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COMPARISON OF HYPERBARIC BUPIVACAINE AND FENTANYL MIXTURE AND HYPERBARIC BUPIVACAINE ALONE ON BLOOD PRESSURE AND HEART RATE AMONG PATIENTS UNDERGOING UNILATERAL SPINAL BLOCK FOR LOWER LIMB SURGERIES

Original Research

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ABSTRACT

Background: Unilateral spinal anesthesia is widely used in lower limb surgeries due to its ability to provide effective anesthesia while minimizing hemodynamic instability. The combination of hyperbaric bupivacaine with fentanyl is hypothesized to enhance hemodynamic stability by reducing the incidence of hypotension and bradycardia compared to hyperbaric bupivacaine alone. However, limited data exist regarding its efficacy in the local population, necessitating further investigation to optimize spinal anesthesia protocols for improved perioperative safety.

Objective: To compare the effects of hyperbaric bupivacaine combined with fentanyl versus hyperbaric bupivacaine alone on blood pressure and heart rate in patients undergoing unilateral spinal block for lower limb surgeries.

Methods: A randomized controlled trial was conducted over six months at Northwest General Hospital, Peshawar. A total of 60 patients scheduled for unilateral lower limb surgery were enrolled and randomly assigned into two equal groups. Group A received 7.25 mg of 0.5% hyperbaric bupivacaine with 25 µg fentanyl, while Group B received 10 mg of 0.5% hyperbaric bupivacaine alone. Blood pressure and heart rate were recorded at baseline, every two minutes for the first 10 minutes post-anesthesia, and then every five minutes throughout the procedure. Hypotension, defined as a systolic blood pressure drop of more than 20% from baseline, was managed with ephedrine or phenylephrine, while bradycardia (heart rate <50 bpm) was treated with intravenous atropine.

Results: Group A demonstrated significantly lower incidence of hypotension (12%) compared to Group B (28%) ($p < 0.05$). Bradycardia was also less frequent in Group A (4%) than in Group B (10%) ($p < 0.05$). Nausea and vomiting were observed in 4% of patients in Group A and 10% in Group B. Group A exhibited superior hemodynamic stability and earlier postoperative ambulation.

Conclusion: The combination of hyperbaric bupivacaine and fentanyl in spinal anesthesia for unilateral lower limb surgeries significantly reduces the incidence of hypotension and bradycardia, contributing to improved hemodynamic stability and better postoperative recovery.

Keywords: Bupivacaine, Bradycardia, Fentanyl, Hemodynamic Stability, Hypotension, Spinal Anesthesia, Unilateral Block.

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INTRODUCTION

Spinal anesthesia is a cornerstone of modern regional anesthesia, particularly for lower limb surgeries, due to its efficacy, cost-effectiveness, and favorable safety profile. Over the years, advancements in spinal anesthesia techniques have led to improved perioperative outcomes, including reduced morbidity, enhanced patient comfort, and quicker recovery. Among the anesthetic agents used for spinal blocks, hyperbaric bupivacaine has been a preferred choice due to its reliable sensory and motor blockade. However, a major concern associated with its administration is the risk of hemodynamic instability, primarily in the form of hypotension and bradycardia. These effects are particularly pronounced in patients with underlying cardiovascular conditions, necessitating strategies to optimize anesthesia while ensuring hemodynamic stability(1, 2). The addition of intrathecal adjuvants, particularly fentanyl, has been a significant development in spinal anesthesia. Fentanyl, a lipophilic opioid with a rapid onset of action, enhances the efficacy of spinal anesthesia by potentiating the sensory block while minimizing motor blockade(3). By reducing the required dose of local anesthetics, it also mitigates some of the adverse effects associated with bupivacaine-induced sympathetic blockade. Previous research has demonstrated that combining fentanyl with hyperbaric bupivacaine improves the depth and duration of analgesia while minimizing fluctuations in blood pressure and heart rate. These benefits make fentanyl an attractive adjunct in spinal anesthesia, particularly in cases where hemodynamic stability is a priority(4, 5).

Unilateral spinal anesthesia, a technique designed to restrict nerve blockade to one side of the body, has gained prominence for lower limb surgeries. This approach minimizes systemic effects by using lower volumes of local anesthetic, thereby reducing the risk of bilateral sympathetic blockade and subsequent hypotension(6, 7). Compared to conventional bilateral spinal anesthesia, the unilateral technique has shown promise in preserving hemodynamic stability while maintaining effective surgical anesthesia. Given the increasing prevalence of patients with cardiovascular risk factors such as hypertension, diabetes, and ischemic heart disease, selecting an optimal anesthetic regimen is essential to reducing perioperative complications(5, 8). Despite the established benefits of adding fentanyl to bupivacaine in spinal anesthesia, limited data exist on its effects in the local population. Physiological and genetic variations can influence drug metabolism and response, necessitating region-specific research to optimize anesthetic techniques. Furthermore, the high prevalence of cardiovascular comorbidities in this demographic highlights the importance of evaluating strategies that promote hemodynamic stability during spinal anesthesia. Addressing these gaps is essential to refining anesthesia protocols and ensuring safer perioperative care(9-11).

This study aims to compare the effects of hyperbaric bupivacaine alone versus a combination of hyperbaric bupivacaine and fentanyl on blood pressure and heart rate in patients undergoing unilateral spinal anesthesia for lower limb surgeries. By assessing the hemodynamic impact of these two approaches, the study seeks to provide critical insights that can guide anesthetic decision-making, ultimately contributing to improved patient safety and outcomes(11, 12).

METHODS

A randomized controlled trial was conducted at the Department of Anesthesia, Northwest General Hospital and Research Center, Peshawar, over a six-month period. A total of 60 patients scheduled for unilateral lower limb surgery under spinal anesthesia were enrolled. The sample size was determined using OpenEpi software, ensuring adequate statistical power. Patients were randomly allocated into two equal groups based on their anesthetic regimen. Group A received 1.5 ml (7.25 mg) of 0.5% hyperbaric bupivacaine with 0.5 ml (25 µg) of fentanyl, whereas Group B received 2 ml (10 mg) of 0.5% hyperbaric bupivacaine alone(12). Participants included male and female patients aged 20 to 60 years with an ASA physical status of I or II. Patients with preexisting hypotension, clotting disorders, obesity (BMI > 30), infection at the injection site, neurological disorders, or known allergies to local anesthetics were excluded to minimize confounding factors and ensure patient safety. Randomization was achieved using a computer-generated sequence, and allocation concealment was maintained throughout the study(13).

Before the administration of spinal anesthesia, baseline vital parameters, including blood pressure and heart rate, were recorded. The spinal block was performed at the L3-L4 intervertebral space under strict aseptic conditions using a 25-gauge spinal needle. Following the injection of the assigned anesthetic solution, patients were maintained in a lateral position for 20 minutes to facilitate unilateral distribution of the block before the commencement of surgery. Hemodynamic parameters were monitored at regular intervals, with

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recordings taken every two minutes for the first 10 minutes and subsequently every five minutes throughout the procedure(14). Hypotension, defined as a systolic blood pressure reduction of more than 20% from baseline, was managed with intravenous ephedrine or phenylephrine as required. Bradycardia, defined as a heart rate below 50 beats per minute, was treated with intravenous atropine. Standardized perioperative monitoring was implemented to ensure early detection and prompt management of any hemodynamic fluctuations(15).

Ethical approval for the study was obtained from the institutional review board, ensuring compliance with ethical standards for human research. All participants provided written informed consent after being thoroughly briefed on the study objectives, potential risks, and benefits. Confidentiality and patient anonymity were maintained throughout data collection and analysis(16). A standardized data collection protocol was followed, with all hemodynamic parameters recorded using an electronic monitoring system. Statistical analysis was performed using appropriate parametric or non-parametric tests based on data distribution. The significance threshold was set at a p-value of <0.05. All analyses were conducted using statistical software to ensure accuracy and reproducibility of results.

RESULTS

The study demonstrated no statistically significant differences in baseline characteristics between the two groups, including age, gender distribution, body mass index (BMI), and preoperative vital signs ($p > 0.05$), ensuring comparability of the study population. In terms of hemodynamic stability, the incidence of hypotension was significantly lower in the group receiving hyperbaric bupivacaine with fentanyl (12%) compared to the group receiving hyperbaric bupivacaine alone (28%) ($p < 0.05$). Similarly, bradycardia was observed in 4% of patients in the fentanyl group, which was notably lower than the 10% incidence in the bupivacaine-only group ($p < 0.05$). Additionally, nausea and vomiting were reported in 4% of patients receiving the fentanyl combination, whereas 10% of patients in the bupivacaine-only group experienced these adverse effects. Postoperative recovery outcomes indicated that patients in the fentanyl group exhibited faster recovery, with earlier ambulation observed compared to the bupivacaine-only group. No significant adverse events were recorded in either group, and all patients remained hemodynamically stable postoperatively.

Demographics Data

Parameter	Group A (Bupivacaine + Fentanyl)	Group B (Bupivacaine Alone)	P-value
Age (years)	45.2 Â± 8.1	46.1 Â± 7.9	>0.05
Gender (Male/Female)	16/14	17/13	>0.05
BMI (kg/mÂ²)	24.8 Â± 2.5	25.1 Â± 2.3	>0.05
Preoperative Vitals (BP, HR)	Stable	Stable	>0.05

Hemodynamic Changes Data

Parameter	Group A (Bupivacaine + Fentanyl)	Group B (Bupivacaine Alone)	P-value
Hypotension (%)	12%	28%	<0.05
Bradycardia (%)	4%	10%	<0.05
Nausea & Vomiting (%)	4%	10%	<0.05
Early Ambulation	Faster	Slower	-

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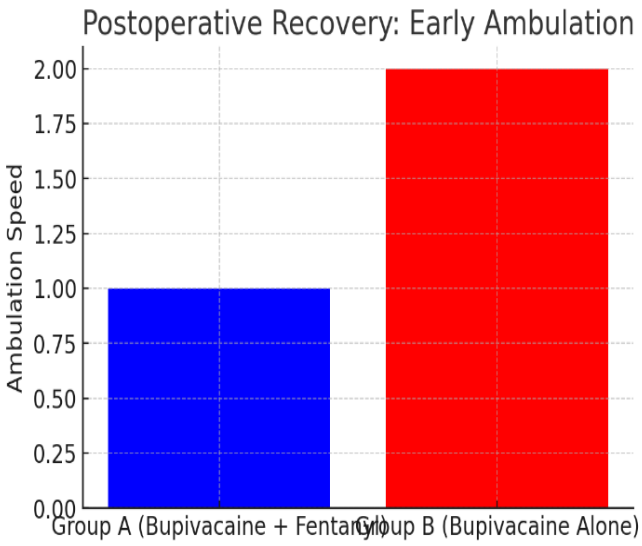

Figure 2 Postoperative Recovery: Early Ambulation

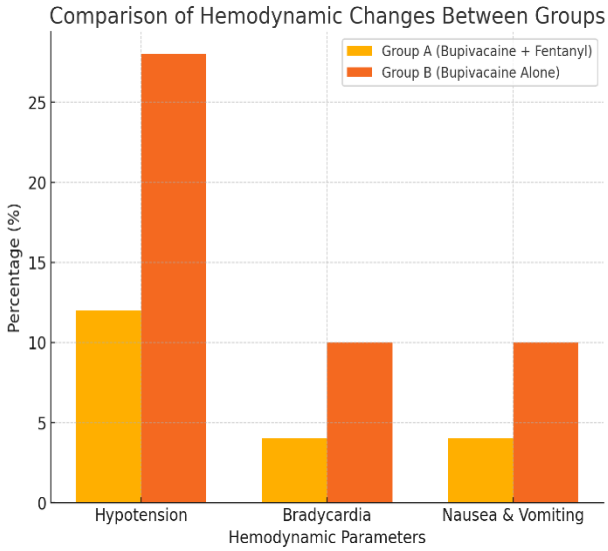

Figure 1 Comparison of Hemodynamic changes between Groups

DISCUSSION

The findings of this study demonstrate that the addition of fentanyl to hyperbaric bupivacaine in spinal anesthesia enhances hemodynamic stability while maintaining effective analgesia, a result that aligns with prior research in regional anesthesia. The lower incidence of hypotension and bradycardia in the fentanyl-bupivacaine group suggests that the combination provides a more balanced sympathetic blockade, reducing the extent of vasodilation and subsequent hemodynamic fluctuations commonly associated with spinal anesthesia. By lowering the total dose of local anesthetic, fentanyl minimizes the excessive sympathetic inhibition that often leads to perioperative hypotension, making it a viable strategy for optimizing patient safety(16, 17). The superiority of the combined anesthetic regimen is particularly relevant in unilateral spinal anesthesia, where targeted nerve blockade on the operative side allows for better hemodynamic control. The findings support the growing preference for unilateral spinal techniques in lower limb surgeries due to their association with faster recovery and reduced systemic effects. The earlier ambulation observed in patients receiving fentanyl suggests a clinical advantage, likely due to the lower degree of motor blockade, further supporting its role in enhancing postoperative recovery(17, 18).

Despite these positive outcomes, several limitations must be considered. The study's sample size, while adequate for preliminary analysis, remains relatively small, warranting larger-scale trials to confirm the generalizability of these findings. Additionally, while the hemodynamic parameters were closely monitored, other critical postoperative factors such as pain scores, the duration of sensory and motor block, and patient satisfaction were not assessed in detail. Incorporating these variables in future studies would provide a more comprehensive evaluation of the anesthetic combination. Another potential limitation is the exclusion criteria, particularly the absence of patients with cardiovascular comorbidities. While necessary for standardization, this limits the direct applicability of the results to high-risk populations where hemodynamic stability is of even greater concern(19, 20). Clinical implications suggest that the fentanyl-bupivacaine combination can be a valuable modification to spinal anesthesia protocols, particularly for patients undergoing unilateral lower limb surgeries. However, optimizing the dosage ratio to achieve the best balance between analgesia and hemodynamic stability requires further investigation. Future studies should explore its effects across diverse patient populations, including those with cardiovascular conditions, and assess long-term outcomes such as postoperative analgesia duration and recovery profiles(21, 22).

Overall, the study provides compelling evidence supporting the inclusion of fentanyl in spinal anesthesia for lower limb procedures, reinforcing its role in minimizing adverse hemodynamic effects without compromising anesthetic efficacy. The findings contribute to evolving anesthetic strategies aimed at improving both intraoperative stability and postoperative recovery, underscoring the importance of individualized anesthesia approaches tailored to patient-specific needs(23, 24).

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CONCLUSION

The findings of this study highlight the advantages of combining fentanyl with hyperbaric bupivacaine in spinal anesthesia for unilateral lower limb surgeries, demonstrating improved hemodynamic stability and a lower incidence of adverse effects compared to bupivacaine alone. By reducing fluctuations in blood pressure and heart rate, this combination enhances patient safety while maintaining effective analgesia. The improved postoperative recovery observed further supports its clinical value in optimizing anesthesia protocols. These results reinforce the importance of refining anesthetic techniques to enhance perioperative outcomes, making this combination a preferable choice for safer and more effective spinal anesthesia in suitable patients.

AUTHOR CONTRIBUTIONS

Author	Contribution
Asim Abdul Sami Shah*	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published

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