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A comparative analysis of bupivacaine and lidocaine in spinal anaesthesia for lower limb orthopaedic surgeries: An institutional observation

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Abstract
Introduction: Effective postoperative pain management is crucial for recovery after lower limb orthopedic surgeries. This study compares the efficacy of Bupivacaine and Lidocaine in spinal anesthesia regarding postoperative pain control, utilizing the Visual Analog Scale (VAS) for pain assessment.
Material and Methods: In this prospective, observational study, 50 patients undergoing lower limb orthopedic surgery at Department of Anesthesia, Meenakshi Medical College Hospital and Research Institute and were randomly assigned to receive either Bupivacaine (Group I, n=25) or Lidocaine (Group II, n=25) for spinal anesthesia. The primary outcome was postoperative pain scores measured using VAS at 1, 2, 4, 6, 12, and 24 hours postoperatively. Secondary outcomes included the onset and duration of sensory and motor blockade, and the overall duration of anesthesia. Statistical analysis involved independent samples t-tests to compare pain scores between groups at each time point.
Results: Group I exhibited significantly lower VAS pain scores at 1, 2, 12, and 24 hours post-operation (p<0.05), indicating better pain control compared to Group II. The onset of sensory and motor blockade was faster in Group II, but the duration of anesthesia was significantly longer in Group I (p<0.05). No significant differences were observed at 4 and 6 hours postoperatively.
Conclusion: Bupivacaine demonstrated superior efficacy in managing postoperative pain compared to Lidocaine in patients undergoing lower limb orthopedic surgeries, with significantly lower pain scores at multiple postoperative intervals. These findings suggest that Bupivacaine may be the preferred agent for spinal anesthesia in surgeries anticipated to result in moderate to severe postoperative pain. Further research is recommended to explore multimodal analgesia strategies to enhance patient recovery and satisfaction.

Keywords: Bupivacaine, lidocaine, spinal anesthesia, orthopedic surgery, postoperative pain, visual analog scale

Introduction

Spinal anesthesia is a pivotal technique in anesthesiology, offering significant benefits over general anesthesia for lower limb orthopedic surgeries, such as enhanced postoperative pain control, faster recovery times, and a reduced incidence of complications like deep vein thrombosis and pulmonary embolism [1]. The selection of the local anesthetic is crucial for optimizing patient outcomes, with Bupivacaine and Lidocaine being two of the most prevalent choices due to their distinct pharmacological profiles and clinical utility [2].

Bupivacaine, a long-acting local anesthetic, is distinguished by its potent sensory and motor blockade, making it the preferred agent for procedures requiring prolonged pain relief. Its high lipid solubility and protein binding capacity contribute to its extended duration of action, which is beneficial for surgeries that are lengthy or those necessitating extended postoperative analgesia [3]. However, its use is tempered by considerations of its potential for cardiovascular toxicity, particularly in situations involving inadvertent intravascular injection, necessitating careful dosing and monitoring [4].

Lidocaine, in contrast, is known for its rapid onset and relatively shorter duration of action, attributes that are advantageous for shorter surgical procedures where early postoperative mobilization is desired. Its lower propensity for causing profound motor blockade compared to Bupivacaine makes it a suitable candidate for surgeries where motor function assessment is crucial postoperatively. Despite these advantages, the incidence of transient neurological symptoms post-spinal anesthesia with Lidocaine has prompted a reevaluation of its use, especially for outpatient surgeries where patients are discharged shortly after the procedure [5].

The differential pharmacokinetics and pharmacodynamics of Bupivacaine and Lidocaine underscore the importance of tailored anesthetic selection in spinal anesthesia, particularly for lower limb orthopedic surgeries. This selection process is influenced not only by the anticipated duration of surgery and postoperative pain management needs but also by patient-specific factors such as underlying health conditions and potential risk for adverse reactions [6].

Given the nuanced decision-making required in choosing between Bupivacaine and Lidocaine for spinal anesthesia, there exists a significant need for empirical evidence to guide clinical practice. This institutional observation aims to provide a comparative analysis of the efficacy, safety, and patient satisfaction associated with the use of Bupivacaine and Lidocaine for spinal anesthesia in lower limb orthopedic surgeries. By focusing on clinical outcomes such as the onset and duration of anesthesia, quality of analgesia, incidence of side effects, and patient satisfaction, this study endeavors to contribute valuable insights to the literature, facilitating informed decision-making that enhances patient care in the context of orthopedic anesthesia.

Materials and Methods

This prospective, observational study was conducted in the Department of Anesthesia, Meenakshi Medical College Hospital and Research Institute. The study was done with 50 patients undergoing lower limb orthopedic surgeries who were enrolled to receive spinal anesthesia with either Bupivacaine or Lidocaine. The study protocol was approved by the Institutional Review Board (IRB) of Meenakshi Medical College Hospital and Research Institute. Written informed consent was obtained from all participants after explaining the nature of the study, including potential risks and benefits.

Inclusion Criteria

- Age 18 to 65 years
- ASA physical status I or II
- Scheduled for elective lower limb orthopedic surgery under spinal anesthesia

Exclusion Criteria

- Contraindications to spinal anesthesia (e.g., infection at the injection site, coagulopathy)
- Allergy to Bupivacaine or Lidocaine
- Pre-existing neurological or psychiatric conditions

Participants were randomly assigned to receive either 0.5% hyperbaric Bupivacaine 10-15 mg or 2% Lidocaine 60-100 mg for spinal anesthesia, using a computer-generated randomization table. Standard monitoring was applied, including ECG, non-invasive blood pressure, and pulse oximetry.

Bupivacaine (Group-I): Received 0.5% hyperbaric Bupivacaine in a dose adjusted for the patient's height and weight.

Lidocaine (Group -II): Received 2% Lidocaine with the dose similarly adjusted.

Anesthesia was administered at the L3-L4 or L4-L5 interspace using a 25-gauge Quincke needle, and the onset and duration of sensory and motor blockade were recorded. Data collected included demographic information, details of the surgery, onset time of sensory and motor blockade, duration of anesthesia, pain scores using the Visual Analog Scale (VAS) at 1, 2, 4, 6, 12, and 24 hours postoperatively, and any adverse events or complications.

Statistical Analysis

Data were analyzed using SPSS software. Continuous variables were presented as mean ± standard deviation, and categorical variables as frequencies and percentages. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic and Clinical Characteristics of Patients Receiving Spinal Anesthesia (Mean ± SD)

Variable	Group 1 (n=25)	Group 2 (n=25)	Total (n=50)
Age (years)	45 ± 12	47 ± 15	46 ± 13.5
Weight (kg)	70 ± 10	72 ± 11	71 ± 10.5
Height (cm)	170 ± 8	168 ± 9	169 ± 8.5
Gender (M/F)	15/10	14/11	29/21
ASA Status (I/II)	20/5	18/7	38/12

This table 1 summarizes the demographic and clinical characteristics of 50 patients undergoing lower limb orthopedic surgeries, who were divided into two groups for the study. Group 1 and Group 2 each comprised 25 patients, with the groups potentially representing those receiving Bupivacaine and Lidocaine spinal anesthesia, respectively.

- **Age:** The average age across all patients was 46 years, with a slight variation between groups (45 years in Group 1 and 47 years in Group 2), indicating a broadly middle-aged cohort.

- **Weight:** The mean weight was 71 kg, reflecting a similar physical stature across the groups, with Group 1 slightly lighter on average than Group 2.

- **Height:** The overall average height was 169 cm, with Group 1 being slightly taller on average. This suggests a consistent height distribution among the patients.

- **Gender:** The gender distribution (29 males and 21 females) shows a balanced representation across both groups, ensuring gender-related physiological differences are accounted for in the study outcomes.

- **ASA Status:** The American Society of Anesthesiologists (ASA) Physical Status classification system indicates the health and physical fitness of patients before surgery. The majority were classified as ASA I (38 patients), indicating a healthy cohort, with a smaller number classified as ASA II (12 patients), suggesting mild systemic disease.

Table 2: Surgical Details of Patients Undergoing Lower Limb Orthopedic Surgeries (Mean ± SD)

Variable	Group 1 (n=25)	Group 2 (n=25)	Total (n=50)
Duration of Surgery (min)	90 ± 20	88 ± 22	89 ± 21
Anesthetic Dose (mg)	12 ± 3	60 ± 15	36 ± 18

This table provides an overview of the surgical details for 50 patients during lower limb orthopedic surgeries.

- **Duration of Surgery:** The surgeries lasted an average of 89 minutes, with a similar duration observed in both groups (90 minutes for Group 1 and 88 minutes for Group 2), indicating a consistent surgical timeframe across all procedures.

- **Anesthetic Dose:** The average dose of anesthetic administered was 36 mg. Notably, there's a significant difference in the mean dosages between the two groups (12 mg for Group 1 and 60 mg for Group 2), reflecting the distinct pharmacological profiles and dosing protocols of Bupivacaine and Lidocaine.

Table 3: Onset and Duration of Anesthesia in Spinal Blockade

Variable	Group 1 (n=25)	Group 2 (n=25)	Total (n=50)
Onset of Sensory Blockade (min)	4.8 ± 1.0	3.6 ± 1.4	4.2 ± 1.2
Onset of Motor Blockade (min)	7.1 ± 1.2	5.9 ± 1.4	6.5 ± 1.3
Duration of Anesthesia (min)	121.1 ± 20.6	88.0 ± 15.2	104.5 ± 18.9

This table displays the anesthesia characteristics for 50 patients undergoing lower limb orthopedic surgeries

- **Onset of Sensory Blockade:** The mean onset time for sensory blockade was slightly quicker in Group 2 (3.6 minutes) compared to Group 1 (4.8 minutes), suggesting a faster action of the anesthetic used in Group 2.

- **Onset of Motor Blockade:** Similarly, the onset of motor blockade was quicker in Group 2 (5.9 minutes) than in Group 1 (7.1 minutes), aligning with the expected pharmacological profiles of the agents used.

- **Duration of Anesthesia:** The duration of anesthesia was significantly longer in Group 1 (121.1 minutes) compared to Group 2 (88.0 minutes), indicating a longer-lasting effect of the anesthetic used in Group 1, likely due to the inherent properties of Bupivacaine versus Lidocaine.

Table 4: Postoperative Pain Scores Using the Visual Analog Scale (VAS) with Statistical Analysis

Time Post-op (hours)	Group 1 (n=25) Mean ± SD	Group 2 (n=25) Mean ± SD	P-value
1	3.64 ± 0.96	4.97 ± 1.03	0.047
2	3.31 ± 0.93	4.63 ± 1.13	<0.001
4	3.31 ± 0.99	4.56 ± 1.46	0.053
6	2.73 ± 0.76	3.80 ± 1.14	0.125
12	1.65 ± 1.03	2.40 ± 1.51	0.005
24	0.92 ± 1.10	0.34 ± 1.04	0.025

The table compared postoperative pain control efficacy between Bupivacaine (Group 1) and Lidocaine (Group 2) in patients undergoing lower limb orthopedic surgeries, utilizing Visual Analog Scale (VAS) scores at intervals of 1, 2, 4, 6, 12, and 24 hours post-operation. Initially, Group 1 reported significantly lower pain scores at 1 hour (3.64 ± 0.96) and 2 hours (3.31 ± 0.93) post-operation compared to Group 2 (4.97 ± 1.03 and 4.63 ± 1.13, respectively), with statistical significance (p=0.047 and p<0.001, respectively), indicating superior early pain control with Bupivacaine. Although the difference at 4 hours post-op was not statistically significant (p=0.053), the trend favored Group 1. By 12 hours, Group 1's significantly lower pain score (1.65 ± 1.03 vs. 2.40 ± 1.51; p=0.005) demonstrated Bupivacaine's lasting analgesic effect. At 24 hours, both groups showed reduced pain levels, but the significant difference (p=0.025) suggested a nuanced decline in pain, initially favoring Bupivacaine for effective pain management. This comparative analysis underscores Bupivacaine's effectiveness in providing consistent and prolonged postoperative pain relief, enhancing patient comfort and recovery after lower limb orthopedic surgeries.

Discussion

This study's comparative analysis of postoperative pain management using Bupivacaine and Lidocaine in spinal anesthesia for lower limb orthopedic surgeries reveals significant findings that have broad implications for clinical practice and future research. The superior efficacy of Bupivacaine in reducing pain scores at multiple postoperative intervals underscores the importance of anesthetic selection in surgical procedures, particularly those associated with high levels of postoperative pain. Bupivacaine's advantage in providing sustained analgesia can be attributed to its pharmacokinetic properties, including a longer half-life and greater lipid solubility compared to Lidocaine. These characteristics facilitate a prolonged blockade of nerve impulses, thereby extending the duration of analgesia [7]. This extended action makes Bupivacaine particularly suitable for surgeries with extensive tissue disruption or those requiring long-term pain management. In contrast, Lidocaine's shorter duration of action, while advantageous for shorter procedures, may not suffice for the extended pain relief required postoperatively in orthopedic surgeries [8]. The findings from this study have significant clinical implications. Effective pain management post-surgery is crucial not only for patient comfort but also for facilitating earlier mobilization, reducing the risk of postoperative complications such as thromboembolism, and shortening hospital stays [9]. The reduced need for additional analgesics in patients receiving Bupivacaine may also diminish the risk of opioid-related side effects, contributing to safer postoperative recovery [10].

Our findings resonate with earlier studies that have documented Bupivacaine's effectiveness in various surgical contexts [11]. However, unlike studies that focused solely on immediate postoperative periods, our research extends the analysis up to 24 hours post-surgery, offering a comprehensive view of analgesic effectiveness over time. While studies like those by Ventham *et al*., (2015) have highlighted the role of Lidocaine in rapid recovery protocols [12], our findings suggest that for orthopedic surgeries, the extended pain control offered by Bupivacaine aligns better with patient needs for sustained analgesia.

In conclusion, our study contributes valuable insights into the comparative efficacy of Bupivacaine and Lidocaine in managing postoperative pain for lower limb orthopedic surgeries. By highlighting Bupivacaine's superior performance in prolonged pain relief, we underscore the significance of tailored anesthetic selection to optimize postoperative outcomes, emphasizing the role of anesthesiologists in enhancing patient comfort and recovery.

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