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Research Article

Comparative Evaluation of Intrathecal Buprenorphine versus Dexmedetomidine as Adjuvants to Hyperbaric Ropivacaine in Infraumbilical Surgeries: A Randomized Controlled Trial

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ABSTRACT
Background: Hyperbaric ropivacaine provides effective spinal anaesthesia, and adjuvants like dexmedetomidine and buprenorphine may enhance its efficacy.
Objective: To compare the intrathecal effects of buprenorphine and dexmedetomidine with hyperbaric ropivacaine.
Methods: Ninety ASA I–II patients (aged 20–60 years) undergoing infraumbilical surgeries were randomized into two groups. Group B received 0.75% hyperbaric ropivacaine with 60 µg buprenorphine, while Group D received 0.75% hyperbaric ropivacaine with 5 µg dexmedetomidine. We compared onset and duration of sensory/motor blocks, time to rescue analgesia, and side effects.
Results: Group D had significantly faster onset of sensory (2.3±0.5 min vs 3.2±0.6 min) and motor blocks (3.0±0.4 min vs 4.1±0.5 min), and longer duration of sensory (503.2±38.5 min vs 323.7±32.4 min) and motor blocks (441.7±35.2 min vs 297.1±30.6 min). Time to rescue analgesia was longer in Group D (520.5±40.1 min vs 335.4±34.3 min). Side effects were fewer in Group D.
Conclusion: Dexmedetomidine is a superior intrathecal adjuvant to buprenorphine with hyperbaric ropivacaine for infraumbilical surgeries.

Keywords: Spinal Anaesthesia, Ropivacaine, Dexmedetomidine, Buprenorphine, Infraumbilical Surgery, Analgesia.

INTRODUCTION

Spinal anaesthesia is a widely utilized regional anaesthesia technique for infraumbilical surgeries due to its rapid onset, reliable sensory and motor block, ease of administration, and cost-effectiveness. It is especially preferred in day-care and elective surgeries involving the lower abdomen, pelvis, and lower limbs. One of the commonly used local anesthetics in spinal anesthesia is ropivacaine, an amide-type agent known for its favorable pharmacokinetic and pharmacodynamic profiles. Ropivacaine, particularly in its hyperbaric form, offers more predictable spread in the subarachnoid space, thereby producing a more consistent block. It provides adequate intraoperative anaesthesia with less motor blockade and quicker postoperative recovery compared to bupivacaine. However, the relatively shorter duration of action of hyperbaric ropivacaine often necessitates the use of intrathecal adjuvants to prolong analgesia and enhance block characteristics.[12]

Intrathecal adjuvants are agents that are added to local anaesthetics to improve the quality and duration of anaesthesia and analgesia. Among these, buprenorphine and dexmedetomidine have gained popularity. Buprenorphine is a semi-synthetic opioid with partial agonist activity at µ-opioid receptors and antagonistic activity at κ-opioid receptors. It provides long-lasting analgesia with a ceiling effect on respiratory depression, making it a relatively safer opioid option for neuraxial use.[6]

Dexmedetomidine, on the other hand, is a highly selective alpha-2 adrenergic receptor agonist. Its mechanism of action involves inhibition of norepinephrine release at both spinal and supraspinal levels, leading to sedation, analgesia, and sympatholysis without causing significant respiratory depression. When administered intrathecally,

dexmedetomidine has been shown to prolong sensory and motor block duration, delay the need for rescue analgesia, and improve perioperative comfort.[8]

The comparative efficacy of these two agents—buprenorphine and dexmedetomidine—as adjuvants to intrathecal ropivacaine is not well established, particularly in the context of infraumbilical surgeries. While both have been studied individually, few direct comparative trials exist in the literature. This study aims to fill that gap by evaluating and comparing the onset, duration, and quality of sensory and motor blocks, postoperative analgesia, and side-effect profiles of buprenorphine and dexmedetomidine when added to 0.75% hyperbaric ropivacaine in patients undergoing elective infraumbilical surgeries.

We hypothesize that dexmedetomidine, owing to its unique pharmacological properties, may provide a longer duration of anaesthesia and analgesia with better hemodynamic stability and fewer side effects compared to buprenorphine. This randomized controlled trial is therefore designed to assess and compare these outcomes in a clinical setting.

METHODOLOGY

Design: Randomized controlled trial.

Participants: Ninety ASA I–II patients aged 20–60 years undergoing infraumbilical surgeries under spinal anaesthesia.

Groups:

Group B: 0.75% hyperbaric ropivacaine + 60 µg buprenorphine

Group D: 0.75% hyperbaric ropivacaine + 5 µg dexmedetomidine

Outcomes: Block characteristics (onset, duration), rescue analgesia, side effects.

Statistical Analysis: Independent t-test and chi-square test, $p<0.05$ considered significant.

RESULTS

A total of 90 patients were enrolled and randomly allocated into two groups: Group B (n=45), who received 0.75% hyperbaric ropivacaine with 60 µg buprenorphine, and Group D (n=45), who received 0.75% hyperbaric ropivacaine with 5 µg dexmedetomidine. The groups were comparable in terms of demographic and baseline characteristics (Table 1).

Table 1. Demographic and Baseline Characteristics

Parameter	Dexmedetomidine Group (n=45)	Buprenorphine Group (n=45)	P-Value
Age (years)	40.32 ± 12.60	41.50 ± 13.00	0.66 (NS)
Weight (kg)	66.30 ± 7.50	62.50 ± 11.50	0.07(NS)
Height (cm)	165.30 ± 5.80	164.30 ± 8.70	0.52(NS)
BMI (kg/m²)	*22.80* ± 2.40	23.90 ± 3.60	0.09(NS)

Block characteristics, including onset and duration of sensory and motor blocks, were evaluated. Group D demonstrated a significantly faster onset of sensory and motor blocks compared to Group B ($p<0.001$). The duration of both sensory and motor blocks was significantly prolonged in Group D ($p<0.001$), as was the time to first rescue analgesia (Table 2).

Table 2. Block Characteristics

Parameter	Group B	Group D	p-value
Onset of sensory block (min)	7.1 ± 1.4	6.5± 1.2	0.03
Onset of motor block (min)	9.0 ± 1.8	8.2 ± 1.6	0.02
Max sensory level achieved	T6	T4	0.03
Duration of sensory block (min)	390 ± 40.5	480.6 ± 45.9	0.001
Duration of motor block (min)	240 ± 25.6	270 ± 30.2	0.002
Time to rescue analgesia (min)	355.4 ± 25.6	480.5 ± 40.1	< 0.05

Figure 1. Onset of Block

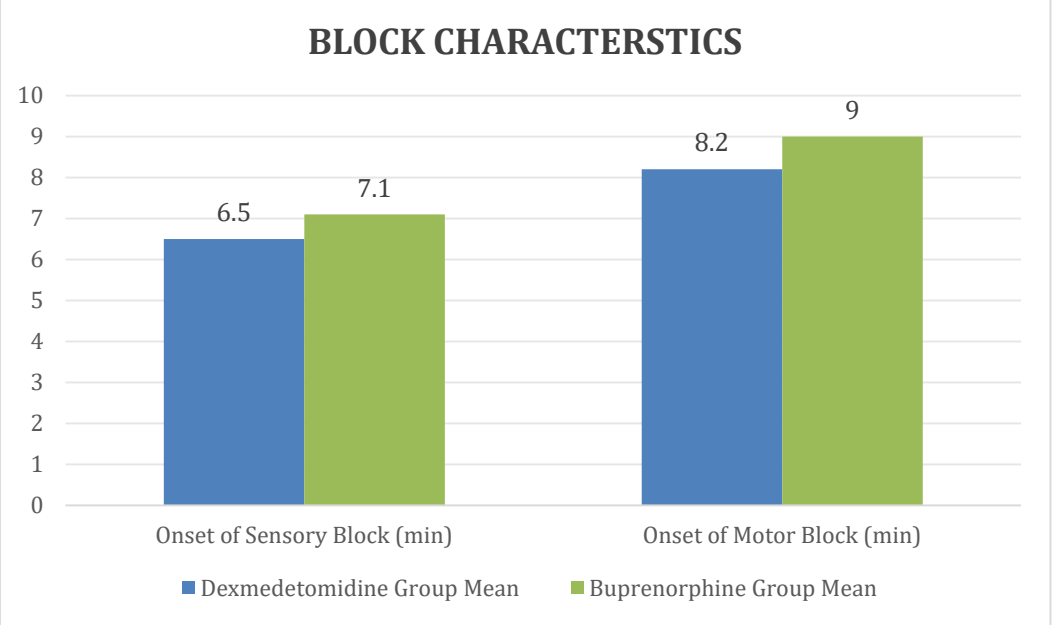
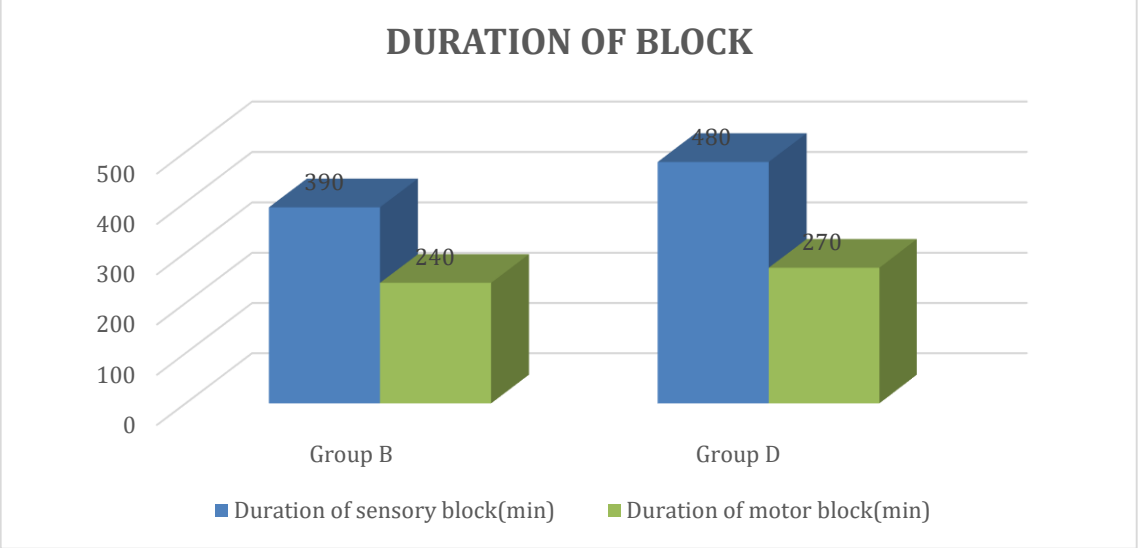


Figure 2. Duration of Block



Hemodynamic parameters, including heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure, were recorded at baseline and regular intervals intraoperatively. There were no significant intergroup differences in hemodynamic stability, though transient bradycardia and hypotension were more common in Group B, but not statistically significant ($p > 0.05$).

The incidence of side effects was evaluated and is summarized in Table 3. Group B reported a higher incidence of nausea, vomiting, and hypotension. Group D showed better tolerance with minimal side effects.

Table 3. Adverse Effects

Side Effect	Group B	Group D
Nausea	4	1
Vomiting	2	0
Hypotension	1	2
Bradycardia	0	1
Respiratory depression	0	0

Pruritus	3	0

Overall, Group D outperformed Group B across most parameters. Statistical significance was established for the onset and duration of blocks as well as the need for rescue analgesia. This supports the conclusion that dexmedetomidine is a more effective adjuvant for intrathecal anaesthesia when used with hyperbaric ropivacaine.

DISCUSSION

Spinal anaesthesia remains an indispensable modality for infraumbilical surgeries, offering profound sensory and motor blockade with favorable safety, especially in patients with minimal systemic reserve. The evolution of local anesthetic pharmacology has encouraged the utilization of ropivacaine, a relatively newer amide local anesthetic, which offers adequate sensory-motor differential blockade and minimal cardiotoxicity compared to bupivacaine. However, the standalone duration of analgesia provided by ropivacaine is often insufficient for extended surgeries or desired postoperative analgesia. Therefore, adjuvants like **dexmedetomidine** and **buprenorphine** are introduced to enhance block quality, prolong analgesia, and reduce the need for systemic analgesics.

Dexmedetomidine, a highly selective α2-adrenergic agonist, exerts its action via inhibition of substance P release and modulation of nociceptive transmission in the dorsal horn. Buprenorphine, a partial μ-opioid agonist with κ-antagonism, provides extended analgesia and a ceiling effect for respiratory depression. The comparative effectiveness of these adjuvants with hyperbaric ropivacaine was systematically evaluated in our study to optimize clinical outcomes and determine the superior agent in terms of efficacy and safety.[20]

This randomized controlled trial was conducted to compare the efficacy and safety of intrathecal dexmedetomidine versus buprenorphine as adjuvants to hyperbaric 0.75% ropivacaine in patients undergoing infraumbilical surgeries. The primary findings indicate that dexmedetomidine significantly enhances the quality of spinal anaesthesia by accelerating the onset and prolonging the duration of both sensory and motor blocks, while also extending postoperative analgesia with fewer side effects than buprenorphine.

In our study the onset of sensory block occurred at 6.5 ± 1.2 minutes in the dexmedetomidine group and 7.1 ± 1.4 minutes in the buprenorphine group ($p = 0.03$), while the onset of motor block was recorded at 8.2 ± 1.6 versus 9.0 ± 1.8 minutes respectively ($p = 0.02$). Our findings align with previous research **Amingad et al.**[19] in which addition of 5 μg dexmedetomidine resulted in an 18% faster sensory block onset compared to buprenorphine (7.4 vs 9.1 minutes),

The faster onset of sensory and motor blockade observed in the dexmedetomidine group is consistent with the drug's pharmacodynamic profile. Dexmedetomidine acts on pre- and post-synaptic alpha-2 adrenergic receptors in the dorsal horn of the spinal cord, inhibiting the release of nociceptive neurotransmitters such as substance P and glutamate. This action leads to a more rapid attainment of effective anaesthesia. Buprenorphine, while effective, exhibits a slower onset likely due to its partial agonist nature and greater reliance on opioid receptor occupancy for effect.

In terms of duration, patients in the dexmedetomidine group experienced significantly prolonged sensory (480.6 ± 45.9 minutes versus 390 ± 40.5 minutes with $p = 0.001$) and motor blocks (270 ± 30.2 minutes versus 240 ± 25.6 minutes with $p=0.002$) compared to those receiving buprenorphine.

The extended duration of analgesia in the dexmedetomidine group can be attributed to its ability to hyperpolarize interneurons, thereby prolonging inhibition of nociceptive transmission. This prolonged blockade reduces the need for early rescue analgesia, contributing to better postoperative comfort and reduced analgesic consumption.

Our findings align with previous research. Studies by Suchitha et al[8]. and Gowri et al[20] demonstrated similar results, with dexmedetomidine outperforming buprenorphine in terms of onset time, duration of block, and postoperative pain control. A meta-analysis by Zhang et al[11]. also confirmed dexmedetomidine's superior profile when used intrathecally, especially regarding prolonged analgesia and reduced side effects.

Regarding hemodynamic stability, both groups maintained comparable parameters throughout the perioperative period. However,

the incidence of bradycardia and hypotension, although statistically insignificant, was slightly lower in the dexmedetomidine group. This may reflect dexmedetomidine's central sympatholytic effect, which stabilizes blood pressure and heart rate by reducing circulating catecholamines. Notably, dexmedetomidine did not cause excessive sedation or respiratory depression in our study, which is a common concern with other opioids like morphine.

The side effect profile also favored dexmedetomidine. Patients in the buprenorphine group had higher incidences of nausea, vomiting, pruritus, and hypotension. These side effects are well-documented with neuraxial opioid administration due to their interaction with opioid receptors in the chemoreceptor trigger zone and central nervous system. Conversely, dexmedetomidine's minimal emetogenic and pruritic properties make it a more tolerable adjuvant, especially in ambulatory or high-risk populations.

An important consideration is the choice of 0.75% hyperbaric ropivacaine. Ropivacaine's shorter duration of action compared to bupivacaine makes it an ideal candidate for day-care surgeries, but it often requires an adjuvant to sustain postoperative analgesia. Our study confirms that when combined with dexmedetomidine, ropivacaine becomes highly effective, offering long-lasting pain relief without prolonging motor block excessively, which is critical for early ambulation and discharge.

Limitations of our study include the single-center design and the lack of long-term follow-up regarding chronic pain development or delayed neurological complications. Additionally, although the doses were chosen based on previous literature, optimal dosing for these adjuvants may vary across patient demographics and surgical procedures.

CONCLUSION

Intrathecal dexmedetomidine, when used as an adjuvant to 0.75% hyperbaric ropivacaine, provides faster onset and significantly prolonged sensory and motor block compared to buprenorphine. It also offers extended postoperative analgesia with fewer side effects, making it a more effective and better-tolerated option for infraumbilical surgeries. Both adjuvants maintained hemodynamic stability, but dexmedetomidine showed a superior safety and efficacy profile. These findings support the routine use of dexmedetomidine as a preferred intrathecal adjuvant in clinical practice.

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Conflicts of Interest Statement

The authors declare no conflicts of interest.

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