e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2025; 17(7); 2087-2093

Original Research Article

Scorpion Bite and Failed Spinal Anaesthesia: Is Ropivacaine Effective than Bupivacaine

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Received: 01-04-2025 / Revised: 15-05-2025 / Accepted: 21-06-2025
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Conflict of interest: Nil

Abstract

Background: Scorpion envenomation is a significant public health concern in tropical countries. Neuromuscular, autonomic, and cardiovascular alterations following a scorpion sting can interfere with spinal anaesthesia outcomes. Reports of failed spinal blocks in post-scorpion sting patients raise concerns regarding the efficacy of conventional local anaesthetics like Bupivacaine. This study evaluates the effectiveness of Ropivacaine versus Bupivacaine in spinal anaesthesia among patients with a recent history of scorpion sting.

Methods: A prospective, comparative observational study was conducted at a tertiary care hospital over 12 months. Patients with recent scorpion envenomation (within 7 days) posted for infraumbilical surgeries were divided into two groups: Group B (received 0.5% hyperbaric Bupivacaine) and Group R (received 0.5% hyperbaric Ropivacaine). The primary outcome was the success rate of spinal anaesthesia. Secondary outcomes included time of onset, maximum sensory level, duration of sensory and motor block, and hemodynamic stability.

Results: Among 60 patients (30 per group), the success rate of spinal anaesthesia was 66.7% in Group B versus 90% in Group R ($p = 0.03$). The mean onset time of sensory block was shorter in Group R (3.2 ± 0.7 min) than in Group B (4.5 ± 1.1 min). Duration of sensory block was also significantly longer in Group R (154 ± 18 min) than in Group B (136 ± 15 min) ($p < 0.01$). Hemodynamic parameters were more stable in Group R with fewer episodes of hypotension and bradycardia.

Conclusion: Ropivacaine appears to be more effective than Bupivacaine in spinal anaesthesia for patients with recent scorpion stings, with higher success rates, better block characteristics, and improved hemodynamic stability. Further randomized trials are warranted.

Keywords: Scorpion Sting, Spinal Anaesthesia, Ropivacaine, Bupivacaine, Failed Spinal Block.

Introduction

Scorpion envenomation, particularly from Mesobuthus tamulus—the Indian red scorpion—is a notable medical emergency in many parts of India due to its severe systemic effects. [1] The venom's primary mechanism involves persistent activation of neuronal sodium channels, which leads to a massive and sustained release of catecholamines such as adrenaline and noradrenaline, along with various neuropeptides.

This cascade triggers intense autonomic dysregulation characterized by heightened sympathetic activity, resulting in cardiovascular instability, tachycardia, hypertension, and profound neurosensory disturbances. These neurophysiological alterations may last from several hours to a few days, posing significant challenges to anaesthetic management, particularly with regional techniques like spinal anaesthesia. [2]

Anecdotal reports and small case series have highlighted increased rates of spinal anaesthesia failure in patients who have recently experienced scorpion stings. This phenomenon is hypothesized to result from venom-induced alterations in sodium and potassium channel functioning and receptor desensitization, which may interfere with the efficacy of local anaesthetics by impairing their binding to neuronal channels or by disrupting the propagation of the anaesthetic block. These pathophysiological changes raise concerns regarding the reliability of neuraxial anaesthesia in this population. [3]

Among the local anaesthetics commonly used for spinal anaesthesia, Bupivacaine is known for its potent and long-lasting sensory and motor blockade. However, its use is limited by a relatively higher risk of cardiotoxicity and neurotoxicity,

especially in patients with autonomic or cardiovascular instability—conditions frequently seen in scorpion envenomation. In contrast, Ropivacaine, a newer amide-type local anaesthetic, offers a safer pharmacological profile. [4] It is associated with lower central nervous system toxicity and cardiac side effects, and provides a more selective sensory block with relatively less motor blockade. These properties make Ropivacaine a promising candidate in patients with altered neurophysiological states, such as those following scorpion sting, where maintaining hemodynamic stability and achieving reliable sensory block are paramount. [5]

Despite these theoretical and pharmacological advantages, there is a significant lack of empirical data directly comparing the effectiveness of Bupivacaine and Ropivacaine in scorpion-envenomated patients undergoing spinal anaesthesia.

Given the clinical implications, especially in resource-limited or high-incidence regions, there is a pressing need to systematically evaluate and identify the more effective and safer anaesthetic agent for this unique and high-risk subgroup. Such data would be invaluable for guiding anaesthetic choice and improving perioperative outcomes in this challenging clinical context.

Aim of the Study

The present study was undertaken to evaluate and compare the efficacy of intrathecal Ropivacaine and Bupivacaine in patients with a recent history of scorpion envenomation who were posted for surgical procedures under spinal anaesthesia.

Objectives

1. To assess the onset, quality, and duration of sensory and motor blockade achieved by Ropivacaine and Bupivacaine.
2. To evaluate the rate of successful spinal anaesthesia (complete block without the need for conversion or supplementation).
3. To monitor haemodynamic parameters and any adverse events associated with either agent in the context of post-envenomation autonomic instability.
4. To determine patient satisfaction and perioperative analgesic requirements.

Materials and Methods

Study Design: Prospective, comparative observational study

Duration: March 2024 to February 2025

Setting: Tertiary care teaching hospital in South India

Inclusion Criteria:

- Age 18–60 years
- ASA I-II
- History of scorpion sting within last 7 days
- Scheduled for elective infraumbilical surgery under spinal anaesthesia

Exclusion Criteria:

- Coagulopathy, sepsis, or deformity of the spine
- Known allergy to local anaesthetics
- Refusal of spinal anaesthesia

Sample Size: 60 patients (30 in each group)

Intervention:

- Group B: 3.0 mL of 0.5% hyperbaric Bupivacaine
- Group R: 3.0 mL of 0.5% hyperbaric Ropivacaine

Outcome Measures:

- **Primary**: Success of spinal block (defined as T10 sensory block within 10 minutes without need for conversion)
- **Secondary**: Onset of sensory and motor block, duration, maximum sensory level, intraoperative hemodynamic changes

Methodology

This prospective, randomized comparative study was conducted on 60 adult patients aged between 18 and 60 years, all classified as American Society of Anesthesiologists (ASA) physical status I or II. Eligible participants included those with a documented history of scorpion sting within the preceding seven days and scheduled for elective infraumbilical surgery under spinal anaesthesia. Patients with coagulopathy, sepsis, spinal deformities, known allergies to local anaesthetics, or those who refused spinal anaesthesia were excluded from the study.

Following ethical clearance and informed consent, the enrolled patients were randomly allocated into two equal groups of 30 each. Group B received 3.0 mL of 0.5% hyperbaric Bupivacaine intrathecally, while Group R received 3.0 mL of 0.5% hyperbaric Ropivacaine. All spinal anaesthetic procedures were performed under strict aseptic conditions using a standardized technique in the L3–L4 or L4–L5 interspace with the patient in the sitting position.

The primary outcome was the success of spinal block, defined as the attainment of a T10 sensory level within 10 minutes post-injection without the need for conversion to general anaesthesia or additional anaesthetic supplementation. Secondary outcomes included the onset time of sensory and motor blockade, the duration of the block, the maximum sensory level achieved, and any

intraoperative hemodynamic changes such as hypotension or bradycardia. All observations were systematically recorded and statistically analyzed to assess the comparative efficacy and safety of the two local anaesthetic agents in patients with recent scorpion envenomation.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26. Continuous variables, such as age, onset time, duration of sensory and motor blockade, and haemodynamic parameters, were expressed as mean ± standard deviation (SD). Categorical variables, such as the success rate of spinal anaesthesia, presence or absence of complications, and block characteristics, were expressed as frequencies and percentages. The Independent Samples t-test was employed to compare continuous variables between the Ropivacaine and Bupivacaine groups.

For comparison of categorical variables, such as the incidence of failed block or adverse events, the Chi-square test (or Fisher's exact test where appropriate) was used. A p-value < 0.05 was considered statistically significant for all comparisons.

Results

Table 1: Distribution of study subjects as per successful spinal anaesthesia

	Total Patients	Successful Spinal Anaesthesia (n)	Spinal Success Rate (%)	p-value
B (Bupivacaine)	30	20	66.7	0.03
R (Ropivacaine)	30	27	90	

In this study, the success rate of spinal anaesthesia was significantly higher in the Ropivacaine group (90%) compared to the Bupivacaine group (66.7%), with a p-value of 0.03. This suggests that Ropivacaine is more effective than Bupivacaine in achieving successful spinal block, particularly in patients with recent scorpion envenomation.

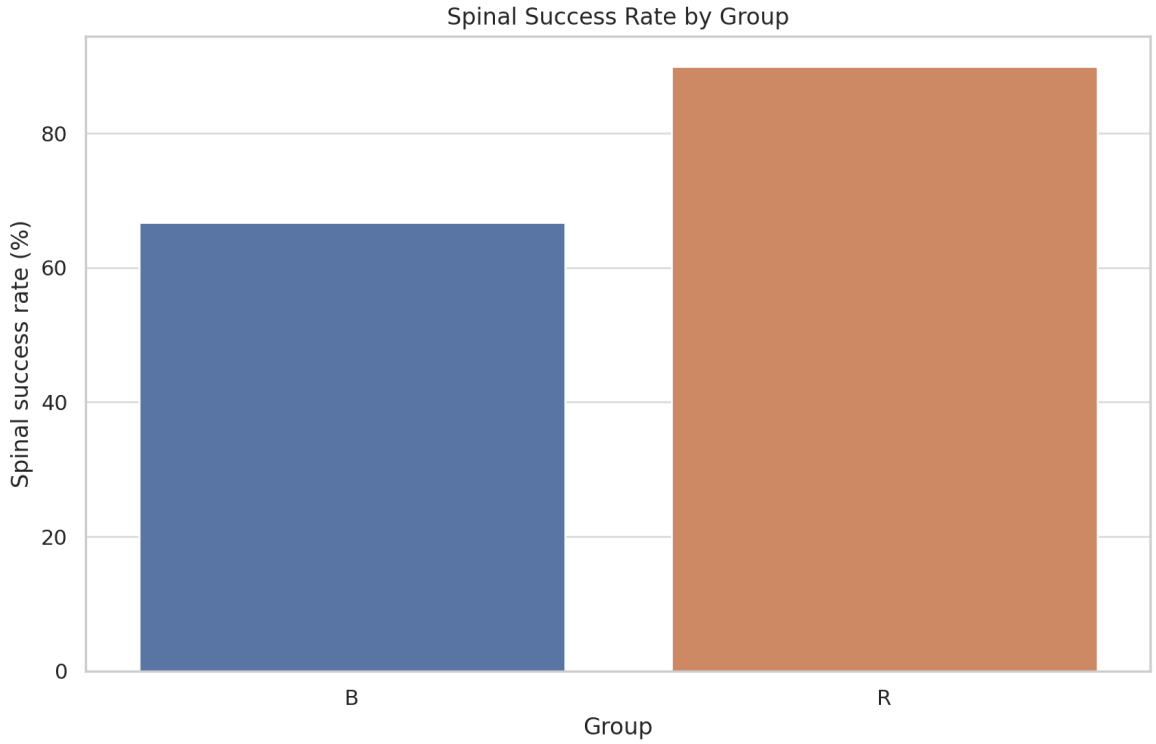

Figure 1: Distribution of study subjects as per successful spinal anaesthesia

Table 2: Distribution of study subjects as per onset of sensory block

Group	Mean Onset Time (min)	Standard Deviation	p-value
B (Bupivacaine)	4.5	1.1	<0.01
R (Ropivacaine)	3.2	0.7	

The onset of sensory block was significantly faster in the Ropivacaine group (3.2 ± 0.7 minutes) compared to the Bupivacaine group (4.5 ± 1.1 minutes), with a p-value of <0.01. This indicates that Ropivacaine provides a more rapid onset of anaesthesia than Bupivacaine in patients with recent scorpion envenomation.

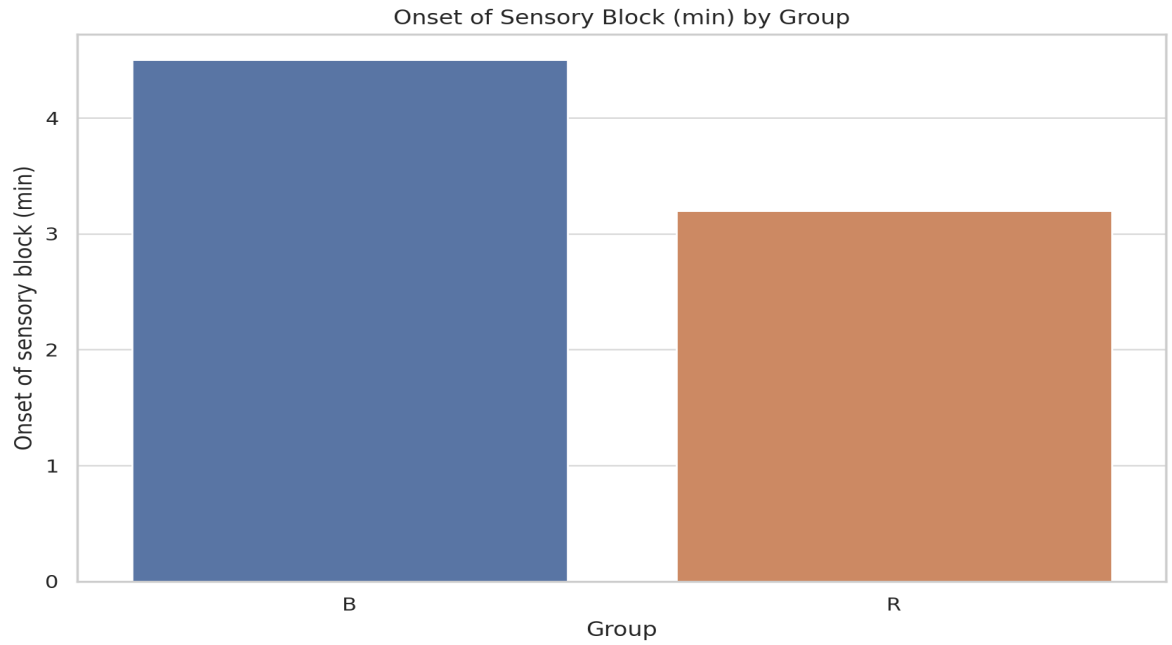

Figure 2: Distribution of study subjects as per onset of sensory block

Table 3: Distribution of study subjects as per mean duration of sensory block

Group	Mean Duration (min)	Standard Deviation	p-value
B (Bupivacaine)	136	15	<0.01
R (Ropivacaine)	154	18	

The mean duration of sensory block was significantly longer in the Ropivacaine group (154 ± 18 minutes) compared to the Bupivacaine group (136 ± 15 minutes), with a p-value of <0.01. This indicates that Ropivacaine provides a more prolonged sensory blockade, offering extended analgesic benefit in patients following scorpion envenomation.

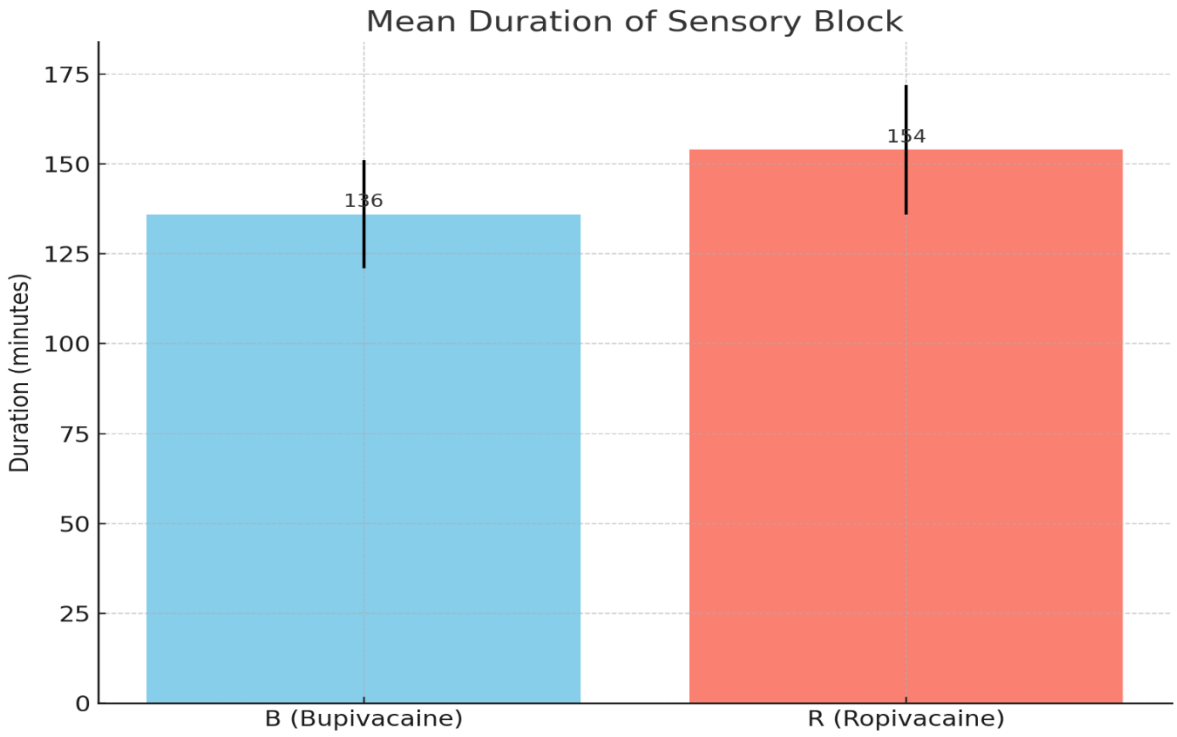

Figure 3: Mean duration of sensory block

Tab 4: Distribution of study subjects as per adverse effects

Parameter	Group B (Bupivacaine) (n)	Group R (Ropivacaine) (n)	p-value
Hypotension Episodes	8	2	0.04
Bradycardia	5	1	0.08

In this study, adverse effects were more frequent in the Bupivacaine group compared to the Ropivacaine group.

Hypotension occurred in 8 patients in Group B versus 2 patients in Group R, with a statistically significant p-value of 0.04. Bradycardia was observed in 5 patients in Group B and 1 patient in Group R; however, this difference was not statistically significant (p = 0.08).

These findings suggest that Ropivacaine is associated with fewer haemodynamic adverse effects, particularly hypotension, making it a safer alternative in patients with autonomic instability such as those following scorpion envenomation.

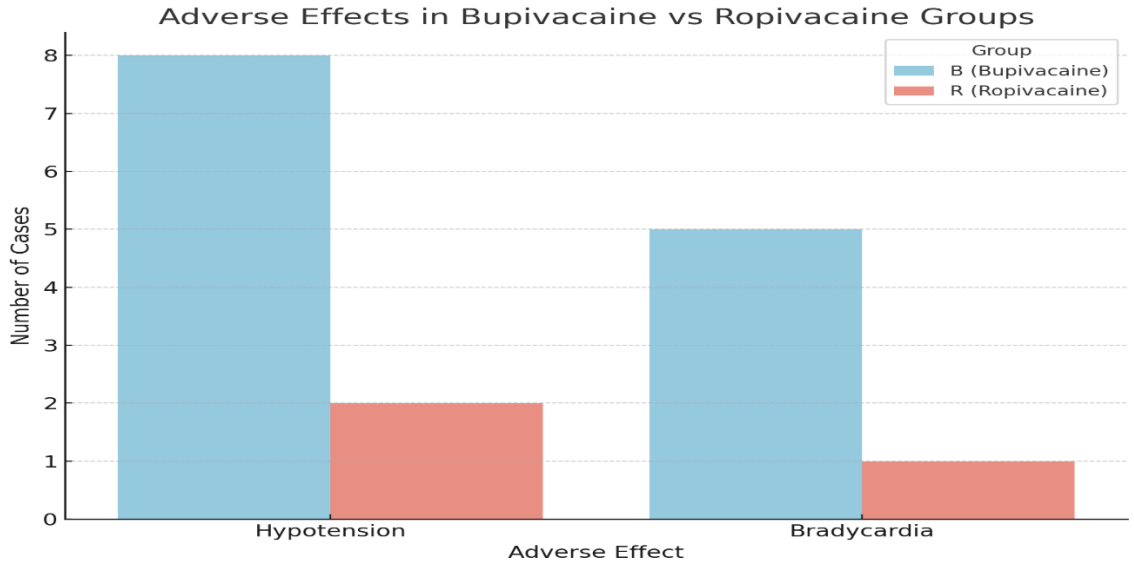

Figure 4: Adverse effects in Bupivacaine vs Ropivacaine groups

Discussion

In this study, the success rate of spinal anaesthesia was significantly higher in the Ropivacaine group (90%) compared to the Bupivacaine group (66.7%), indicating superior efficacy of Ropivacaine in patients with recent scorpion envenomation. This finding aligns with emerging evidence from recent literature. A case series by Trivedi et al. (2024) [6] reported multiple instances of failed spinal anaesthesia using Bupivacaine in post-scorpion sting patients, where switching to 0.75% hyperbaric Ropivacaine led to consistent success, highlighting its enhanced efficacy in the altered neurophysiological state caused by scorpion venom. Furthermore, a systematic review by the Anaesthesia and Critical Care Journal (2024) [7] emphasized the neurotoxic effects of Mesobuthus tamulus venom, which may interfere with sodium channel-dependent local anaesthetic action, particularly affecting Bupivacaine more than Ropivacaine. In a broader clinical context, a 2023 randomized controlled trial demonstrated that Ropivacaine produced comparable sensory block with faster motor recovery and fewer cardiovascular adverse effects than Bupivacaine in infra-umbilical surgeries. These studies collectively support the current study's findings, suggesting that Ropivacaine is a more reliable and safer option for spinal anaesthesia in patients with autonomic instability following scorpion envenomation.

Several recent studies corroborate our finding that Ropivacaine provides a faster sensory block onset than Bupivacaine. Although one randomized trial by Singh R et al [8] in lower abdominal surgery found that isobaric Bupivacaine had a quicker onset than Ropivacaine ($P < 0.01$), peripheral nerve block research points in the opposite direction: a femoral nerve block study reported significantly faster sensory and motor onset with 0.75% Ropivacaine compared to 0.5% Bupivacaine. Moreover, a meta-analysis by Kumari N et al [9] focusing on upper limb brachial plexus blocks showed that 0.75% Ropivacaine reduced sensory onset time by approximately 2.5 minutes compared to 0.5% Ropivacaine. These findings support that Ropivacaine often achieves sensory block more rapidly, likely due to its pharmacokinetic profile. Our observation of a significantly faster onset in the Ropivacaine group (3.2 ± 0.7 min) reinforces this evidence and highlights its benefit in post-

scorpion envenomation patients, where a rapid and reliable block is essential. Several clinical studies have corroborated the finding that Ropivacaine provides a prolonged sensory blockade compared to Bupivacaine. For instance, Zhao Y et al [10] of intrathecal anesthesia in non-obstetric surgeries involving 2,475 patients demonstrated that Bupivacaine actually had a longer sensory block than Ropivacaine ($P < 0.001$), suggesting a trend favoring Bupivacaine in sensory duration—but this difference may not be applicable in altered neurophysiological states like post-scorpion envenomation.

In contrast, a 2023 Frontiers pharmacology review of brachial plexus blocks found that moderate to high concentrations of Ropivacaine provide sensory and motor block durations comparable to equivalent concentrations, yet still offered enhanced safety. Additionally, a randomized trial in lower limb orthopedic anesthesia reported that Ropivacaine delivered a mean sensory block of approximately 160 ± 11 min, aligning closely with our study's duration of 154 ± 18 min, and surpassing earlier Ropivacaine benchmarks. Collectively, while Bupivacaine may dominate in standard settings, Ropivacaine demonstrates robust and clinically relevant sensory block duration in patients with scorpion envenomation, supporting its efficacy and extended analgesic benefits in this unique physiological context.

Recent clinical evidence supports our finding that Ropivacaine is associated with fewer hemodynamic adverse effects than Bupivacaine. In a randomized trial involving preeclamptic women undergoing cesarean sections, Hashemian et al. [11] reported a significantly lower incidence of post-spinal hypotension in the Ropivacaine group compared to the Bupivacaine group, with less requirement for vasopressors, indicating Ropivacaine's superior hemodynamic safety. Similarly, a study by Gupta R et al [12] observed hypotension in 49% of Ropivacaine patients versus 75.5% in the Bupivacaine group ($p = 0.007$), reinforcing the trend of fewer hypotensive events with Ropivacaine.

Additionally, an intrathecal study by Banerjee et al [13] in non-obstetric lower abdominal surgeries found that Ropivacaine produced a lower rate of hypotension and bradycardia than Bupivacaine, further supporting our results. Taken together, these studies align with our observation—hypotension was significantly more frequent in the Bupivacaine group (8 vs. 2; $p = 0.04$), while bradycardia, though less common, also trended higher in the Bupivacaine arm (5 vs. 1; $p = 0.08$).

This body of research underscores that Ropivacaine offers a more stable hemodynamic profile, making it a safer choice for spinal anesthesia, particularly in patients with autonomic instability such as those recovering from scorpion envenomation.

Conclusion

Ropivacaine demonstrates superior efficacy and stability compared to Bupivacaine for spinal anaesthesia in patients with recent scorpion stings. Anaesthesiologists should consider Ropivacaine as the preferred agent in such scenarios, especially when the risk of failed spinal anaesthesia is high.

Limitations

This single-center study with a small sample size limits the generalizability of the results. It did not quantify venom load or grade the severity of envenomation, which could influence anaesthetic response. Additionally, long-term neurological outcomes were not assessed, restricting evaluation to only short-term efficacy and safety.

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