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Anaesthesia Section

Dexmedetomidine versus Clonidine as Intrathecal Adjuvants to Hyperbaric Ropivacaine for Subarachnoid Block in Patients with History of Scorpion Bite undergoing Infraumbilical Surgery: A Double-blinded Randomised Clinical Study

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ABSTRACT

Introduction: Patients with previous scorpion sting may show variable response to spinal local anaesthetics because scorpion toxins can alter voltage-gated sodium-channel behaviour. Ropivacaine and intrathecal alpha-2 agonists may improve block reliability in this subgroup.

Aim: To compare intrathecal dexmedetomidine and clonidine as adjuvants to 0.75% hyperbaric ropivacaine for Subarachnoid Block (SAB) in patients with history of scorpion bite undergoing infraumbilical surgery.

Materials and Methods: This double-blinded randomised clinical study was conducted in the Department of Anaesthesiology, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India. The study included 78 American Society of Anaesthesiologists (ASA) I-II adults aged 18-60 years with documented scorpion bite history scheduled for elective infraumbilical surgery. Patients were allocated equally. Group RD received 3 mL 0.75% hyperbaric ropivacaine with dexmedetomidine 5 µg intrathecally, while Group RC received 3 mL 0.75% hyperbaric ropivacaine with clonidine 30 µg. Block characteristics, block success and haemodynamic variables were recorded. Normality was assessed using the Shapiro-Wilk test. Continuous variables were compared using the independent-samples t-test, and categorical variables using the Chi-square or Fisher's exact test. A p-value <0.05 was considered significant.

Results: A total of 78 patients were randomised, with 39 patients allocated to each group. Baseline characteristics were comparable between Group RD and Group RC, including age (42.6±9.8 vs 43.9±10.2 years), sex distribution (21/18 vs 23/16 male/female), weight (63.4±8.1 vs 64.1±7.6 kg), height (162.8±6.9 vs 163.2±7.1 cm), baseline heart rate (78.4±7.0 vs 79.5±6.8 beats/min), baseline mean arterial pressure (94.8±5.9 vs 93.7±6.1 mmHg), and duration of surgery (73.4±15.2 vs 75.1±14.8 minutes). Among patients with successful measurable block, sensory onset was significantly faster in Group RD than in Group RC (3.5±0.9 vs 5.3±1.3 minutes; p-value <0.001), and motor onset was also earlier (4.3±0.9 vs 5.7±1.2 minutes; p-value <0.001). Group RD demonstrated a longer duration of sensory block (274.2±24.9 vs 228.8±23.7 minutes; p-value <0.001) and motor block (245.8±28.0 vs 196.7±23.4 minutes; p-value <0.001). Successful spinal block was achieved in 38/39 (97.4%) patients in Group RD and 36/39 (92.3%) patients in Group RC; however, the difference was not statistically significant (p-value=0.615).

Conclusion: Intrathecal dexmedetomidine added to 0.75% hyperbaric ropivacaine produced faster sensory and motor onset and prolonged block duration compared with clonidine in patients with previous scorpion bite. Both regimens were haemodynamically acceptable, but dexmedetomidine showed superior overall block characteristics and reliability.

Keywords: Alpha-2 adrenergic agonist, Envenomation, Haemodynamic stability, Local anaesthetic resistance, Neuraxial anaesthesia, Postoperative analgesia, Sympatholysis

INTRODUCTION

The SAB is a commonly used regional anaesthetic technique for infraumbilical surgeries because it provides dense sensory-motor blockade, reduces the need for systemic anaesthetic drugs, and offers favourable perioperative recovery. However, spinal anaesthesia may occasionally be delayed, patchy, incomplete, or unsuccessful despite confirmed cerebrospinal fluid flow and technically appropriate intrathecal drug administration. Such failure is not always technical; altered spread of drug or reduced local anaesthetic action at neural tissue may also contribute to inadequate spinal anaesthesia [1].

A previous history of scorpion sting is a clinically relevant detail in rural and semi-urban regions where scorpion envenomation is frequently encountered. Scorpion venom contains neurotoxins that interact with voltage-gated sodium channels, which are essential for nerve impulse generation and are also the principal targets of local anaesthetic drugs [2-4]. Several clinical studies have reported delayed onset, inadequate spread, or failed spinal anaesthesia in patients with previous scorpion sting, particularly with intrathecal bupivacaine and related local anaesthetic agents [5-8]. A recent systematic review also noted that local anaesthetic resistance or reduced block efficacy may occur in patients with a history of scorpion sting [9].

Ropivacaine is a long-acting amide local anaesthetic available as a pure S-enantiomer. Compared with bupivacaine, it has a more favourable cardiotoxicity profile and tends to produce effective sensory blockade with relatively less intense motor blockade [10]. Hyperbaric ropivacaine has been evaluated for spinal anaesthesia and has shown acceptable block characteristics in lower limb and infraumbilical procedures [11]. Recent reports have suggested that ropivacaine may be a useful alternative in patients with previous scorpion sting when conventional spinal local anaesthetic response is uncertain [12,13]. Nevertheless, consistency of onset, adequacy of surgical block, and duration of anaesthesia remain important concerns in this subgroup.

Intrathecal adjuvants are used to improve the reliability and duration of spinal anaesthesia. Alpha-2 adrenergic agonists such as clonidine and dexmedetomidine enhance neuraxial analgesia by reducing nociceptive neurotransmitter release and modulating dorsal horn neuronal activity [14]. Previous clinical studies have shown that both dexmedetomidine and clonidine can improve spinal block characteristics when added to intrathecal local anaesthetics [15-18]. Systematic review evidence also supports the efficacy of intrathecal dexmedetomidine in prolonging sensory-motor blockade and improving analgesic outcomes [19]. Ropivacaine-based studies have further explored dexmedetomidine and clonidine as intrathecal adjuvants for improving spinal block duration [20]. Ropivacaine has previously produced successful SAB in patients with recent scorpion sting, while the addition of intrathecal fentanyl has been reported to improve the onset and duration of ropivacaine spinal anaesthesia in patients with a history of scorpion bite [13,21]. Dexmedetomidine and clonidine have also been compared as intrathecal adjuvants to 0.75% ropivacaine in patients without a history of scorpion bite [20]. However, to our knowledge, no published study has directly compared these two alpha-2 agonists with intrathecal hyperbaric ropivacaine specifically in patients with a previous scorpion bite.

Therefore, the present study was conducted to compare intrathecal dexmedetomidine and clonidine as adjuvants to 0.75% hyperbaric ropivacaine in patients with a previous history of scorpion bite undergoing infraumbilical surgeries. The primary objective was to compare sensory onset time, motor onset time, duration of sensory block, and duration of motor block between the two groups. The secondary objectives were to compare block success rate, failed block rate, intraoperative haemodynamic stability, oxygen saturation, and postoperative recovery-related adverse events.

MATERIALS AND METHODS

This double-blinded randomised clinical study was conducted in the Department of Anaesthesiology, Krishna Vishwa Vidyapeeth (Deemed to be University), Karad, Maharashtra, India, over 18 months from June 2024 to November 2025. The study was initiated after approval from the Institutional Ethics Committee vide approval number (Protocol Number 307/2023-2024) KVV/IEC/05/2024, dated 15/04/2024. Written informed consent was obtained from all participants before enrolment.

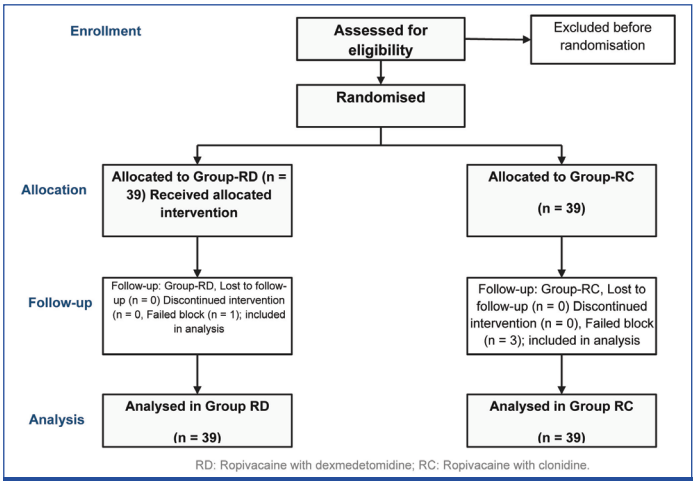
Sample size: The sample size was calculated for comparison of two independent means using the formula $n=2(Z_{\alpha/2}+Z_{\beta})^2\sigma^2/d^2$. There was sensory regression to S2 of 286.60±50.21 minutes with dexmedetomidine and 258.83±20.93 minutes with clonidine [20]. Thus, the expected mean difference was 27.77 minutes, and the calculated pooled standard deviation was 38.46 minutes. Substituting $Z_{\alpha/2}=1.96$, $Z_{\beta}=0.84$, $\sigma=38.46$ and $d=27.77$, the sample size was $n=2(1.96+0.84)^2(38.46)^2/(27.77)^2=30.08$, rounded up to 31 patients per group. After allowing for 20% attrition, 31/0.80=38.75, rounded to 39 patients per group. Therefore, 78 patients were enrolled.

Inclusion criteria: Adult patients aged 18-60 years, of either sex, belonging to ASA Physical Status I or II, with documented history of scorpion bite and scheduled for elective infraumbilical surgery under SAB were included in the study.

Exclusion criteria: Patients with refused consent, had known hypersensitivity to ropivacaine, dexmedetomidine or clonidine, coagulopathy, ongoing anticoagulant therapy, seizure disorder, local infection at the lumbar puncture site, significant spinal deformity, recent spinal trauma, pre-existing neurological deficit, or any other accepted contraindication to SAB were excluded from the study.

Study Procedure

During the study period, 78 eligible patients were included and randomised into two equal groups. The flow of participants through eligibility assessment, randomisation, allocation, follow-up, and final analysis is presented in [Table/Fig-1]. No patient was excluded after randomisation. Patients with failed spinal block were included for block-success analysis, while sensory and motor onset/duration variables were analysed only among patients in whom these endpoints were clinically measurable.



[Table/Fig-1]: CONSORT flow diagram of study participants.

Randomisation, allocation concealment and blinding: Patients were enrolled by the principal investigator after eligibility confirmation. The random allocation sequence was generated by an independent anaesthesiologist using a computer-generated random number table. Allocation concealment was maintained with sequentially numbered, sealed, opaque envelopes, and group assignment was performed only after enrolment. The study drug was prepared by an anaesthesiologist who was not involved in block administration, intraoperative care, postoperative assessment, or statistical analysis. Both study solutions were colourless, loaded in identical syringes, coded according to allocation, and prepared with the same final intrathecal volume. The patient, anaesthesiologist performing the block, postoperative assessor, and statistician were blinded to group allocation. These measures were adopted to reduce selection, performance, detection, and analytical bias.

Study groups and intervention: Group RD received 3 mL of 0.75% hyperbaric ropivacaine with dexmedetomidine 5 µg intrathecally. Group RC received 3 mL of 0.75% hyperbaric ropivacaine with clonidine 30 µg intrathecally. The final intrathecal study solution volume was kept identical in both groups to preserve blinding. The adjuvant doses were selected based on previous intrathecal alpha-2 agonist studies and ropivacaine-adjuvant literature [15,17,20]. The type of infraumbilical surgery performed was recorded and categorised according to the operative procedure.

Anaesthetic procedure and intraoperative monitoring: After routine preanaesthetic evaluation, patients were shifted to the operation theatre. Standard monitoring was attached, including electrocardiography, non-invasive blood pressure, pulse oximetry, heart rate, mean arterial pressure, and oxygen saturation. Baseline values were recorded before SAB. Under aseptic precautions,

spinal anaesthesia was performed in the sitting position at the L3-L4 interspace using a 25-gauge Quincke spinal needle. After confirmation of free cerebrospinal fluid flow, the allocated study solution was injected slowly, and the patient was placed supine. Surgical incision was permitted after achievement of the target sensory level of T10.

Assessment of block characteristics: Sensory block was assessed by loss of pin-prick sensation, while motor block was assessed using the modified Bromage scale. Sensory onset time was defined as the time from intrathecal injection to achievement of T10 sensory level. Motor onset time was defined as the time from intrathecal injection to complete motor block. Duration of sensory block was defined as the time from intrathecal injection to sensory regression to S2 dermatome. Duration of motor block was defined as the time from intrathecal injection to recovery to modified Bromage score 0.

Block failure and haemodynamic assessment: Block success was defined as adequate surgical anaesthesia without conversion to general anaesthesia. Failed spinal block was defined as failure to achieve T10 sensory level within 20 minutes or inadequate analgesia requiring conversion to general anaesthesia. Patients with failed spinal block were managed according to institutional anaesthesia protocol and included in the block-failure outcome. Heart rate and mean arterial pressure were compared between the groups at baseline and at 5, 10, 20, and 30 minutes after spinal injection. Standard intraoperative monitoring, including oxygen saturation, was continued until completion of surgery.

Postoperative anaesthetic protocol: After surgery, patients were monitored in the post-anaesthesia care unit until sensory regression, motor recovery, and haemodynamic stability were adequate for transfer to the ward. Oxygen saturation, haemodynamic stability, level of consciousness, nausea, vomiting, bradycardia, hypotension, respiratory depression, shivering, and requirement for rescue medication were recorded. Postoperative analgesia was provided according to institutional protocol.

Variable	Group RD (n=39)	Group RC (n=39)	p-value
Age (years), mean±SD	42.6±9.8	43.9±10.2	0.62
Male, n (%)	21 (53.8)	23 (59.0)	0.64
Female, n (%)	18 (46.2)	16 (41.0)	0.64
Weight (kg), mean±SD	63.4±8.1	64.1±7.6	0.71
Height (cm), mean±SD	162.8±6.9	163.2±7.1	0.81
ASA I, n (%)	26 (66.7)	24 (61.5)	0.64
ASA II, n (%)	13 (33.3)	15 (38.5)	0.64
Single scorpion sting, n (%)	30 (76.9)	29 (74.4)	0.79
Multiple scorpion stings, n (%)	9 (23.1)	10 (25.6)	0.79
Time since sting >1 year, n (%)	22 (56.4)	21 (53.8)	0.82
Time since sting ≤ 1 year, n (%)	17 (43.6)	18 (46.2)	0.82
Hospitalised after sting, n (%)	11 (28.2)	12 (30.8)	0.81
Not hospitalised after sting, n (%)	28 (71.8)	27 (69.2)	0.81
Duration of surgery (mins), mean±SD	73.4±15.2	75.1±14.8	0.61

[Table/Fig-2]: Baseline demographic, clinical and scorpion-bite profile.
Values are expressed as mean±SD or n (%), as appropriate. ASA: American Society of Anaesthesiologists; RD: Ropivacaine with dexmedetomidine; RC: Ropivacaine with clonidine.

Outcome measures: The primary outcome measures were sensory onset time, motor onset time, duration of sensory block, and duration of motor block. The secondary outcome measures were block success rate, failed block rate, heart rate, mean arterial pressure, oxygen saturation, haemodynamic adverse events, and postoperative recovery parameters.

STATISTICAL ANALYSIS

Data were entered in Microsoft Excel and analysed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 26.0. Normality of continuous variables was assessed using the Shapiro-Wilk test. Continuous variables were expressed as mean±standard deviation and compared between groups using the independent samples t-test. Categorical variables with adequate expected cell counts were analysed using the Chi-square test. Fisher's exact test was used for categorical comparisons with small expected cell counts, including block success and failed spinal block. Haemodynamic variables were compared between groups at each predefined time point using the independent samples t-test. All randomised patients were included for baseline comparison and block-success analysis, while onset and duration outcomes were analysed among patients with successful measurable block. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 78 eligible patients were randomised equally into Group RD (n=39) and Group RC (n=39). All patients received the allocated intervention, and there were no losses to follow-up or discontinuations. Failed spinal block occurred in 1 (2.6%) patient in Group RD and 3 (7.7%) patients in Group RC. Therefore, all 78 patients were analysed for baseline characteristics and block success, while onset and duration outcomes were analysed in patients with clinically measurable blocks, namely 38 patients in Group RD and 36 patients in Group RC [Table/Fig-1].

Mean weight, height, ASA physical status distribution, baseline heart rate, baseline mean arterial pressure, scorpion-bite characteristics, and duration of surgery showed no statistically significant between-group difference [Table/Fig-2].

Group RD demonstrated significantly faster sensory and motor block onset and significantly longer sensory and motor block duration than Group RC. These findings indicate a superior overall block profile with intrathecal dexmedetomidine [Table/Fig-3].

Haemodynamic parameters were comparable at baseline; however, Group RC showed greater early reductions in heart rate and mean arterial pressure than Group RD. No clinically significant oxygen desaturation or respiratory depression occurred in either group [Table/Fig-4].

Block success was high in both groups. Successful spinal block was achieved in 38 of 39 patients (97.4%) in Group RD and 36 of 39 patients (92.3%) in Group RC. Failed block occurred in one patient (2.6%) in Group RD and three patients (7.7%) in Group RC. Although the failure rate was numerically lower with dexmedetomidine, the between-group difference was not statistically significant (Fisher-exact test p-value=0.615) [Table/Fig-5].

Overall, dexmedetomidine as an intrathecal adjuvant to hyperbaric ropivacaine produced faster sensory and motor onset, longer sensory

Parameter	Group RD (n=38)	Group RC (n=36)	Mean difference (RD–RC)	95% CI	p-value
Sensory onset (mins)	3.5±0.9	5.3±1.3	–1.8	–2.3 to –1.2	<0.001
Motor onset (mins)	4.3±0.9	5.7±1.2	–1.4	–1.9 to –0.9	<0.001
Sensory block duration (mins)	274.2±24.9	228.8±23.7	+45.5	+34.2 to +56.7	<0.001
Motor block duration (mins)	245.8±28.0	196.7±23.4	+49.1	+37.2 to +61.0	<0.001

[Table/Fig-3]: Comparison of primary sensory and motor block outcomes among patients with successful measurable block.
Negative mean difference indicates faster onset in Group RD, whereas positive mean difference indicates longer duration in Group RD.

Time interval	Parameter	Group RD (mean±SD)	Group RC (mean±SD)	p-value
Baseline	Heart rate (beats/min)	78.4±7.0	79.5±6.8	0.47
Baseline	Mean arterial pressure (mmHg)	94.8±5.9	93.7±6.1	0.45
5 minutes	Heart rate (beats/min)	76.3±8.4	70.6±7.5	0.002
5 minutes	Mean arterial pressure (mmHg)	89.4±5.3	83.9±6.9	<0.001
10 minutes	Heart rate (beats/min)	74.0±7.1	71.2±7.2	0.08
10 minutes	Mean arterial pressure (mmHg)	89.2±7.4	82.7±7.0	<0.001
20 minutes	Heart rate (beats/min)	71.2±6.8	68.3±8.4	0.10
20 minutes	Mean arterial pressure (mmHg)	88.6±5.9	83.4±5.4	<0.001
30 minutes	Heart rate (beats/min)	72.1±7.9	66.8±7.2	0.002
30 minutes	Mean arterial pressure (mmHg)	87.5±7.1	81.7±6.6	<0.001

[Table/Fig-4]: Haemodynamic comparison at different time intervals.
HR: Heart rate; MAP: Mean arterial pressure.

Group	Failed block	Successful block	p-value
Group RD	1/39 (2.6%)	38/39 (97.4%)	0.615
Group RC	3/39 (7.7%)	36/39 (92.3%)	

[Table/Fig-5]: Block success and failure in the two groups.
Fisher-exact test was used because of the low number of failed blocks. RD: Ropivacaine with dexmedetomidine; RC: Ropivacaine with clonidine.

and motor block duration, and a numerically higher block success rate than clonidine. Haemodynamic parameters remained within clinically manageable ranges in both groups, with comparatively greater early reductions in heart rate and mean arterial pressure in Group RC. No serious adverse event, persistent neurological deficit, respiratory depression, or clinically important postoperative safety concern was observed in either group.

DISCUSSION

In the present randomised double-blind clinical study, the two groups were comparable with respect to age, sex distribution, anthropometric variables, ASA physical status, baseline haemodynamic parameters, duration of surgery, and scorpion-bite related characteristics. This comparability strengthens the interpretation of block-related outcomes because patient profile, surgical duration, autonomic response, and previous envenomation-related factors may influence spinal anaesthetic spread and effectiveness. Previous studies have reported delayed onset, inadequate block, and failed spinal anaesthesia in patients with previous scorpion sting, particularly when bupivacaine or similar intrathecal local anaesthetics were used [5-8]. A recent systematic review also observed that resistance or reduced response to local anaesthetics may be encountered in patients with a history of scorpion sting [9]. In the present study, use of hyperbaric ropivacaine was justified by its favourable pharmacological profile and by recent reports suggesting its usefulness in patients with scorpion sting history [10-13].

The present study demonstrated significantly faster sensory and motor block onset with dexmedetomidine than with clonidine. Sensory onset was 3.5±0.9 minutes in Group RD and 5.3±1.3 minutes in Group RC, while motor onset was 4.3±0.9 minutes and 5.7±1.2 minutes, respectively; both differences were statistically significant (p-value <0.001). This finding suggests that dexmedetomidine facilitated earlier establishment of surgical anaesthesia when used with hyperbaric ropivacaine. Alpha-2 agonists enhance spinal analgesia through modulation of nociceptive transmission at the spinal cord level [14]. Kanazi GE et al., reported improved spinal block characteristics with low-dose dexmedetomidine and clonidine as adjuvants to bupivacaine [15]. Mahendru V et al., also observed more favourable block characteristics with intrathecal dexmedetomidine compared with clonidine and fentanyl [17]. Raut K et al., reported comparable ropivacaine-based evidence using intrathecal dexmedetomidine and clonidine as adjuvants [20]. The present study extends these findings to patients with previous scorpion bite receiving hyperbaric ropivacaine.

The duration of both sensory and motor block was significantly prolonged in the dexmedetomidine group. Sensory block duration was 274.2±24.9 minutes in Group RD compared with 228.8±23.7 minutes in Group RC, while motor block duration was 245.8±28.0 minutes and 196.7±23.4 minutes, respectively; both differences were statistically significant (p-value <0.001). These results indicate a stronger and more sustained adjuvant effect with dexmedetomidine. Similar prolongation of sensory and motor blockade was reported by Mahendru V et al., when dexmedetomidine was compared with clonidine and fentanyl as an intrathecal adjuvant [17]. Gupta R et al., also observed that intrathecal dexmedetomidine improved postoperative analgesic profile when added to spinal local anaesthetic agents [18]. A systematic review and meta-analysis by Kumar S et al., further supported the efficacy of intrathecal dexmedetomidine in prolonging block duration and analgesic outcomes [19]. Although clonidine also prolongs local anaesthetic spinal block, its effect may be dose-related and may be accompanied by haemodynamic effects [16]. The present findings therefore support dexmedetomidine as the more effective adjuvant for prolonging ropivacaine spinal block in this subgroup.

Block success was numerically higher in Group RD than Group RC, although the difference was not statistically significant. Failed spinal block occurred in one patient in Group RD and three patients in Group RC, giving success rates of 97.4% and 92.3%, respectively. This outcome should be interpreted carefully because the study was not primarily powered to detect differences in block failure. However, it remains clinically meaningful in patients with previous scorpion sting, where altered response to local anaesthetics has been repeatedly reported [5-9]. Mechanistically, scorpion toxins can alter sodium-channel behaviour [2-4], and sodium channels are central to the action of intrathecal local anaesthetic agents [2]. Recent clinical observations have suggested that ropivacaine may retain efficacy in this situation [12,13]. The present findings suggest that adding dexmedetomidine to hyperbaric ropivacaine may further improve the predictability of SAB in patients with previous scorpion bite.

Haemodynamic variables remained clinically acceptable in both groups, although heart rate and mean arterial pressure were lower at several post-block intervals in the clonidine group. This pattern is compatible with the sympatholytic action of alpha-2 adrenergic agonists. Elia N et al., reported that intrathecal clonidine prolongs spinal anaesthesia, but hypotension and bradycardia may occur in a dose-dependent manner [16]. Dexmedetomidine also has sympatholytic activity, but at the selected dose in the present study, it provided better block characteristics without clinically unacceptable haemodynamic instability. The findings are consistent with previous evidence supporting intrathecal dexmedetomidine as an effective and generally safe adjuvant to spinal local anaesthetic agents [18,19]. Overall, dexmedetomidine appears to offer a favourable balance between sensory-motor block enhancement

and haemodynamic stability when added to hyperbaric ropivacaine in patients with a previous history of scorpion bite.

Limitation(s)

This study had certain limitations. It was conducted at a single centre with a moderate sample size; hence, the findings require confirmation through larger multicentre trials. Only ASA physical status I and II patients were included, so the safety profile may not be directly generalisable to patients with significant cardiovascular or systemic co-morbidities. The follow-up was limited to the perioperative period, and long-term neurological assessment was not performed. In addition, the study did not evaluate different doses of dexmedetomidine or clonidine, so the optimal dose-response relationship could not be determined. The sample size was derived from an isobaric ropivacaine study and baricity may influence block duration.

CONCLUSION(S)

Intrathecal dexmedetomidine, when added to 0.75% hyperbaric ropivacaine, provided a faster onset of sensory and motor blockade and prolonged the duration of sensory and motor block compared with clonidine in patients with a previous history of scorpion bite undergoing infraumbilical surgery. Both adjuvants showed clinically acceptable haemodynamic profiles. However, dexmedetomidine demonstrated a more favourable overall block pattern, suggesting that it may be a useful intrathecal adjuvant to ropivacaine for achieving more reliable spinal anaesthesia in this distinct patient group.

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