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Original Research Article

Comparison of Intrathecal Fentanyl versus Pethidine as Adjuvants to Bupivacaine for Spinal Anaesthesia in Patients Undergoing Hip Surgery: A Randomized Double-Blind Study

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Abstract

Background: Intrathecal opioids are commonly used as adjuvants to local anaesthetics during spinal anaesthesia to improve intraoperative block quality and prolong postoperative analgesia. Fentanyl and pethidine possess differing pharmacological profiles that may influence onset, duration, and adverse-effect patterns.

Objective: To compare intrathecal fentanyl and pethidine as adjuvants to bupivacaine in patients undergoing hip surgery with respect to onset and duration of sensory and motor block, postoperative analgesia, rescue analgesic requirement, and adverse effects.

Materials and Methods: This prospective, randomized, double-blind study enrolled 66 patients undergoing hip surgery under spinal anaesthesia at the Department of Anaesthesiology, National Institute of Medical Sciences and Research Hospital, Jaipur. Patients were randomized in a 1:1 ratio into Group F (bupivacaine + fentanyl 25 µg, n = 33) and Group P (bupivacaine + pethidine 25 mg, n = 33). Block characteristics, Visual Analogue Scale (VAS) scores, time to first rescue analgesia, 24-hour analgesic consumption, and adverse effects were recorded and analysed.

Results: Sensory block onset was significantly faster in Group F (2.86 ± 0.20 min) than Group P (3.86 ± 0.20 min; $p<0.001$), as was motor block onset (5.25 ± 0.29 vs 6.88 ± 0.25 min; $p<0.001$). Duration of analgesia was significantly longer in Group P (279.55 ± 11.13 min) than Group F (199.12 ± 10.29 min; $p<0.001$). VAS scores were significantly lower in Group F at 3 and 12 hours. Time to first rescue analgesia was comparable between groups ($p=0.305$). Adverse effects were numerically more frequent in Group P but did not reach statistical significance.

Conclusion: Intrathecal fentanyl provides faster onset of block and superior early postoperative analgesia, while pethidine provides prolonged analgesia with lower early rescue requirement. Both agents demonstrated an acceptable safety profile.

Keywords: Spinal Anaesthesia; Fentanyl; Pethidine; Bupivacaine; Hip Surgery; Postoperative Analgesia; VAS.

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Introduction

Hip surgery, including procedures performed for traumatic fractures and degenerative hip disease, is frequently associated with substantial perioperative pain and may involve older patients with limited physiological reserve. Effective spinal anaesthesia should provide an adequate sensory level for surgery, stable haemodynamic, timely recovery of motor function, and sustained postoperative analgesia.

Intrathecal administration allows a local anaesthetic to act directly on spinal nerve roots and the spinal cord, producing reliable surgical anaesthesia with comparatively small drug doses. [1,2] Spinal anaesthesia has an established role in hip-fracture surgery, particularly in older adults, in whom avoidance of airway instrumentation and reduction of systemic anaesthetic exposure may be advantageous. [3] Hyperbaric bupivacaine is commonly used for spinal anaesthesia because it produces a dense sensory and motor block with a predictable distribution when patient position is appropriately controlled.

However, bupivacaine alone may provide postoperative analgesia of limited duration, while hip surgery can produce pain extending well beyond resolution of the surgical block. The

addition of intrathecal adjuvants is therefore intended to improve block quality, prolong analgesia, and reduce the need for systemic analgesics in the early postoperative period. [4,5]

Intrathecal opioids produce analgesia predominantly through activity at opioid receptors in the dorsal horn of the spinal cord, reducing nociceptive transmission without necessarily increasing the density of motor blockade. [6] Fentanyl is a highly lipophilic synthetic opioid. Its rapid penetration into neural tissue makes it a widely used intrathecal adjuvant, often chosen when a rapid onset of analgesia is desirable. The usual intrathecal fentanyl dose when combined with bupivacaine is commonly in the range of 10–25 micrograms. [7] In lower-limb orthopaedic surgery, studies have shown that the addition of fentanyl to hyperbaric bupivacaine can provide satisfactory surgical anaesthesia and postoperative analgesia with generally stable haemodynamic parameters. [8]

Pethidine, also termed meperidine, differs pharmacologically from fentanyl because it possesses both opioid-receptor activity and local-anaesthetic-like sodium-channel blocking properties. This dual mechanism may contribute to its prolonged spinal analgesic effect and its usefulness in reducing perioperative shivering. [9,10]However, intrathecal pethidine has also been associated with opioid-related adverse effects, particularly nausea, vomiting, and pruritus; therefore, dose selection and postoperative surveillance are essential. [10]

The practical choice between fentanyl and pethidine involves balancing rapid onset, duration of analgesia, postoperative pain scores, need for rescue analgesia, and adverse effects. Although both drugs have been studied as intrathecal adjuvants, direct comparative evidence in patients undergoing hip surgery remains limited. The present prospective randomized double-blind study was therefore undertaken to compare intrathecal fentanyl and pethidine, each administered with hyperbaric bupivacaine, with respect to sensory and motor block characteristics, postoperative VAS scores, duration of analgesia, rescue analgesic requirement, and adverse effects.

Materials and Methods

Study Design and Setting: This prospective, randomized, double-blind comparative study was conducted in the Department of Anaesthesiology in a tertiary centre, over an 18-month period.

Ethical Approval: The study was approved by the Institutional Ethics Committee and conducted in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Sample Size: Sample size was calculated using a two-sided test at 95% confidence and 80% power based on the expected mean difference in postoperative analgesic requirement between groups, yielding 33 patients per group (total N = 66).

Eligibility Criteria

Inclusion: Patients of ASA physical status I–II scheduled for hip surgery, able to provide informed consent and communicate pain levels. Exclusion: ASA III–IV, known allergy/sensitivity to study drugs, coagulopathy, contraindication to spinal anaesthesia, and pregnancy-induced hypertension.

Intervention: Group F received 0.5% hyperbaric bupivacaine with fentanyl 25 µg intrathecally. Group P received the same bupivacaine regimen with pethidine 25 mg intrathecally. Spinal anaesthesia was administered using a 25-G Quincke needle at the L3–L4 or L4–L5 interspace with the patient in the sitting position, who remained seated for 5 minutes after injection.

Randomization and Blinding: Patients were randomized using computer-generated allocation with sealed opaque envelopes.

Assessment: Sensory block was assessed by loss of cold sensation and motor block using the Modified Bromage Scale. Heart rate, blood pressure, respiratory rate, and SpO_2 were monitored intraoperatively. Postoperative VAS scores were recorded at 30 minutes and 1, 3, 6, 12, and 24 hours. Time to first rescue analgesia (VAS ≥3), total 24-hour analgesic consumption, and adverse events were recorded.

Statistical Analysis: Data were analysed using IBM SPSS Statistics version 28.0. Continuous variables were compared using the independent t-test or Mann–Whitney U test as appropriate; categorical variables were compared using the chi-square or Fisher's exact test. Normality was assessed with the Kolmogorov–Smirnov test. A p-value <0.05 was considered statistically significant.

Results

Table 1: Baseline demographic and operative characteristics

Variable	Group F (n=33)	Group P (n=33)	p-value
Age (years)	63.58 ± 9.72	62.52 ± 10.57	0.673
Male	20 (60.6%)	18 (54.5%)	0.618
Female	13 (39.4%)	15 (45.5%)	0.618
ASA I	14 (42.4%)	17 (51.5%)	0.459
ASA II	19 (57.6%)	16 (48.5%)	0.459
Duration of surgery (min)	94.70 ± 10.37	97.09 ± 10.21	0.348

The two groups were comparable with respect to baseline demographic and operative characteristics. Mean age was 63.58 ± 9.72 years in Group F and 62.52 ± 10.57 years in Group P (p = 0.673). Sex distribution, ASA physical status, and duration of surgery were also statistically similar between groups, indicating comparable baseline characteristics.

Table 2: Baseline haemodynamic parameters

Parameter	Group F	Group P	p-value
SBP (mmHg)	119.91 ± 6.11	123.09 ± 5.61	0.031
DBP (mmHg)	72.97 ± 4.19	73.33 ± 4.39	0.732
MAP (mmHg)	88.64 ± 3.19	89.89 ± 3.25	0.120
HR (beats/min)	78.18 ± 6.75	78.52 ± 7.20	0.847
SpO_2 (%)	99.27 ± 0.87	99.24 ± 0.79	0.883
RR (breaths/min)	20.12 ± 1.43	20.39 ± 1.43	0.442

Baseline haemodynamic parameters were comparable between the groups for diastolic blood pressure, mean arterial pressure, heart rate, oxygen saturation, and respiratory rate (all p > 0.05). Baseline systolic blood pressure was statistically higher in Group P than in Group F (123.09 ± 5.61 vs. 119.91 ± 6.11 mmHg; p = 0.031); however, the absolute difference was small.

Table 3: Block characteristics and duration of analgesia

Outcome	Group F	Group P	p-value
Sensory block onset (min)	2.86 ± 0.20	3.86 ± 0.20	<0.001
Motor block onset (min)	5.25 ± 0.29	6.88 ± 0.25	<0.001
Sensory block duration (min)	6.28 ± 0.75	6.17 ± 0.75	0.571
Motor block duration (min)	5.75 ± 0.79	5.48 ± 0.74	0.153
Duration of analgesia (min)	199.12 ± 10.29	279.55 ± 11.13	<0.001

The onset of sensory block was significantly faster in Group F than in Group P (2.86 ± 0.20 vs. 3.86 ± 0.20 min; p < 0.001).

Similarly, motor block developed significantly earlier in Group F (5.25 ± 0.29 min) compared with Group P (6.88 ± 0.25 min; p < 0.001). Sensory and motor block durations were comparable between groups.

However, the duration of postoperative analgesia was significantly longer in Group P than in Group F (279.55 ± 11.13 vs. 199.12 ± 10.29 min; p < 0.001).

Table 4: Postoperative VAS scores

Time	Group F	Group P	p-value
3 h	0.33 ± 0.54	0.91 ± 0.81	<0.001
6 h	1.03 ± 0.73	1.21 ± 0.86	0.357
12 h	1.39 ± 0.56	1.82 ± 0.98	0.035
24 h	2.24 ± 0.66	2.64 ± 1.22	0.108

Postoperative VAS scores were significantly lower in Group F at 3 hours (0.33 ± 0.54 vs. 0.91 ± 0.81; p < 0.001) and 12 hours (1.39 ± 0.56 vs. 1.82 ± 0.98; p = 0.035). At 6 and 24 hours, VAS scores did not differ significantly between the groups.

Time to first rescue analgesia was comparable between Group F (179.94 ± 6.39 min) and Group P (178.39 ± 5.74 min; p=0.305). Distribution of 24-hour analgesic consumption differed significantly between groups (p<0.001).

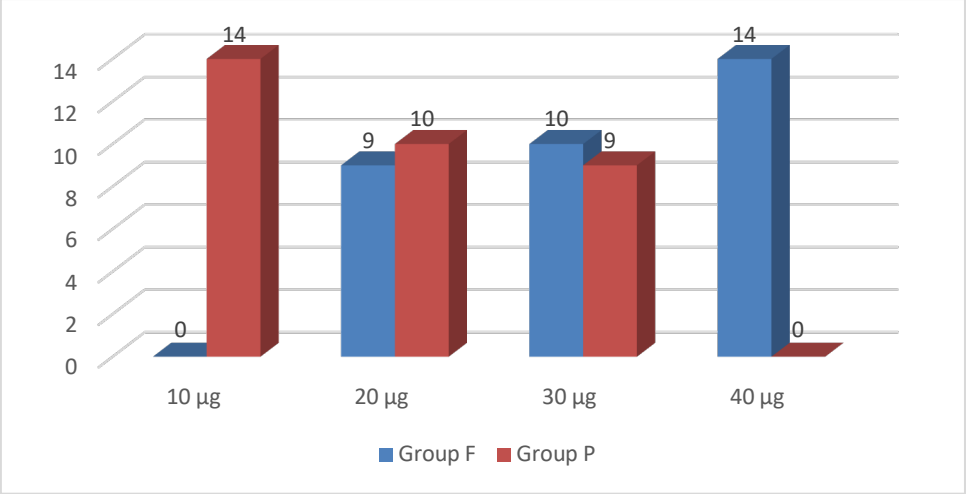

Figure 1: Consumption of analgesia in both the Groups

Adverse effects were comparable between the groups, with nausea (9.1% vs. 24.2%, p=0.099), vomiting (9.1% vs. 15.2%, p=0.451), pruritus (6.1% vs. 15.2%, p=0.230), and shivering (12.1% vs. 6.1%, p=0.392) showing no statistically significant difference between Group F and Group P.

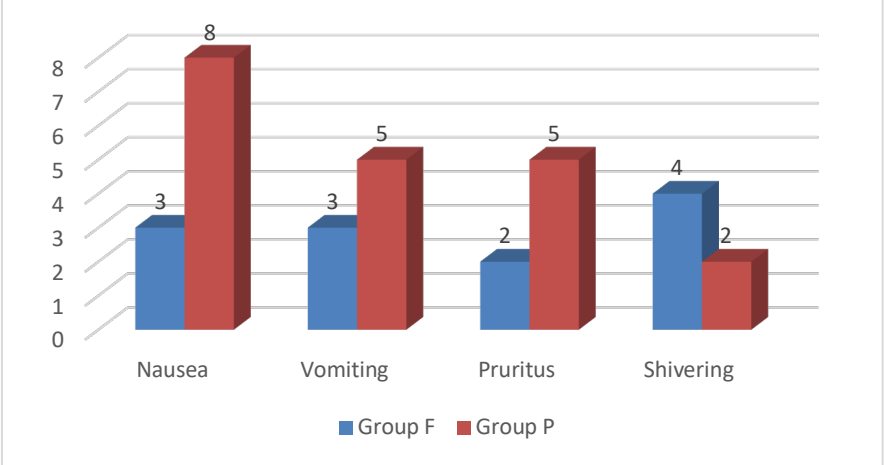

Figure 2: Distribution of Adverse effects in study population

Discussion

The present study showed that intrathecal fentanyl, when added to hyperbaric bupivacaine, produced a significantly faster onset of sensory and motor block than intrathecal pethidine. Sensory block began at 2.86 ± 0.20 minutes in Group F compared with 3.86 ± 0.20 minutes in Group P, while motor block onset was 5.25 ± 0.29 and 6.88 ± 0.25 minutes, respectively. This finding is consistent with the high lipid solubility of fentanyl, which facilitates rapid penetration into neural tissue and early activation of spinal opioid receptors. [3,5,7]

Although fentanyl provided faster onset, pethidine produced a significantly longer duration of postoperative analgesia. The mean duration of analgesia was 279.55 ± 11.13 minutes in Group P compared with 199.12 ± 10.29 minutes in Group F. This difference may be explained by pethidine's dual pharmacological actions: opioid-receptor agonism and local-anaesthetic-like sodium-channel blockade. [4,6] Pethidine may therefore offer an advantage when prolonged postoperative pain relief is the principal anaesthetic objective.

VAS scores were significantly lower in the fentanyl group at 3 hours and 12 hours after surgery, whereas values at 6 and 24 hours were comparable. The lower early VAS scores in Group F may reflect fentanyl's rapid intrathecal onset and early analgesic effect. However, postoperative pain scores are influenced by several factors, including individual pain thresholds, surgical tissue trauma, mobilisation, and use of rescue analgesics. The observed convergence of VAS scores at later time points suggests that the early analgesic advantage of fentanyl did not persist throughout the entire 24-hour observation period. [5,7]

Time to first rescue analgesia was comparable between Group F and Group P (179.94 ± 6.39 vs. 178.39 ± 5.74 minutes; p = 0.305). However, Group P demonstrated a significantly longer overall duration of analgesia and lower 24-hour analgesic consumption. This may indicate that, although the

initial need for rescue analgesia was similar, pethidine provided more sustained analgesic benefit during the postoperative period.

Adverse effects such as nausea, vomiting, and pruritus occurred more frequently in the pethidine group, although the differences were not statistically significant. Intrathecal opioids are known to produce opioid-related adverse effects, particularly nausea, vomiting, pruritus, urinary retention, and respiratory depression therefore, appropriate dose selection and postoperative monitoring remain essential. [6,8] The findings of the present study are also consistent with Safavi et al., who compared intrathecal meperidine and fentanyl in lower-limb orthopaedic surgery and reported that both drugs reduced shivering without a significant difference between the two agents. [9]

A systematic review and meta-analysis of randomized trials evaluating fentanyl or sufentanil added to spinal local anaesthetics found that intrathecal fentanyl can improve perioperative analgesic outcomes, with adverse-effect surveillance remaining important. [11] This supports the clinical use of fentanyl as an intrathecal adjuvant while reinforcing the need to balance analgesic benefit against opioid-related complications.

Therefore, intrathecal fentanyl may be preferred where a rapid onset of block and early postoperative analgesia are desired. Intrathecal pethidine may be useful where longer postoperative analgesia is a priority, provided patients are monitored for opioid-related adverse effects. The selection of an intrathecal adjuvant should be individualized according to the planned procedure, anticipated postoperative pain, patient comorbidities, and available postoperative monitoring.

Strengths and Limitations: Strengths include the prospective randomized design, equal group allocation, and standardized assessment tools. Limitations include the single-centre design and restriction to hip surgery patients, which may limit generalisation of result in population.

Conclusion

Both intrathecal fentanyl and pethidine are effective adjuvants to bupivacaine for spinal anaesthesia in hip surgery. Fentanyl provides faster block onset and superior early postoperative analgesia, while pethidine offers prolonged analgesia with a comparable safety profile.

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