4 mg dexamethasone reported higher somatic pain scores than the other active treatment groups, while simultaneously demonstrating one of the lowest requirements for rescue analgesia. Although the clinical significance of this finding remains uncertain, it highlights the complexity of glucocorticoid pharmacodynamics and suggests that analgesic efficacy may depend not only on dose but also on timing and interaction with other components of multimodal analgesia. Another notable finding of the present study relates to visceral pain. Cesarean delivery produces both somatic pain from the abdominal incision and visceral pain related to uterine manipulation and contraction. These two pain components involve different neural pathways and may respond differently to pharmacological interventions [14]. Visceral pain is primarily mediated by unmyelinated C-fiber afferents and involves distinct spinal and supraspinal processing mechanisms compared with somatic pain [14-15]. In our study, the lowest visceral pain scores at two hours were observed in the dexamethasone 2 mg group, suggesting that lower corticosteroid doses may still exert meaningful effects on visceral nociception. However, the clinical relevance of this difference should be interpreted cautiously because visceral pain scores increased substantially in all groups by six hours. Intravenous paracetamol also demonstrated a beneficial effect compared with placebo, although its analgesic efficacy was generally less pronounced than that observed with higher doses of dexamethasone during the early postoperative period. Paracetamol is widely used in postoperative pain management because of its favorable safety profile, minimal effects on platelet function, and compatibility with breastfeeding [8,16]. Previous studies have shown that intravenous paracetamol can reduce postoperative opioid consumption and improve pain control after cesarean delivery when incorporated into multimodal analgesic regimens [8, 18-20]. The results of our study support its continued role as a safe and effective component of multimodal analgesia, particularly when combined with other analgesic strategies [22-24].

Several strengths of the present study should be highlighted. First, the randomized triple-blind design minimized the risk of selection, performance, and assessment bias. Second, the inclusion of multiple dexamethasone doses allowed for exploration of potential dose-dependent effects, which remain insufficiently studied in obstetric anesthesia. Third, the comparison with both an active analgesic control (paracetamol) and a placebo provided a clinically relevant context for interpreting the magnitude of the observed analgesic effects. Finally, the study evaluated both somatic and visceral components of postoperative pain, offering a more comprehensive assessment of the pain experience following cesarean delivery.

Nevertheless, several limitations should also be acknowledged. This study was conducted at a single center, which may limit the generalizability of the findings to other institutions or patient populations. Although the overall sample size was adequate for detecting differences in early postoperative pain outcomes, the subgroup sizes within each treatment arm were relatively modest, potentially limiting the statistical power for detecting smaller effects or interactions between patient characteristics and treatment response. In addition, pain was assessed at predefined time points rather than continuously, which may not fully capture the dynamic nature of postoperative pain and analgesic consumption. The follow-up period was limited to the early postoperative hours, and therefore, the longer-term effects of dexamethasone on postoperative pain and recovery were not evaluated. Finally, biochemical markers of inflammation or stress response were not measured, which limits the ability to explore the mechanistic pathways underlying the observed analgesic effects.

Conclusion

In conclusion, the findings of this randomized triple-blind controlled trial suggest that intravenous dexamethasone and paracetamol both contribute to improved early postoperative analgesia after cesarean section under spinal anesthesia. Higher doses of dexamethasone appear to provide greater reduction in early somatic pain and analgesic requirements, while lower doses may also influence visceral pain during the early postoperative period. However, the analgesic benefits of a single preoperative dose appear to diminish within several hours after surgery. These results support the continued use of multimodal analgesic strategies in cesarean delivery and highlight the need for further studies to clarify the optimal dosing and timing of dexamethasone in obstetric anesthesia.

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Appendix

Appendix 1- Pairwise intergroup comparisons of somatic and visceral pain scores (Tukey's post-hoc, P values)

Pain type	Time	Comparison	P value
Somatic	2h	Control vs. Dexa-2	<0.001
		Control vs. Dexa-4	<0.001
		Control vs. Dexa-6	<0.001
		Control vs. PARA	<0.001
		Dexa-2 vs. Dexa-4	0.015
		Dexa-2 vs. Dexa-6	0.002
		Dexa-2 vs. PARA	0.003
		Dexa-4 vs. Dexa-6	1
		Dexa-4 vs. PARA	<0.001
		Dexa-6 vs. PARA	<0.001
Somatic	4h	Control vs. Dexa-2	<0.001
		Control vs. Dexa-4	1
		Control vs. Dexa-6	<0.001
		Control vs. PARA	<0.001
		Dexa-2 vs. Dexa-4	<0.001
		Dexa-2 vs. Dexa-6	1
		Dexa-2 vs. PARA	1
		Dexa-4 vs. Dexa-6	<0.001
		Dexa-4 vs. PARA	<0.001
		Dexa-6 vs. PARA	1
Somatic	6h	All pairwise	>0.05*
Visceral	2h	Control vs. Dexa-2	<0.001
		Control vs. Dexa-4	<0.001
		Control vs. Dexa-6	<0.001
		Control vs. PARA	<0.001
		Dexa-2 vs. Dexa-4	<0.001
		Dexa-2 vs. Dexa-6	0.98
		Dexa-2 vs. PARA	<0.001
		Dexa-4 vs. Dexa-6	0.128
		Dexa-4 vs. PARA	1
		Dexa-6 vs. PARA	0.001
Visceral	6h	All pairwise	>0.975*

Appendix 2- Pairwise comparisons for analgesic use between groups (Tukey's post-hoc, P values)

Time	Comparison	P value
2 h	Dexa-2 vs. Control	<0.001
	Dexa-4 vs. Control	<0.001
	Dexa-6 vs. Control	<0.001
	PARA vs. Control	<0.001
	Dexa-2 vs. Dexa-4	= 0.001
	Dexa-2 vs. Dexa-6	= 0.001
	Dexa-2 vs. PARA	= 0.352 (not significant)
	Dexa-4 vs. Dexa-6	= 0.351
	Dexa-4 vs. PARA	<0.001
	Dexa-6 vs. PARA	<0.001
4 h	Dexa-2 vs. Control	= 0.990
	Dexa-4 vs. Control	<0.001
	Dexa-6 vs. Control	= 0.980
	PARA vs. Control	<0.001
	Dexa-2 vs. Dexa-4	<0.001
	Dexa-2 vs. Dexa-6	= 0.940
	Dexa-2 vs. PARA	<0.001
	Dexa-4 vs. Dexa-6	<0.001
	Dexa-4 vs. PARA	= 0.990
	Dexa-6 vs. PARA	<0.001