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Original Research Article

Comparative Analysis of Bupivacaine-Fentanyl and Ropivacaine-Fentanyl for Labor Epidural Analgesia

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Abstract:

Introduction: In the realm of labor analgesia, the choice between Bupivacaine-Fentanyl and Ropivacaine-Fentanyl for epidural administration holds significance in optimizing pain relief while ensuring maternal safety. Bupivacaine, known for its long-lasting analgesic effect, and Ropivacaine, lauded for its reduced motor block, both combined with the potent opioid Fentanyl, offer distinct profiles in efficacy and side effect profiles. This study compares bupivacaine-fentanyl and ropivacaine-fentanyl for labor epidural analgesia, assessing efficacy, safety, and obstetric outcomes.

Material and Methods: In this prospective randomized comparative study conducted at the department of obstetrics and gynecology, we aimed to evaluate the potential advantages of ropivacaine over bupivacaine in terms of obstetric outcomes for parturients undergoing labor epidural analgesia. A total of 70 eligible parturients, meeting specific inclusion criteria, were randomly assigned to receive either ropivacaine-fentanyl or bupivacaine-fentanyl epidural infusions. Pain levels were assessed using the visual analog scale (VAS), while motor function, adverse effects, and hemodynamic parameters were closely monitored throughout labor. Additionally, neonatal outcomes, including Apgar scores and NICU admission rates, were recorded.

Results: In this study, ropivacaine/fentanyl recipients exhibited significantly higher local anesthetic use (14.45 ± 5.6 mL/h) and lower demands (7 ± 2.0) compared to the bupivacaine/fentanyl group. VAS scores were comparable between the ropivacaine and bupivacaine groups at various time points. In the bupivacaine/fentanyl group, one patient experienced moderate motor block (score of 2 on a 0–3 scale), while no profound motor block was observed in either group. These effects were noticeable within 60 minutes post-epidural catheter insertion and remained consistent during labor. Additionally, one patient in the bupivacaine/fentanyl group exhibited motor block (score of 1 on a 0–3 scale) following the initial 1.5% lidocaine epidural test dose.

Conclusion: In conclusion, the ropivacaine-fentanyl combination demonstrated lower local anesthetic requirements and reduced need for supplemental analgesia during labor and delivery, suggesting potential advantages over bupivacaine-fentanyl in terms of analgesic efficiency and resource utilization.

Keywords: Labor Analgesia, Epidural, Ropivacaine, Bupivacaine, Fentanyl, Obstetric Outcomes.

Introduction

Childbirth is a profound and transformative experience, both for the mother and her family. Amidst the myriad of emotions and physical sensations associated with labor, pain management stands out as a crucial aspect that significantly influences the birthing experience. [1] Effective and safe pain relief during labor has long been a challenge amid misconceptions and debates. [2] The discussion on labor anesthesia persisted until 1853 when John Snow administered chloroform to Queen Victoria during the birth of Prince Leopold. [3] Highlighting the necessity for intervention, the American Society of Anesthesiologists stressed that no individual under a physician's care should endure untreated severe pain, especially during labor. [4] Epidural analgesia has emerged as a cornerstone in obstetric anesthesia, offering effective pain relief while allowing mothers to actively participate in the labor process. Within the realm of epidural analgesia, the choice of local anesthetic agent, combined with adjuncts such as opioids, plays a pivotal role in determining the efficacy and safety profile of the technique. [5]

Bupivacaine, traditionally hailed as the gold standard for epidural analgesia owing to its robust analgesic properties and favorable safety profile, has faced scrutiny due to concerns over cardiotoxicity and motor block, stimulating the exploration of alternative agents. [6,7] In response, ropivacaine, a newer entrant in the amino-amide local anesthetic family, has emerged, offering a

more promising cardiovascular profile while upholding comparable analgesic efficacy. [8] The adjunctive use of fentanyl, a potent opioid agonist, with both bupivacaine and ropivacaine, synergistically heightens analgesia through its lipophilic nature, facilitating rapid onset and profound pain relief. [9] Moreover, fentanyl's opioid-sparing effect holds the potential to curtail the total dose of local anesthetic required, thereby potentially mitigating adverse effects such as motor block and maternal hypotension. [10]

The decision between bupivacaine-fentanyl and ropivacaine-fentanyl combinations demands a nuanced grasp of their comparative pharmacodynamics, pharmacokinetics, and clinical outcomes. In our study, we aimed to assess whether ropivacaine presents advantages over bupivacaine in obstetric outcomes and if transitioning between the two is justified. Specifically, we compared ropivacaine-fentanyl and bupivacaine-fentanyl combinations in epidural labor analgesia for pain relief, motor block, labor characteristics, and neonatal outcomes, including Apgar scores and NICU admission rates.

Material and Methods

In this prospective randomized comparative study involving a total of 70 parturients, 35 in each group, attending the department of obstetrics and gynecology, we aimed to assess whether ropivacaine offers any significant advantages over bupivacaine concerning obstetric outcomes in our institutional practice, and whether transitioning from bupivacaine to ropivacaine is justified. Parturients of ASA physical status classes I and II, in active labor with term singleton pregnancies of 36–42 weeks in the vertex position and cervical dilatation of 3–4 cm, were included in the study. Patients with contraindications to epidural block, inability to cooperate, high-risk pregnancies, and drug sensitivity were excluded from the study.

Following random allocation into two groups of 35 each, using a computer-generated table of random numbers, patients received epidural infusions of either 0.125% ropivacaine with fentanyl 2 µg/mL or 0.125% bupivacaine with fentanyl 2 µg/mL. Automated maternal blood pressure and heart rate, tocodynamometry, and continuous fetal heart rate monitoring were conducted throughout labor. Epidural analgesia was maintained using patient-controlled epidural analgesia (PCEA), with additional boluses administered as required. Hypotension and other adverse effects were managed promptly.

Before the placement of the epidural catheter, the participants' baseline pain levels were meticulously assessed utilizing the visual analog scale (VAS), a well-established tool in pain assessment. The VAS is a subjective measure that allows individuals to express the intensity of their pain on a continuous scale. Participants were asked to rate their pain level by indicating a point along a line, typically 10 centimeters in length, with one end representing "no pain" and the other end representing "the worst imaginable pain." This method provided a quantifiable measure of pain perception, facilitating a comprehensive understanding of the participants' pain experiences before the administration of epidural analgesia.

The utilization of the VAS ensured that pain relief outcomes could be accurately evaluated and compared between participants receiving ropivacaine-fentanyl and bupivacaine-fentanyl combinations during labor. An 18-gauge intravenous cannula was inserted for Ringer's lactate infusion. The epidural space between L2 and L4 was identified, and a catheter was threaded through. Motor function, adverse effects, and pain levels were monitored. Epidural analgesia was maintained during labor, with urinary catheterization performed and removed before delivery. Hypotension and bradycardia were treated as needed. Sensory blockade height, time for top-up dose, mode of delivery, and neonatal outcomes were recorded, including Apgar scores and NICU admission rates. Pain intensity, sensory levels, motor block, and side effects were monitored regularly. Cumulative study solution volumes and PCEA demands were recorded, and patient satisfaction was evaluated post-delivery.

By comparing the efficacy of ropivacaine-fentanyl and bupivacaine-fentanyl combinations, this study contributes valuable insights into optimizing epidural labor analgesia, thereby enhancing maternal comfort and neonatal outcomes.

In our analysis, categorical data were presented as n (%), while continuous data were expressed as mean ± standard deviation (SD) or median with interquartile range. Categorical comparisons were made using Pearson's Chi-square test or Fisher's exact test. Time-related variables were analyzed with the Wilcoxon signed-rank test or ANOVA followed by post hoc multiple comparison test for normally distributed data. Statistical significance was set at $\alpha = 0.05$. Analysis was conducted using IBM SPSS Statistics version 22.0. Sample size was determined to detect a 40% difference in motor block incidence, assuming a baseline incidence of 30% with 80% power and $\alpha = 0.05$.

Results

The demographic characteristics of the study participants, divided into Ropivacaine-fentanyl and Bupivacaine-fentanyl groups, were assessed. (Table 1) These characteristics include age, height, weight, BMI, and parity. There were no statistically significant differences observed between the

groups for any of the measured parameters (p>0.05).

Table 1: Demographic Characteristics of study participants

Characteristics	Ropivacaine-fentanyl Group (n=35)	Bupivacaine-fentanyl Group (n=35)	P-value (NS)
Age (years)	25.10±3.50	24.50±2.80	0.96
Height (m)	1.60±0.25	1.55±0.30	0.69
Weight (kg)	70.0±3.50	67.0±4.0	0.07
BMI (kg/m²)	30.00±1.50	29.00±1.60	0.086
Parity (Multi: Primi)	15:15	12:18	0.43

Maternal heart rate before and after analgesia did not significantly differ between the ropivacaine and bupivacaine groups (P > 0.05), nor did maternal systolic and diastolic blood pressure, or fetal heart rate (P > 0.05). (Fig 1)

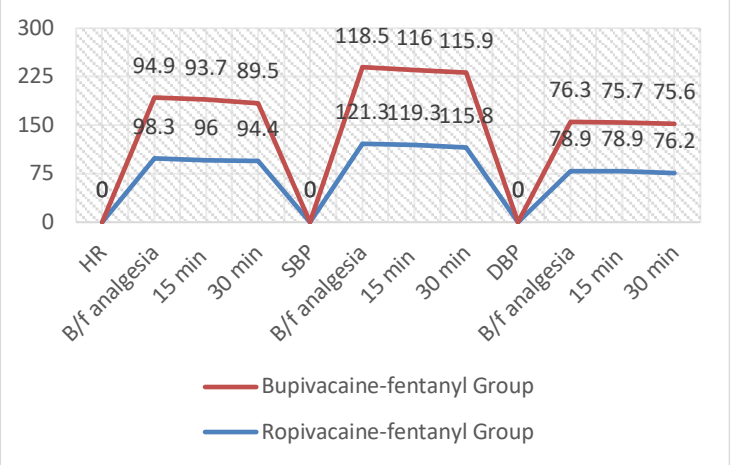

Figure 1: Maternal Hemodynamics

The initial cervical dilatation showed no significant difference between the Ropivacaine-Fentanyl (4.20 ± 0.7) and Bupivacaine-Fentanyl (3.90 ± 0.55) groups (P = 0.32). No significant differences were observed in the duration of the first stage of labor (P = 0.523) or the second stage (P = 0.12). The duration of the third stage approached significance (P = 0.053). Mode of delivery proportions were similar between groups. Apgar scores at 1 minute showed 30 infants with Apgar scores ≤7 in the Ropivacaine-Fentanyl group and 27 in the Bupivacaine-Fentanyl group, with 5 and 8 infants, respectively, having Apgar scores ≥7. All infants had Apgar scores ≥7 at 5 minutes. (Table 2)

Table 2: Obstetric characteristics and data of obstetrical and neonatal outcomes

Obstetric Characteristics	Ropivacaine-Fentanyl Group	Bupivacaine-Fentanyl Group	P-value
Initial cervical dilatation	4.20 ± 0.7	3.90 ± 0.55	0.32
Duration of first stage (min)	155.3 ± 11.2	181.8 ± 10.3	0.523
Duration of second stage (min)	17.5 ± 4.5	14.8 ± 4.8	0.12
Duration of third stage (min)	14.2 ± 2.0	12.8 ± 1.9	0.053
Mode of delivery (%)			
Normal vaginal	15 (42.86%)	17 (48.57%)	
LSCS	4 (11.43%)	5 (14.29%)	
Vaginal delivery with episiotomy	16 (45.71%)	13 (37.14%)	
Apgar score (min) (%)			
At 1			0.57
≤7	30	27	
≥7	5	8	
At 5			
≥7	35	35	

The ropivacaine/fentanyl group exhibited significantly higher local anesthetic use (14.45 ± 5.6 mL/h) and lower demands (7 ± 2.0) compared to the bupivacaine/fentanyl group. However, fewer

patients in the ropivacaine/fentanyl group required supplemental analgesia during labor (10%, $p < 0.05$) and delivery (25%) compared to the bupivacaine/fentanyl group, which showed slightly lower use (13.2 ± 4.2 mL/h) and similar demands (6 ± 3). Nonetheless, a higher percentage of patients in the bupivacaine/fentanyl group required supplemental analgesia during labor (35%, $p < 0.05$), although fewer required it during delivery (12.5%).

Table 3: Local anaesthetic use

Characteristics	Ropivacaine/Fentanyl	Bupivacaine/Fentanyl
Local anesthetic use (mL/h)	14.45 ± 5.6	13.2 ± 4.2
PCEA patient demands delivered	7 ± 2.0	6 ± 3
Patients requiring supplemental analgesia during labor (%)	10*	35
Patients requiring supplemental analgesia for delivery (%)	25	12.5

VAS scores were comparable between the Ropivacaine and Bupivacaine groups at various time points, with no significant differences observed ($P > 0.05$). (Figure 2)

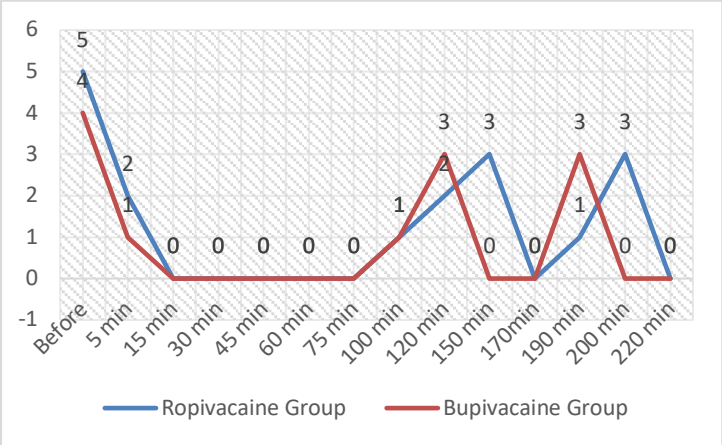

Figure 2: Mean VAS score among both groups

Among bupivacaine/fentanyl recipients, one patient exhibited moderate motor block (2 on a 0–3 scale), while profound motor block did not occur in either group (Figure). These differences were evident within 60 minutes post-epidural catheter placement and persisted throughout labor. Only one patient, eventually given bupivacaine/fentanyl, showed motor block (1 on a 0–3 scale) after the initial 1.5% lidocaine epidural test dose.

Discussion

Labor pain management is of paramount importance in obstetric care, ensuring maternal comfort and well-being during childbirth. The choice between different local anesthetic agents, such as bupivacaine and ropivacaine, combined with opioids like fentanyl, significantly impacts the efficacy and safety of epidural analgesia in labor.

In our study, maternal vital signs before and after epidural analgesia, including heart rate and blood pressure, showed no significant differences between the ropivacaine and bupivacaine groups ($P > 0.05$), indicating similar hemodynamic effects in both groups. Additionally, fetal heart rate did not vary significantly between the two groups ($P > 0.05$), suggesting comparable effects on fetal well-being. Comparing our findings with those of Kulkarni et al. [11], significant differences were noted in heart rate between the two anesthetic groups, particularly at specific time points. However, similar to our study, no significant differences were observed in blood pressure parameters between the groups. Comparing our findings with those of previous studies, including Finegold et al. [12], Chora et al. [13], and Bhatia et al. [14], we observed consistent results regarding maternal hemodynamics between the ropivacaine and bupivacaine groups. Despite some variations in specific parameters and patient populations, such as maternal age and gestational age, no significant differences were found in maternal vital signs or obstetric outcomes between the two local anesthetic agents. Several randomized trials have shown that epidural analgesia provides better pain relief and higher maternal satisfaction compared to systemic opioids, nitrous oxide, or their combination. Additionally, neuraxial analgesia offers physiological advantages for both the mother and fetus, improving maternal cardiovascular and pulmonary function, as well as the acid-base balance of the fetus. [15]

Our study findings revealed comparable VAS scores between the Ropivacaine and Bupivacaine groups at various time points, with no significant

differences observed (P > 0.05). Conversely, Kulkarni et al.'s [11] study reported significantly lower VAS scores at 180 min and 300 min in the group receiving ropivacaine, highlighting its potential for improved pain relief over bupivacaine. Adverse effects such as fetal bradycardia, nausea/vomiting, and hypotension were clinically insignificant and similar between the two groups.

Both bupivacaine and ropivacaine, when combined with 2μg/ml fentanyl, showed comparable analgesic efficacy and hemodynamic stability at a 0.1% concentration. However, the ropivacaine group displayed well-maintained heart rates and lower VAS scores, indicating a potentially more favorable analgesic profile. Bhatia et al.'s [14] study echoed these results, demonstrating similar VAS scores between the ropivacaine-fentanyl and bupivacaine-fentanyl groups. Furthermore, Sawhney et al.'s [16] investigation reported stable hemodynamic parameters and minimal side effects across all groups, reinforcing the safety and effectiveness of both ropivacaine and bupivacaine for labor epidural analgesia.

Our study found that bupivacaine/fentanyl recipients exhibited moderate motor block in one patient, with no profound motor block observed in either group. The ropivacaine/fentanyl group showed higher local anesthetic use and lower demands, with fewer patients requiring supplemental analgesia during labor and delivery compared to the bupivacaine/fentanyl group. FineGold et al. [12] noted similar onset times and VAS scores between the bupivacaine and ropivacaine groups, but a higher percentage of patients in the ropivacaine group had no motor block after the first hour. Similarly, Chora et al. [13] found equivalent analgesia between ropivacaine 0.1% and bupivacaine 0.1% with fentanyl 20 μg/mL, with no significant differences in side effects or patient satisfaction. Meister et al. [17] observed significantly less motor block with ropivacaine/fentanyl compared to bupivacaine/fentanyl, while Lee et al. [18] reported shorter duration of motor block with ropivacaine plus fentanyl compared to bupivacaine plus fentanyl in spinal anesthesia. Sawhney et al. [16] found stable hemodynamics and negligible side effects across all groups, with lower VAS scores and epidural consumption in the ropivacaine plus fentanyl group. Overall, these findings suggest that ropivacaine combined with fentanyl provides effective labor analgesia with less motor block and fewer side effects compared to bupivacaine/fentanyl combinations.

Our findings align with previous studies indicating a reduced risk of motor block with ropivacaine compared to bupivacaine, potentially leading to a higher rate of spontaneous vaginal delivery. Halpern et al. [19] also observed a higher frequency of motor block in the bupivacaine group but found similar rates of spontaneous vaginal delivery regardless of the local anesthetic used. Ropivacaine's reduced lipophilicity and lesser penetration of large myelinated nerve fibers contribute to its lower propensity for motor blockade, especially when used in lower concentrations or doses. [20]

The addition of an opioid to the solution, as demonstrated by Chhetty et al. [21], can enhance the efficacy of ropivacaine-based analgesia. Harms et al. [22] identified 0.125% bupivacaine as the most suitable concentration for epidural analgesia in labor, supporting our choice of concentrations in the study. The intermittent bolus technique, favored by Patkar et al. [23], was employed in our study due to its efficacy in reducing total drug consumption and breakthrough pain incidence. Comparisons between bupivacaine and ropivacaine, such as those conducted by Lee et al. [24] and Fernández-Guisasola et al. [25], have highlighted ropivacaine's superior sensory-motor differentiation and lower cardiotoxic potential. These factors influenced our decision to compare ropivacaine 0.2% with fentanyl to bupivacaine 0.125% with fentanyl in our study, aiming to leverage ropivacaine's advantages in labor analgesia.

Our study, consistent with prior research, suggests that ropivacaine's preferential action on sensory fibers over motor fibers, attributed to its lower lipophilicity compared to bupivacaine, potentially reduces the risk of motor blockade and neurotoxicity. [7] In our study, utilizing very low and titrated concentrations of local anesthetic with the addition of opioids, no cases of motor blockade (modified Bromage scale 1) were observed in either group, potentially contributing to our high rate of spontaneous vaginal delivery. These findings align with similar studies by Patkar et al. [23] and Chhetty et al.,21 supporting the efficacy of ropivacaine-based analgesia. Additionally, Halpern and Walsh [26] found no significant differences in obstetric outcomes between ropivacaine and bupivacaine, which aligns with our findings of comparable rates of spontaneous vaginal delivery and cesarean delivery between groups. Furthermore, our study, consistent with recent Cochrane review updates, [27] observed favorable neonatal outcomes, with normal fetal heart rates during labor and no instances of postepidural fetal bradycardia. Apgar scores at 1 and 5 minutes were similar between groups, indicating no significant differences in neonatal well-being.

One limitation of our study is the relatively small sample size, which may limit the generalizability of our findings to broader populations. Additionally, our study focused primarily on immediate outcomes such as motor blockade and obstetric

parameters, without extensive follow-up to assess longer-term effects on maternal and neonatal well-being.

Conclusion

In conclusion, our study reinforces the safety and efficacy of both ropivacaine and bupivacaine for labor analgesia when combined with fentanyl. Both agents demonstrated comparable analgesic efficacy and hemodynamic stability, with ropivacaine showing potential advantages such as reduced motor block. Our findings support the use of ropivacaine as a viable alternative to bupivacaine for labor epidural analgesia, offering similar pain relief with potentially fewer side effects.

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