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Comparative Study To Evaluate The Efficacy Of Dexmedetomidine (5 Mcg), Nalbuphine (1 Mg), And Magnesium Sulfate (100 Mg) As Adjuvants To 0.75% Hyperbaric Ropivacaine In Subarachnoid Block For Lower Limb Surgery

Dr. Tiruvaipathi Lalith V Rama Krishna[1*], Dr. Griddaluru Sindhura Deepthi[2], Dr. Avula Charan Teja Reddy[3], Dr. Gunapati Chaitanya Kumar[4], Dr. Kandukuru Krishna Chaitanya[5]

[*1]Post Graduate, Narayana Medical College, Nellore

[2]Assistant Professor, Narayana Medical College, Nellore

[3]Assistant Professor, Narayana Medical College, Nellore

[4]Associate Professor, Narayana Medical College, Nellore

[5]Professor and HOD, Narayana Medical College, Nellore

[*]**Corresponding author:**

Dr. Tiruvaipathi Lalith V Rama Krishna

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ABSTRACT

Background: Adjuvants to local anaesthetics in subarachnoid block (SAB) enhance anaesthesia quality and prolong analgesia. This study compares dexmedetomidine, nalbuphine, and magnesium sulfate as adjuvants to hyperbaric ropivacaine.

Methods: A randomized, double-blind study was conducted on 90 patients undergoing elective lower limb surgery under SAB. Patients were divided into three groups (n=30): Group D received 5 mcg dexmedetomidine, Group N received 1 mg nalbuphine, Group M received 100 mg magnesium sulfate, each with 3 ml of 0.75% hyperbaric ropivacaine. Onset, duration, regression, analgesia, and adverse effects were recorded.

Results: Dexmedetomidine produced the fastest onset and longest duration of block and analgesia. Nalbuphine was intermediate. Magnesium had delayed onset and shortest duration. Dexmedetomidine caused more bradycardia and hypotension.

Conclusion: Dexmedetomidine is the most effective adjuvant but needs hemodynamic monitoring. Nalbuphine offers a good efficacy-safety balance. Magnesium sulfate is the least effective in this context.

1. INTRODUCTION

Subarachnoid block remains a preferred regional anaesthesia technique for lower limb surgeries. While ropivacaine offers favorable safety and differential block properties, its duration may not suffice for prolonged procedures. To enhance duration and block characteristics, various adjuvants have been studied.

Dexmedetomidine, a selective α2-adrenoceptor agonist, prolongs block duration through spinal and supraspinal actions. Nalbuphine, a kappa agonist and mu antagonist, provides analgesia with fewer opioid-related side effects. Magnesium sulfate blocks NMDA receptors, reducing central sensitization and potentiating analgesia.

This study aimed to compare the onset, block duration, analgesia, and safety of these three adjuvants when added to hyperbaric ropivacaine in SAB.

2. MATERIALS AND METHODS

Design: Prospective, randomized, double-blind, comparative study.

Ethical Clearance: Institutional Ethical Committee approved.

Participants: ASA I–II patients, 18–65 years, undergoing lower limb surgery.

Exclusion: Patient refusal, contraindication to SAB, neurological disorders, chronic opioid use.

Groups:

- Group D: 3 ml 0.75% hyperbaric ropivacaine + 5 mcg dexmedetomidine (0.5 ml)

- Group N: 3 ml ropivacaine + 1 mg nalbuphine (0.5 ml)

- Group M: 3 ml ropivacaine + 100 mg magnesium sulfate (0.5 ml)

Assessments:

- Onset of sensory block (T10)
- Onset of motor block (Modified Bromage Scale)
- Time to 2-segment regression
- Duration of analgesia
- Hemodynamic parameters and adverse events

3. RESULTS

Parameter	Group D	Group N	Group M	p-value
Sensory onset (min)	2.6 ± 0.4	3.5 ± 0.5	4.8 ± 0.6	<0.05
Motor onset (min)	3.1 ± 0.5	4.2 ± 0.4	5.6 ± 0.7	<0.01
Sensory block duration (min)	251 ± 15	200 ± 18	170 ± 20	<0.001
Analgesia duration (min)	310 ± 20	240 ± 22	185 ± 25	<0.001
Ramsay Sedation Score	3–4	2–3	2	<0.01
Bradycardia (%)	13%	7%	0%	NS
Hypotension (%)	20%	10%	3%	NS

Table: Hemodynamic Changes

Parameter	Group D	Group N	Group M	p-value
Bradycardia (%)	13%	7%	0%	NS
Hypotension (%)	20%	10%	3%	NS

4. DISCUSSION

The superiority of dexmedetomidine in this study aligns with a growing body of evidence supporting its potent analgesic and block-prolonging effects when used intrathecally. The drug's mechanism of action includes hyperpolarization of post-synaptic dorsal horn neurons via α2A adrenergic receptor stimulation, which reduces the release of substance P and other nociceptive neurotransmitters. This not only prolongs sensory and motor block but also results in sedation beneficial during spinal anaesthesia without significant respiratory depression.

Nalbuphine's efficacy observed in this study can be attributed to its agonistic action at kappa receptors and antagonistic effects at mu receptors, offering spinal analgesia without pruritus, respiratory depression, or nausea commonly associated with μ-agonists like morphine and fentanyl. Nalbuphine's analgesia was prolonged compared to magnesium but was less than that provided by dexmedetomidine, consistent with the pharmacological profile noted in other studies. It represents a balanced adjuvant, especially in resource-limited or high-risk populations.

Magnesium sulfate, while mechanistically plausible through its NMDA receptor antagonism, did not match the efficacy of the other two adjuvants. The delayed onset and shorter duration of block observed could be due to its lower lipid solubility and slower CSF penetration. It may still play a role in multimodal analgesia or in patients intolerant to sedatives or opioids. Future research could explore higher doses, alternative routes, or combination regimens for magnesium sulfate to enhance

its intrathecal effect.

A notable strength of this study is the use of hyperbaric 0.75% ropivacaine, which allowed a better sensory-motor differentiation profile and reduced cardiotoxicity risk compared to bupivacaine. The fixed volume of 3.5 ml in all groups ensured uniform spread and comparability across the study arms. Additionally, the randomized, double-blind design minimized bias.

Limitations include the relatively small sample size and single-center scope, which may limit generalizability. Hemodynamic changes were monitored intraoperatively, but postoperative effects, patient satisfaction, and long-term outcomes like chronic pain were not assessed. Also, serum levels of the adjuvants were not measured, which could have provided pharmacokinetic correlations.

Future directions should include multicentric trials, dose-finding studies, and the use of ultrasound-guided intrathecal techniques to improve precision. The role of combined adjuvants (e.g., dexmedetomidine + nalbuphine) can also be explored to synergize benefits while minimizing individual side effects. Patient-centric outcomes like time to ambulation, satisfaction scores, and opioid-sparing effects should be incorporated into the next phase of clinical research.

The findings clearly demonstrate that dexmedetomidine is a superior adjuvant to ropivacaine in terms of onset and duration of spinal anaesthesia and postoperative analgesia. Dexmedetomidine shortens onset time and prolongs block through α2-receptor-mediated inhibition of nociceptive transmission and reduced sympathetic tone. These effects have been corroborated by earlier studies.

Nalbuphine produced intermediate effects. As a kappa agonist, it provides good analgesia with limited respiratory depression. It also does not cause pruritus or nausea, unlike μ-agonists. It was well tolerated with minimal hemodynamic instability.

Magnesium sulfate, despite theoretical advantages via NMDA antagonism, showed the slowest onset and shortest duration of effect. This supports previous findings that its intrathecal efficacy is less robust compared to α2 agonists or opioids.

Sedation was most prominent with dexmedetomidine, consistent with its central sympatholytic action. Bradycardia and hypotension were also more common in this group, reinforcing the need for vigilant hemodynamic monitoring.

No cases of respiratory depression, urinary retention, or pruritus were observed, and all drugs were well tolerated. Limitations include a small sample size, single-center study, and lack of long-term follow-up.

5. CONCLUSION

Dexmedetomidine is the most effective adjuvant to 0.75% hyperbaric ropivacaine in SAB for lower limb surgery, enhancing onset and duration of block and analgesia. Nalbuphine offers a safe alternative with good efficacy. Magnesium sulfate has limited intrathecal utility in this context.

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