Section: Anesthesiology

Original Research Article

A PROSPECTIVE RANDOMIZED COMPARATIVE STUDY OF INTRATHECAL KETAMINE AND FENTANYL AS ADJUVANTS TO HYPERBARIC BUPIVACAINE IN SUB ARACHANOID BLOCK FOR LOWER LIMB ORTHOPEDIC PROCEDURES

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ABSTRACT

Background: Spinal anaesthesia with hyperbaric bupivacaine is widely used for lower limb orthopaedic surgeries. To enhance block characteristics and prolong postoperative analgesia, various adjuvants such as fentanyl and ketamine are commonly added. This study aims to compare the efficacy of intrathecal ketamine and fentanyl as adjuvants to bupivacaine in terms of sensory and motor block profiles.

Materials and Methods: A prospective, randomized, double-blind study was conducted on 60 ASA grade I and II patients undergoing elective lower limb orthopaedic surgeries under spinal anaesthesia. Patients were randomly assigned into two groups: Group F received 12.5 mg of 0.5% hyperbaric bupivacaine + 25 µg fentanyl. Group K received 12.5 mg of 0.5% hyperbaric bupivacaine + 0.1mg /kg ketamine. Onset, peak, and duration of sensory and motor block were assessed using standard techniques. Hemodynamic parameters and adverse effects were also monitored.

Results: Sensory block onset was faster in Group F (94.0±37.8 sec) than in Group K (118.5 ±40.2 sec) .Time to reach peak sensory level was slightly shorter in Group K (241.5±47.5 sec) vs. Group F (258.8±58.7 sec).Duration of sensory block was longer in Group F (237.7±48.7 min) compared to Group K (196 .7±41.9min).Motor block onset was quicker in Group F (127.9±42.5 sec) vs. Group K (163.4±67.8 sec).Motor block duration was longer in Group F (253 ±51.3min) than Group K (212.2±48.9 min).No significant adverse effects were observed in either group.

Conclusion: Intrathecal fentanyl provides faster onset and longer duration of both sensory and motor block compared to ketamine. However, ketamine may offer advantages in terms of quicker recovery and potential hemodynamic stability. Both agents are effective and safe adjuvants to hyperbaric bupivacaine in spinal anaesthesia for lower limb orthopaedic procedures.

Keywords: Spinal anaesthesia, Ketamine, Fentanyl, Bupivacaine, Lower limb orthopaedic surgeries, Intrathecal adjuvants.

INTRODUCTION

Lower limb orthopaedic surgeries are often associated with significant perioperative pain and physiological stress, necessitating effective and safe anaesthetic techniques. Among the various modalities available, spinal anaesthesia (subarachnoid block) has emerged as the preferred

technique due to its rapid onset, dense sensory and motor blockade, minimal systemic drug exposure, and reduced postoperative complications. It is especially advantageous in lower limb surgeries where regional anaesthesia provides excellent intraoperative conditions and facilitates early mobilisation. Hyperbaric bupivacaine, a long-acting local anaesthetic, is commonly used for spinal anaesthesia. However, its duration of analgesia may be limited, leading to the requirement for supplementary analgesia in the postoperative period. To enhance the quality and duration of spinal block and postoperative analgesia, various adjuvants are added to bupivacaine.

Among these, fentanyl, a synthetic lipophilic opioid, is widely used. It binds to μ-opioid receptors in the spinal cord, providing rapid onset of analgesia and synergistic action with bupivacaine. Fentanyl improves the block quality and prolongs analgesia with minimal motor blockade but may be associated with side effects such as pruritus, nausea, and respiratory depression.[1]

Ketamine, a phencyclidine derivative, acts primarily as an N-methyl-D-aspartate (NMDA) receptor antagonist. When used intrathecally in low doses, it provides analgesia by preventing central sensitization and enhances the effect of bupivacaine. Ketamine also has sympathomimetic properties, contributing to hemodynamic stability during spinal anaesthesia. It has a distinct advantage in terms of maintaining cardiovascular parameters, especially in patients vulnerable to hypotension.[2,3]

The comparative efficacy of ketamine and fentanyl as intrathecal adjuvants remains a subject of ongoing research. This study aims to evaluate and compare the effects of intrathecal ketamine and fentanyl, when used as adjuvants to hyperbaric bupivacaine, on the onset and duration of sensory and motor block,and hemodynamic profile in patients undergoing lower limb orthopaedic surgeries.

MATERIALS AND METHODS

Sixty patients posted for lower limb surgeries under sub arachanoid block were included in the study. After obtaining approval from ethics committee (IEC noGMCM/IEC/005/2025), the study was carried out in SPV Government Medical College , Machilipatnam. A written informed consent was taken from the patients who participated in the study.

Inclusion Criteria

1. Patients of American society ofAnesthesiologists physical status grades 1 and 2(ASA grade 1 & 2).7
2. All adult patients of either sex

Exclusion Criteria

1. Neurological or psychiatric disorders
2. Patients who do not consent for spinal anaesthesia.
3. Contraindications to spinal anesthesia
4. Local site infections.
5. H/o hypersensitivity to study drugs.
6. Pregnant women and lactating mothers.
7. Height-<140 cm.
8. ASA Grade 3 4 5 patients

According to previous studies,[2,8] sample size was taken as 60. Total of 60 patients were enrolled and randomly allocated into two equal groups (n= 30) each using computer generated randomization table.

Group Allocation

Group F (fentanyl group): received 2.5 ml (12.5 mg) of 0.5% hyperbaric bupivacaine + 25mcg (0.5) ml fentanyl

Group K (ketamine group): received 2.5 ml (12.5 mg) of 0.5% hyperbaric bupivacaine + 0.1 mg/kg preservative free ketamine

Total volume in both the groups was adjusted to 3.0 ml using sterile water

Procedure

Upon arrival in the operation theatre, pre anesthetic check up was reviewed, iv access secured with 18 G Cannula. Vital parameters were checked and recorded. Standardanesthesia monitoring was done in all patients throughout the procedure.Under strict aseptic precautions, spinal anaesthesia was administered in the L3–L4 interspace with a 25G Quincke spinal needle in the sitting position. After confirming free flow of CSF, the study drug was injected over 10–15 seconds.

Parameters Observed: Onset time of sensory and motor block, Maximum sensory level achieved, Duration of sensory and motor block

Hemodynamic parameters: heart rate, systolic and diastolic BP, and oxygen saturation at regular intervals. . side effects: hypotension, bradycardia, nausea, vomiting, pruritus, sedation, hallucinations, etc were noted.

Sensory block was assessed using the pinprick method with a sterile 22G needle. The onset of sensory block was defined as the time from the completion of intrathecal injection to the loss of pinprick sensation at the T10 dermatome. The highest level of sensory block was recorded after achieving peak effect. Sensory regression was assessed by noting the time taken for two-segment regression from the highest level achieved. Duration of sensory block was defined as the time from intrathecal injection to regression of block to S2 dermatome.

Motor block was assessed using the Modified **Bromage Scale 4**

Grade 0 – Full movement of legs and feet

Grade 1 – Inability to raise extended leg; able to move knees and feet

Grade 2 – Inability to raise extended leg and move knee; able to move feet

Grade 3 – Complete motor block of lower limbs

The onset of motor block was defined as the time from drug injection to achieving Grade 3 motor block. Duration of motor block was defined as the time from onset to regression to Grade 0.

Assessments were made at 1-minute intervals for the first 10 minutes, then every 5 minutes for 30 minutes,

and subsequently at 15-minute intervals until complete recovery of motor and sensory function.

Statistical Analysis

Data were analyzed using statistical package for social sciences, SPSS version 25.0. Quantitative data were expressed as mean ± SD and analyzed using Student's t-test. Categorical data were compared using Chi-square test. A p-value < 0.05 was considered statistically significant.

RESULTS

Table 1: Charecterstics of sensory block in both the groups

Sensory block	Group K (n=30)	Group F (n=30)	P value
Time to onset of Block to L1 (sec)	118.50 ± 40.2	94.0± 37.8	0.0009
Time to reach max height of the block (sec)	241.5± 47.5	258.8± 58.9	0.341
Time to regression of block below L1(min)	196.7± 41.9	237.7± 48.7	0.0009

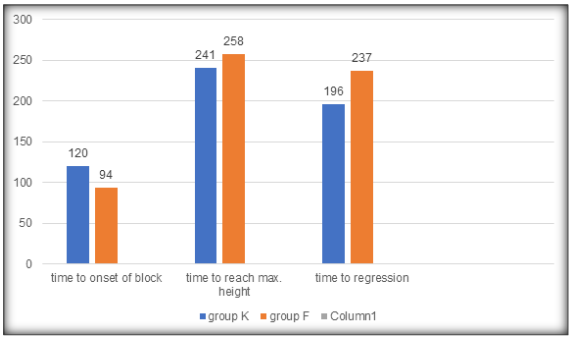

Table 1: Charecterstics of sensory block

The above table and graph show that the time of onset of sensory block for ketamine is 118.50± 40.2 sec, while for fentanyl, it is 94.0±37.8 sec with a P value of 0.0009 which is significant. The time to reach maximum height for sensory block in ketamine is 241.5± 47.5 sec, while for fentanyl it is258.8±58.9 sec with a P value of 0.341 which is not clinically significant. The duration of sensory block in ketamine is 196.7±41.9 min and fentanyl has a duration of sensory block for237.7±48.7 min with a P value of 0.0009 which is clinically significant.

Table 2: Charecterstics of motor block in both the groups

Motor block Quantitative data	Group K (n=30)	Group F (n=30)	P value
Time to onset of motor block (sec)	163.4±67.8	127.9±42.5	0.018
Duration of motor block (min)	212.2± 48.9	253±51.3	0.002

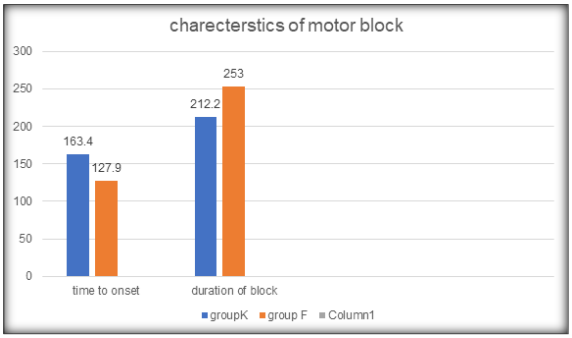

Table 2: Charecterstics of motor block

The above table and graph show the charecterstics of motor block in both the groups. The time taken for onset of motor block in ketamine group is 163.4±67.8 sec and for fentanyl group it is 127.9±42.5 with a P value of 0.018 which is clinically significant. The duration of motor block in ketamine group is 212.2±48.9 min and fentanyl group has a mean duration of 253± 51.3 with a P value of 0.002 which is clinically significant.

DISCUSSION

This study was conducted to compare the effects of intrathecal ketamine and fentanyl as adjuvants to hyperbaric bupivacaine in patients undergoing lower limb orthopaedic surgeries under spinal anaesthesia. The primary parameters observed were onset and duration of sensory and motor block and hemodynamic stability. In our study, the onset of sensory block was faster in the fentanyl group (94 seconds) compared to the ketamine group (118.5 seconds). Fentanyl, being a lipophilic μ-opioid agonist, quickly penetrates the spinal cord and enhances the action of bupivacaine, leading to a rapid onset. Similar findings were reported by Ghimire et al. and Unlugenc et al.[1,2] Tthe time to reach maximum sensory level was slightly shorter with ketamine (241 seconds) compared to fentanyl (258 seconds), though not clinically significant. This may be attributed to ketamine's dual mechanism of action—NMDA antagonism and local anesthetic properties—allowing faster ascent to peak block level. However, the duration of sensory block (time to regression below L1) was longer in the fentanyl group (237 minutes) than in the ketamine group (196 minutes), consistent with earlier studies where fentanyl significantly prolonged postoperative analgesia. This supports fentanyl's role in extending sensory blockade and analgesia when added to bupivacaine.

The onset of motor block was quicker with fentanyl (127 seconds) compared to ketamine (163 seconds), reflecting fentanyl's ability to enhance the depth and speed of spinal block. This is similar to previously published findings where opioids hastened both sensory and motor onset 6. The duration of motor block was also longer in the fentanyl group (253 minutes) than the ketamine group (212 minutes). While fentanyl enhanced both sensory and motor block duration, ketamine provided relatively earlier motor recovery, which may be advantageous in surgeries requiring faster postoperative mobilization. These results suggest: Fentanyl provides faster onset and longer duration of both sensory and motor block.Ketamine, while slower in onset and shorter in duration, enables quicker recovery of motor function, which can be desirable in early ambulation protocols.Ketamine also has the added benefit of hemodynamic stability, as seen in previous literature, although it was not the primary focus in this dataset.No major side effects such as pruritus, nausea, or respiratory depression were observed in either group. Notably, no hallucinations or psychomimetic effects were seen with low-dose intrathecal ketamine (0.1mg/kg), confirming its safety in spinal use.

Limitations of the Study

The sample size was relatively small (n = 60), limiting generalizability.Long-term postoperative outcomes, such as chronic pain development or functional recovery, were not assessed.Serum drug levels were not measured, so systemic absorption and effects could not be evaluated.

Scope for Future Research

Larger multicentric trials comparing multiple intrathecal adjuvants, including dexmedetomidine, clonidine, and midazolam, can further clarify the best combinations for specific surgeries and patient profiles.

CONCLUSION

Both ketamine and fentanyl are effective adjuvants to hyperbaric bupivacaine in spinal anaesthesia. Fentanyl may be preferred where prolonged sensory and motor block is desired, while ketamine can be a suitable alternative in patients requiring faster postoperative motor recovery or better hemodynamic stability.

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