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Single-shot Spinal Versus Epidural Analgesia During Early Labor: A Prospective Randomized Trial

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Abstract: Background: Effective pain relief during labor is essential for maternal comfort and favorable obstetric outcomes. Epidural analgesia (EA) is considered the gold standard ; however, single-shot spinal analgesia (SA) using low-dose local anesthetic represents a faster and simpler alternative, particularly in low-resource settings. Evidence for its use in early labor remains limited. Objective: To compare the efficacy, onset, duration, safety, and maternal-neonatal outcomes of single-shot spinal analgesia versus epidural analgesia initiated at 4 cm cervical dilatation. Methods: In this prospective, randomized, open-label, single-center study, 100 ASA I–II parturients in active labor (4 cm cervical dilatation) were allocated into two groups (n = 50 each). The SA group received an intrathecal injection of 5 mg isobaric bupivacaine combined with 5 µg sufentanil. The EA group received epidural administration of 20 mg bupivacaine with 5 µg sufentanil via catheter. Pain was assessed using the visual analog scale (VAS) at regular intervals. Onset and duration of analgesia, sensory level, motor block, labor duration, need for reinjection, maternal satisfaction, adverse events, oxytocin use, mode of delivery, and neonatal Apgar scores were recorded. Results: Spinal analgesia provided a significantly faster onset of pain relief (1.84 ± 1.09 vs. 8.25 ± 1.88 min, $p < 0.001$) and quicker achievement of maximal sensory block. Labor duration was significantly shorter in SA for both primiparous and multiparous women (84.06 ± 12.11 vs. 94.78 ± 14.06 min, $p < 0.0001$). Analgesic efficacy (VAS scores) and maternal satisfaction were comparable between the two groups (96% vs. 90%, $p = 0.42$). Reinjection was required only in the EA group (16%, $p = 0.01$). Adverse maternal and neonatal outcomes, were similar between groups. Conclusion: Single-shot spinal analgesia using low-dose bupivacaine provides rapid, effective, and sustained labor analgesia with a safety profile comparable to epidural analgesia. It may represent a valuable, practical alternative in busy obstetric units or resource-limited settings.

Keywords: Labor analgesia, spinal analgesia, epidural analgesia, bupivacaine, single-shot.

INTRODUCTION

Effective pain relief during labor remains a central concern in obstetric anesthesia, and the choice of optimal analgesic technique continues to be a subject of debate. Several approaches have been described, including epidural analgesia, pudendal nerve block, and acupuncture. Among these, epidural analgesia (EA) has long been regarded as the gold standard for intrapartum pain management due to its proven efficacy and flexibility in dose titration [1].

In recent years, however, single-shot spinal analgesia (SA) using low doses of local anesthetics combined with opioids has gained increasing attention as a simple, rapid, and effective alternative, particularly in settings with limited resources or when rapid pain relief is desired [2]. Most studies have evaluated this technique when administered in the advanced stages of labor, yet evidence supporting its use at the onset of labor remains limited.

The present study aims to evaluate the efficacy and safety of a single intrathecal injection of 5 mg bupivacaine combined with 5 µg sufentanil administered at 4 cm cervical dilatation. We hypothesized that single-dose spinal analgesia provides comparable pain relief to epidural analgesia, with a faster onset and similar maternal and neonatal outcomes.

Ethical Considerations

This study was conducted in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice (GCP) guidelines. The research protocol was reviewed and approved by the Institutional Ethics Committee of the Bab El Oued University Hospital on September 15, 2024 (approval number: 02/24). All parturients were informed about the study objectives, procedures, potential benefits, and risks. Written informed consent was obtained from each participant prior to inclusion. Confidentiality and anonymity of the participants were strictly maintained throughout data collection, analysis, and publication. No identifying personal information was recorded or disclosed at any stage of the study.

MATERIALS AND METHODS

Study Population

This study included all consenting parturients classified as American Society of Anesthesiologists (ASA) physical status I or II, aged between 18 and 42 years, either primiparous or multiparous, and with a full-term singleton pregnancy. Eligible participants were required to be in active labor with cervical dilatation of 4 cm, a favorable Bishop score, a live fetus in cephalic presentation, and a reassuring fetal heart rate pattern on admission.

Exclusion criteria included a known allergy to local anesthetics, any contraindication to neuraxial anesthesia, ASA physical status greater than II, gestational age below 38 weeks, multiple gestation, or intrauterine fetal demise.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 18.0; IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared between groups using the independent Student's *t*-test. Categorical variables were presented as frequencies and percentages, and comparisons were made using the chi-square or Fisher's exact test, as appropriate. A *p*-value of less than 0.05 was considered statistically significant. The sample size was calculated to include 100 parturients (50 per group), providing 90% power to detect a significant difference between groups, with a two-sided alpha level of 0.05.

Study Design and Procedure

The study was conducted at the "Ibrahim Gharafa" Gyneco-Obstetrics Clinic, Bab El Oued University Hospital, between October 2024 and January 2025. It was designed as a prospective, randomized, single-center, single-blinded, comparative trial aimed at

evaluating the efficacy and safety of single-dose spinal analgesia as an alternative to epidural analgesia for labor pain management. Due to the nature of the interventions, neither the participants nor the care providers could be blinded to group allocation ; therefore, blinding was limited to the outcome assessor, who remained unaware of the assigned intervention throughout the study period. Randomization was performed using the sealed-envelope method. A set of opaque, sequentially numbered envelopes containing group allocations was prepared in advance by an independent investigator, and each envelope was opened only after participant inclusion to ensure proper allocation concealment. Eligible parturients were then assigned to either the epidural analgesia (EA) group or the single-dose spinal analgesia (SA) group accordingly.

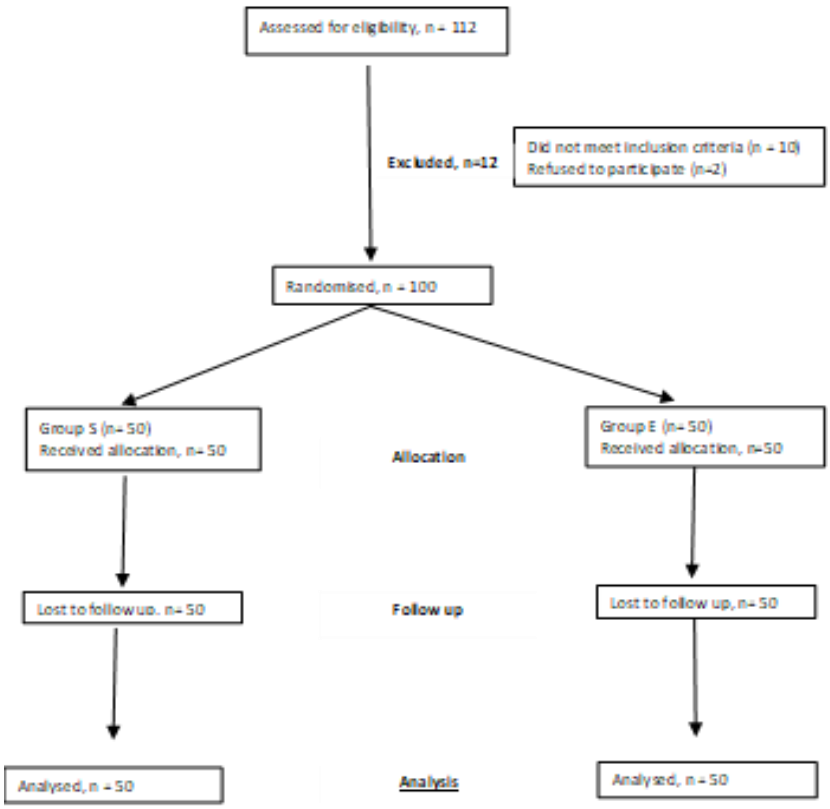


Figure 1: Flow chart of the study

In the delivery room, after obtaining written informed consent and before initiating the analgesic procedure, all parturients were monitored, and baseline data were recorded on a standardized data collection form. Demographic characteristics (age, height, weight, parity), baseline hemodynamic parameters (blood pressure and heart rate), respiratory parameters (respiratory rate and SpO_2), initial pain score using the visual analog scale (VAS), and cervical dilatation were documented.

Following the gynecological examination and confirmation of 4 cm cervical dilatation, all parturients underwent baseline monitoring, including heart rate, noninvasive blood pressure (NIBP), pulse oximetry (SpO_2), respiratory rate, and continuous cardiac rhythm monitoring in lead II. A reliable 18-gauge intravenous line was inserted for fluid and drug administration.

In the spinal analgesia group, parturients received a single intrathecal injection at the L4–L5 interspace using a 27-gauge spinal needle. The injectate consisted of 1 mL (5 mg) of 0.5% hyperbaric bupivacaine combined with 5 µg of sufentanil.

In the epidural analgesia group, a 16-gauge Tuohy needle was inserted at the L4–L5 interspace, and the epidural space was identified using the loss-of-resistance to saline technique. An epidural catheter was then advanced 3–5 cm into the epidural space, through which 4 mL (20 mg) of 0.5% bupivacaine combined with 5 µg of sufentanil was administered as the initial dose.

The onset time of sensory block was defined as the interval between the administration of the anesthetic agents and the complete disappearance of pain. Sensory block level was assessed using the cold–warm discrimination test, with the T10 dermatome considered the minimum level required for effective labor analgesia.

Pain intensity was evaluated using a 10-point visual analog scale (VAS), where 0 represented no pain and 10 the worst imaginable pain. VAS scores were recorded before initiation of analgesia and subsequently at 15-minute intervals until delivery.

The duration of analgesia was defined as the time interval between the onset of the neuraxial block and the recurrence of pain, corresponding to a VAS score ≥ 5.

Labor duration was measured from the onset of active labor, defined as cervical dilatation of 4 cm, until delivery. Oxytocin consumption during labor was also recorded.

The incidence of cesarean delivery, instrumental vaginal delivery, and postpartum hemorrhage was documented in both groups.

The Apgar score of each newborn was assessed at 1 and 5 minutes after delivery. Maternal satisfaction with analgesia was evaluated using a four-point Likert scale: excellent, good, moderate, or poor.

Parturients were assessed for motor block using the modified Bromage scale and closely monitored for potential adverse effects, including hypotension, oxygen desaturation, pruritus, urinary retention, nausea, and vomiting, both during labor and throughout the first 24 hours postpartum.

Hypotension was defined as a decrease in systolic blood pressure of ≥20% from baseline and was initially managed with rapid crystalloid infusion ; if unresponsive, intravenous ephedrine was administered in 3–6 mg boluses. Bradycardia was defined as a heart rate below 50 beats per minute and was treated with intravenous atropine (0.01–0.02 mg/kg).

RESULTS

Baseline demographic and clinical characteristics were well balanced between the two groups, with no statistically significant differences in age, body mass index, ASA classification, gestational age, parity, or comorbidities, confirming the homogeneity and comparability of the study population (Table 1).

Table 1: Baseline characteristics

Parameters	Group S	Group E	p value
Mean age (years)	24.12 ± 3.56	24.78 ± 4.28	0.4
Mean BMI (kg/m2)	26.76 ± 2.91	26 ± 2.76	0.2
ASA classification I	32 (64 %)	35 (70 %)	1
II	18 (28 %)	15 (30 %)	1
Gestational age (weeks)	39.86 ± 1.03	39.52 ± 1.23	0.11
Parity			
- Primiparous	70 %	60%	0.29
- Multiparous	30%	40%	0.25
Comorbidities			
Diabetes	10(20 %)	11 (22 %)	0.8
Cardiovascular	5 (10 %)	6 (12 %)	0.75
Pulmonary	3 (6 %)	2 (4 %)	1
Ophtalmologic	2 (4 %)	3 (6 %)	1
No comorbidity	30 (60 %)	32 (64 %)	0.68

Anesthetic Data

Spinal analgesia was associated with a significantly faster onset of pain relief and a shorter time to reach the highest sensory level compared with epidural analgesia. Additionally, a higher proportion of parturients in the spinal group achieved a sensory block level up to T6, indicating a more extensive block. These findings suggest that spinal analgesia provides more rapid and effective pain control during the early stages of labor (Table 2).

Table 2: Comparison of anesthetic parameters between the two groups

Parameters	Groupe S (spinal)	Groupe E (epidural)	P value
Mean onset time of analgesia (min)	1.84 ± 1.09	8.25 ± 1.88	< 0.001
Mean time to reach highest sensory level (min)	4.23 ± 0.86	12.72± 3.17	< 0.001
Highest sensory level			
T6	45 (90%)	0 (0%)	< 0.0001
T8	50 (100%)	20 (40%)	< 0.0001
T10	50 (100 %)	50 (100%)	1

Motor Block Assessment

A transient, moderate motor block was observed in both groups, with modified Bromage scores ranging from 2 to 4 (Table 5). The incidence of a nearly complete motor block (score = 2, movement limited to the feet) was 16% in Group S compared with 10% in Group E, showing no statistically significant difference. Conversely, the incidence of the mildest motor block (score = 4, detectable weakness on hip flexion) was significantly higher in Group E (20% vs. 4%, p = 0.028). The most frequently observed score in both groups was 3 (partial

block, movement of the feet and knees preserved), recorded in 80% of parturients in Group S and 70% in Group E, with no significant difference.

Table 5: Bromage max of spinal versus epidural analgesia

Bromage max	Group S N (%)	Groupe E N (%)	p-value
2	8 (16%)	5 (10%)	0.554
3	40 (80%)	35 (70%)	0.356
4	2 (4%)	10 (20%)	0.028

Motor block appeared earlier in Group S, with a mean onset of approximately 5 minutes compared with 15 minutes in Group E. Resolution also differed, with recovery occurring at around 20 minutes in Group S versus 15 minutes in Group E. These findings indicate a faster onset and a slightly longer duration of motor block in the spinal group (Figure 2).

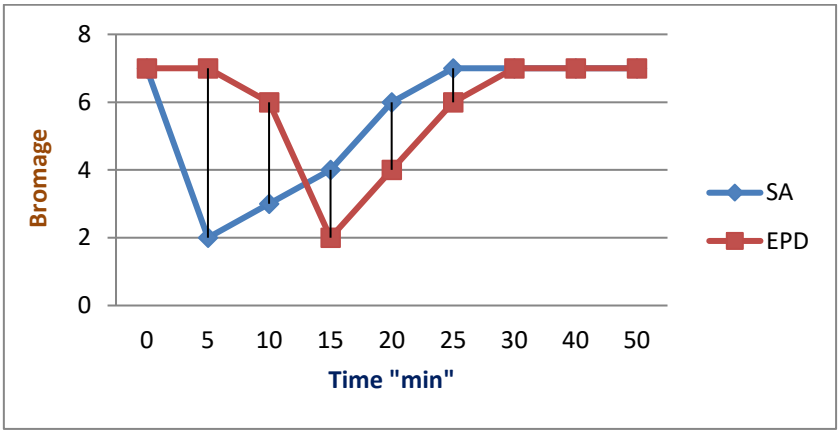


Figure 2: Comparative Bromage scores during labor

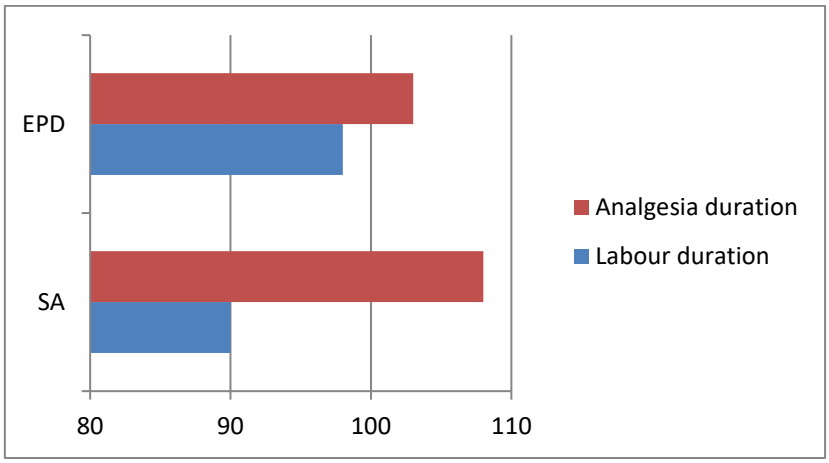
Quality of Analgesia

Labor duration was shorter among multiparous parturients in both groups; however, spinal analgesia was associated with a more pronounced reduction in labor duration compared with epidural analgesia, both in primiparous and multiparous women. These differences were statistically significant (Table 3).

Table 3: Comparison of labor duration between the two groups

Parametres (mean)	Groupe S	Groupe E	P value
Labor duration (min)			
Primiparas	99.45 ± 13.84	112.2 ± 15.7	0.001
Multiparas	68.66 ± 10.08	77.35 ± 12.2	0.03
Primiparas + multiparas	84.06 ± 12.11	94.78 ± 14.06	< 0.0001

The duration of analgesia following the initial dose was also significantly longer in the spinal analgesia group than in the epidural group (Graph 1). This suggests a more sustained and effective pain control with single-dose spinal analgesia.



Graph 1: Comparison of labor duration and analgesia duration between the two groups

Analgesic Efficacy and Maternal Satisfaction

The assessment of analgesic quality using the visual analog scale (VAS) during uterine contractions, delivery, and episiotomy repair showed no statistically significant difference between the two groups, indicating a comparable level of pain control. However, some clinically meaningful differences were noted. The incidence of insufficient analgesia and the need for anesthetic reinjection were higher in the epidural group, with reinjection rates reaching statistical significance ($p = 0.01$). In contrast, no parturients in the spinal group required additional dosing or experienced inadequate analgesia, reflecting the greater reliability and consistency of the spinal technique.

Maternal satisfaction was evaluated qualitatively based on the parturient's overall experience and comfort level during labor. High satisfaction rates were observed in both groups (96% in the SA group vs. 90% in the EA group), without a statistically significant difference ($p = 0.42$) (Table 4)

Table 4: Comparative analgesic parameters

Paramètres	Groupe S	Groupe E	P value
VAS score			
- Before induction	9.2 ±0.71	9.27 ± 0.66	0.6
- At Cervical dilatation	1.31 ± 0.86	1.42 ± 0.81	0.51
- At Expulsion	0.62 ± 0.37	0.66 ± 0.36	0.58
- At Episiotomy repair	1.17 ± 0.78	1.25 ± 0.76	0.6
Réinjections required	0	8 (16%)	0.01
Insufficient analgesia	0	5 (10%)	0.06
Maternal satisfaction	48 (96%)	45 (90%)	0.42

Adverse Effects and Neonatal Outcomes

Maternal side effects were comparable between the two groups, with no significant differences observed in the incidence of pruritus, urinary retention, oxytocin requirement for labor augmentation, mode of delivery (instrumental or cesarean), neonatal Apgar score at 5 minutes, or fetal heart rate decelerations ($p > 0.05$). Regarding hemodynamic effects, the incidence of hypotension was higher in Group S (10% vs. 2% in Group E), although the difference did not reach statistical significance. Overall, the safety profile was similar in both groups, suggesting that spinal and epidural analgesia are equally well tolerated (Table 6).

Table 6: Adverse effects of spinal versus epidural analgesia

Parameters	Groupe S (%)	Groupe E (%)	P value
Oxytocin requirement	50	40	0.31
Hypotension	10	2	0.2
Urinary Rétention	0	0	1
Pruritus	2	0	0.4
Forceps delivery	1	2	0.5
Cesarean section	0	0	1
Apgar score at 5 min (mean ± SD)	9.08 ± 0.79	9.04 ± 0.92	0.81
Fetal heart rate deceleration	10	2	0.2

DISCUSSION

Influence of Neuraxial Analgesia on the First Stage of Labor

In our study, cervical dilation progressed more rapidly under spinal analgesia (SA) compared with epidural analgesia (EA). This difference may be attributed to the faster onset of analgesia achieved with SA, leading to an earlier reduction in maternal catecholamine (particularly adrenaline) levels. Since adrenaline exerts a tocolytic effect by reducing uterine contractility, its decline promotes more coordinated and effective uterine contractions, thereby facilitating faster cervical dilation.[3].

We also observed that the overall duration of the first stage of labor tended to be longer in the EA group, although this difference did not reach statistical significance. These findings are consistent with previous studies, such as that of Tsen et al, who reported faster cervical dilation in nulliparous women receiving spinal or combined spinal–epidural (CSE) analgesia compared with conventional epidural analgesia [4]. Similar results were described by Bhagwat et al and Rajappa et al, who demonstrated a shorter duration of the first stage of labor and faster cervical dilation in women managed with CSE or low-dose spinal techniques compared with standard epidural protocols [5, 6]

Taken together, these observations suggest that spinal analgesia may have a modest but measurable effect in enhancing the dynamics of cervical dilation and progression of labor. However, the clinical significance of this acceleration remains debated and may depend on multiple factors, including parity, baseline uterine activity, and institutional labor management practices.

Influence of Neuraxial Analgesia on the Second Stage of Labor

The available literature provides strong and consistent evidence that neuraxial labor analgesia does not increase the rate of cesarean delivery or instrumental vaginal birth [7, 8, 9]. The mechanisms traditionally proposed to explain potential prolongation of the second stage include the development of motor block, which may impair fetal descent and rotation by reducing the tone of the pelvic floor and psoas muscles, and diminished maternal expulsive efforts during late labor [10]. However, these effects are more likely related to higher concentrations of local anesthetics or to the early use of neuraxial techniques in dystocic labors, rather than to the technique itself.[11].

In our series, mode of delivery (cesarean or instrumental) did not differ significantly between groups, in agreement with previous reports. Our findings were similar to those of Alansary et al., who employed comparable dosing regimens (5 mg bupivacaine in SA vs 20 mg in EA). Nevertheless, their reported rates of instrumental delivery and cesarean were considerably higher (38% in SA and 46% in EA, $p = 0.41$) compared with ours (2% in SA and 6% in EA). This discrepancy may be explained by differences in timing : in our study, neuraxial analgesia was initiated at an earlier stage of labor (cervical dilation to 4 cm) which may have limited the incidence of motor block.

Adverse Effects: Pruritus And Hemodynamic Changes

Pruritus is a well-recognized, dose-dependent side effect of intrathecal opioid administration. A meta-analysis comparing the side effects of spinal (SA) and epidural (EA) analgesia during labor identified pruritus as the only complication significantly more frequent with the spinal technique [12, 13, 14, 15]. Its incidence and severity vary depending on the type and dose of opioid used. For instance, Anabah et al reported high rates of pruritus (31%) and nausea (26.8%) when combining fentanyl (2.5 µg) with morphine (200 µg), with even higher rates following a repeat spinal injection [16]. In contrast, the low incidence of pruritus observed in our cohort likely reflects the use of a single opioid (sufentanil) at a very low dose (2.5 µg), which appears to provide effective analgesia with minimal side effects.

With regard to hemodynamic changes, hypotension was the most frequent adverse event, occurring in 10% of patients in the SA group compared with 2% in the EA group, although the difference was not statistically significant. This early-onset hypotension was most likely related to the relatively high intrathecal dose of bupivacaine administered (5 mg). Nevertheless, all episodes were mild transient and effectively managed with rapid crystalloid infusion, without the need for vasopress or support.

These observations are consistent with previous studies employing lower intrathecal doses of bupivacaine, in which the incidence of hypotension was correspondingly lower [17].

Maternal Satisfaction and Deambulation

Maternal satisfaction is a key indicator in evaluating obstetric analgesia techniques. Kuczkowski and Chandra (2008) reported high satisfaction rates (81%) following the intrathecal administration of low-dose bupivacaine. In our study, satisfaction scores were similarly high and comparable between the two groups : 96% in the SA group and 90% in the

EA group, with no statistically significant difference. These findings confirm that, when properly conducted, both neuraxial techniques provide an excellent level of comfort for parturient.

Regarding ambulation, our results showed that the maximum Bromage score was moderate and transient, in line with previously published data. Anabah et al. reported that spinal analgesia had no effect on ambulation in 87.7% of patients, and only a mild effect in 12.3%, concluding that low-dose spinal anesthesia provides effective labor analgesia without limiting mobility [18].

Neonatal Outcomes

Neonatal outcomes were evaluated through continuous fetal heart rate (FHR) monitoring during labor and Apgar scores assessed at 5 minutes. In our study, no neonate had an Apgar score below 7, underscoring the overall safety of both techniques. Transient FHR decelerations were occasionally observed at the onset of analgesia, most likely related to transient maternal hypotension secondary to sympathetic blockade. These episodes were promptly corrected using standard measures, including left lateral positioning, oxygen supplementation, intravenous fluid loading, and, when necessary, small doses of ephedrine. The overall incidence of FHR abnormalities was low and did not differ significantly between the two groups.

Our results differ from those of Nielsen et al, who reported higher rates of FHR decelerations 23% with spinal analgesia and 22% with epidural analgesia, possibly due to differences in study design, opioid dosage, or diagnostic criteria for FHR changes [18]. Our findings are more consistent with those of Grant et al, who reported that the incidence of FHR changes following spinal anesthesia varies between 15% and 25% [19].

Overall, these results indicate that both spinal and epidural analgesia, when administered at low doses and under vigilant maternal and fetal monitoring, are safe and do not adversely affect neonatal outcomes.

Oxytocin Requirement

Uterine contractions are primarily regulated by endogenous hormones, particularly oxytocin and prostaglandins. Therefore, the routine administration of oxytocin solely on the basis of labor analgesia is not justified ; its indication should remain individualized and guided by uterine dynamics. The need for oxytocin may be indirectly influenced by sympathetic block and the associated maternal hypotension, which can transiently reduce uterine contractility due to uterine muscle hypoxia [20].

In the comparative study by Mousa et al, no significant relationship was found between epidural analgesia and the need for oxytocin augmentation [21]. Conversely, Liu et al, and Leong et al, reported a higher incidence of oxytocin use among women receiving epidural analgesia compared with those without, suggesting a possible mild inhibitory effect on uterine activity [22, 23]. In contrast, Miro et al, found comparable rates of oxytocin augmentation between combined spinal–epidural and epidural techniques, indicating that low-dose neuraxial analgesia may not significantly interfere with uterine dynamics [25].

In our study, the incidence of oxytocin use was approximately 50%, with no statistically significant difference between the spinal and epidural groups. These results are consistent with the literature., supporting the conclusion that when low-dose neuraxial analgesia is used, its influence on uterine contractility and the need for oxytocin augmentation remains minimal.

LIMITATIONS

This was a single-center trial, although this ensured homogeneity in clinical practice and protocol adherence, it may limit the external validity and generalizability of the results to other settings. In addition, the **sample size was statistically powered** to detect differences in primary outcomes, it remains relatively modest (100 parturients). This may have limited the study's ability to detect **rare adverse events** or subtle differences in secondary outcomes such as instrumental delivery, cesarean section rate, and infrequent maternal or neonatal complications. besides, the study focused primarily on short-term maternal and neonatal outcomes.

Future multicenter, double-blinded randomized trials with larger sample sizes are required to confirm these results and better define the optimal role of single-shot spinal analgesia during early labor.

CONCLUSION

Spinal analgesia (SA) represents a simple, cost-effective, and efficient technique particularly suited to settings with limited human resources or high clinical workload. Compared with epidural analgesia (EA), low-dose SA offers a faster onset of sensory block, superior analgesic quality, more rapid cervical dilation, and high maternal satisfaction, while maintaining an excellent maternal and neonatal safety profile. These findings support SA as a valuable and practical alternative to EA in contemporary obstetric practice.

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