ORIGINAL ARTICLE

COMPARISON OF QUADROILIAC PLANE BLOCK AND PERICAPSULAR NERVE GROUP BLOCK FOR ANALGESIA AFTER PROXIMAL FEMORAL NAIL SURGERY: A PROSPECTIVE RANDOMIZED TRIAL

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Abstract

Introduction: Pain control after proximal femoral nail surgery remains difficult, especially in older adults. The pericapsular nerve group block provides anterior hip analgesia, whereas the quadroiliac plane block may offer broader coverage. This study compared their postoperative analgesic efficacy in patients undergoing proximal femoral nail surgery under spinal anesthesia.

Materials and Method: In this prospective, randomized, multicenter, non-inferiority trial, 52 patients were included. At the end of surgery, patients received either quadroiliac plane block or pericapsular nerve group block. All patients received standardized spinal anesthesia and multimodal postoperative analgesia, including intravenous patient-controlled tramadol. The primary outcome was cumulative tramadol consumption at 24 postoperative hours. Secondary outcomes were pain intensity, quality of recovery, postoperative nausea and vomiting, rescue analgesic requirement, and adverse events. Non-inferiority was assessed using the mean between-group difference in 24-hour tramadol consumption with bias-corrected and accelerated 95 percent confidence intervals.

Results: Mean tramadol consumption at 24 hours was 67.7 milligrams in the quadroiliac plane block group and 81.5 milligrams in the pericapsular nerve group block group. The mean difference was minus 13.8 milligrams. Because the upper bound of the confidence interval did not exceed the prespecified non-inferiority margin of 32 milligrams, quadroiliac plane block was considered non-inferior. Overall, pain and quality of recovery were similar between groups. Postoperative nausea and vomiting occurred less frequently in the quadroiliac plane block group. No adverse events or motor weakness were observed.

Conclusions: Quadroiliac plane block provided non-inferior postoperative analgesia compared with pericapsular nerve group block after proximal femoral nail surgery under spinal anesthesia.

Keywords: Hip Fractures; Nerve Block; Postoperative Pain; Anesthesia, Spinal.

INTRODUCTION

In older adults, hip fractures are commonly accompanied by significant morbidity, mortality, and decline in functional capacity, and many of these patients require fixation with a proximal femoral nail (PFN) . Effective perioperative analgesia is essential in this population to facilitate early mobilization, reduce postoperative complications, and support postoperative rehabilitation (1). However, opioid-based analgesia alone is often limited by adverse effects such as nausea, vomiting, respiratory depression, and urinary retention, particularly in frail older patients (2). Accordingly, regional anesthesia techniques have gained increasing interest as opioid-sparing components of multimodal analgesia strategies (3).

The pericapsular nerve group (PENG) block is one of the currently used regional anesthesia techniques and is intended to provide analgesia of the anterior hip capsule through blockade of the articular branches of the femoral, obturator, and accessory obturator nerves. Because of this selective anatomical target, the PENG block has been regarded as a useful motor-sparing option for hip surgery analgesia (3). However, pain after PFN surgery may not arise solely from the anterior hip capsule; it may also result from peri-incisional soft-tissue trauma, retraction, and manipulation of structures extending beyond the anterior capsular innervation territory.

The quadroiliac plane block (QIPB) is a recently described fascial plane block performed at the caudal site where the quadratus lumborum muscle attaches to the iliac crest (4). Injection into this closed fascial compartment may allow cranio-caudal and mediolateral spread toward the thoracolumbar and upper lumbosacral territories, potentially involving the iliohypogastric, ilioinguinal, genitofemoral, and parts of the lumbar plexus (4). On this anatomical basis, QIPB may provide broader sensory coverage than PENG, which could be relevant in PFN surgery, where postoperative pain may include both deep articular and superficial soft-tissue components. Early clinical reports have suggested that QIPB may be feasible in procedures involving the lumbar spine and proximal femur (5-8).

Accordingly, we designed and performed a prospective randomized trial to evaluate and compare the analgesic effectiveness of QIPB and PENG block after PFN surgery performed under spinal anesthesia.We hypothesized that QIPB would be non-inferior to PENG with respect to 24-hour postoperative tramadol consumption, while also exploring whether its broader sensory distribution might influence early postoperative pain scores, recovery quality, postoperative nausea and vomiting, rescue analgesic requirements. Because both blocks were performed after spinal anesthesia, secondary outcomes related to early postoperative pain and sensory assessments should be interpreted cautiously.

MATERIALS AND METHOD

Study Design and Ethics

We conducted this prospective, randomized, multicenter, open-label, non-inferiority study at two tertiary referral hospitals between November 1, 2024, and September 15, 2025. The study protocol was approved by the Institutional Ethics Committee (IRB No: KAEK-11/24.07.2024.77) and prospectively registered at ClinicalTrials.gov (NCT06604806; October 20, 2024). Before enrollment, written informed consent was obtained from each participant or their legal representative. The study was carried out in compliance with the Declaration of Helsinki and Good Clinical Practice guidelines.

Study Population

Adult patients (≥65 years) with American Society of Anesthesiologists (ASA) physical status I–III who were scheduled to undergo proximal femoral nail surgery under spinal anesthesia for hip fracture were eligible. Patients were excluded if they had contraindications to regional anesthesia, including coagulopathy, anticoagulant use, pre-existing

neuropathy, or allergy to local anesthetics; required revision surgery; developed major intraoperative complications; withdrew consent; or were unable to use patient-controlled analgesia (PCA).

Data Variables and outcomes

For each participant, demographic and perioperative data (age, sex, ASA score, comorbidities, surgical duration, and intraoperative details) were recorded. Postoperative analgesic efficacy and recovery were evaluated using a combination of objective and patient-reported measures.

Opioid Consumption and Rescue Analgesia: In both groups, intravenous patient-controlled analgesia was used postoperatively as part of the multimodal analgesia protocol. The PCA solution contained Tramadol HCl at a concentration of 4 mg/mL, prepared in 100 mL of normal saline, and was delivered without a basal infusion. Patients were allowed to self-administer 20 mg bolus doses with a 20-minute lockout interval, while the maximum permitted dose was limited to 200 mg over 4 hours. Total tramadol consumption during the first 24 postoperative hours was automatically recorded by the PCA device.

Rescue analgesia was administered according to a predefined postoperative analgesia protocol. If the patient reported moderate-to-severe pain despite the standardized PCA regimen, defined as an NRS score ≥4 at rest or upon patient request due to inadequate analgesia, 50 mg intravenous dexketoprofen was administered as rescue analgesia, unless contraindicated. The need for rescue analgesia, timing of administration, and total rescue analgesic requirement during the first 24 postoperative hours were recorded prospectively.

Pain Assessment:

Pain at rest was assessed postoperatively at 1, 6, 12, and 24 hours using the Numeric Rating Scale (NRS), where 0 indicated no pain and 10 represented the worst pain imaginable.

Motor Block Evaluation

Postoperative motor function was assessed by ankle dorsiflexion, plantar flexion, and knee extension at the same time points as the NRS evaluations (1, 6, 12, and 24 hours postoperatively). Any weakness in these movements was recorded as postoperative motor weakness. Adverse events, including persistent motor block, nausea, vomiting, pruritus, hematoma, and signs of local anesthetic systemic toxicity, were prospectively documented.

Quality of Recovery:

Overall postoperative recovery was assessed at 24 hours using the Turkish validated QoR-15 questionnaire (9). The QoR-15 is a patient-reported recovery instrument comprising 15 items across five domains: pain, physical comfort, physical independence, psychological support, and emotional well-being. Each item is rated on a 0–10 scale, resulting in a total score of 0–150, with higher scores representing superior quality of recovery.

Interventions

All procedures were performed under spinal anesthesia, with patients placed in the lateral decubitus position according to the operative requirements. Standard intraoperative monitoring was applied in line with ASA recommendations and included electrocardiography, noninvasive arterial blood pressure measurement, and peripheral oxygen saturation monitoring.

Spinal anesthesia was administered while the patient was in the lateral decubitus position, with the fractured side positioned upward. A 25G Quincke spinal needle (Egemen®, İzmir, Türkiye) was inserted at the L3–L4 or L4–L5 interspace, and 10–15 mg of isobaric bupivacaine was injected intrathecally. No intrathecal adjuvants were used. Intraoperative sedatives and opioids were not administered.

At the end of surgery, before transfer to the recovery unit and while the spinal anesthetic effect was still present, the assigned regional block was performed.

PENG Block

At the completion of surgery, patients allocated to the PENG group were turned to the supine position for block application. A low-frequency curvilinear ultrasound transducer was initially positioned transversely over the anterior superior iliac spine. Once the anterior superior iliac spine was identified, the probe was angled approximately 45° in line with the inguinal crease and then shifted medially until the anterior inferior iliac spine, iliopubic eminence, and psoas tendon were clearly visualized.

Using an in-plane technique, a 22G × 100 mm block needle (Stimuplex® Ultra 360®, B. Braun) was advanced toward the iliopubic eminence. After careful negative aspiration, correct needle placement was verified by saline hydrodissection. Subsequently, 50 mg of 0.25% bupivacaine was administered in divided doses, with ultrasound confirmation of local anesthetic spread beneath the psoas tendon (Figure 1).

QIPB

In the QIPB group, the block was performed with patients maintained in the same lateral decubitus position used during surgery. A low-frequency curve ultrasound probe (2–6 MHz) was placed transversely at the L3 level to identify the spinous processes. The probe was then moved laterally to visualize the transverse process and the overlying erector spinae muscle. It was then rotated parasagittally and moved caudally to identify the attachment of the quadratus lumborum muscle (QLM) to the iliac crest, representing the target fascial plane. Using a 22G×100 mm peripheral nerve block needle (Stimuplex® Ultra 360®, B-Braun), the needle was advanced in-plane to the posterior fascial interface at this location. After confirming the position with saline, 75 mg of 0.25% bupivacaine was injected under the fascia in a controlled manner (Figure 2).

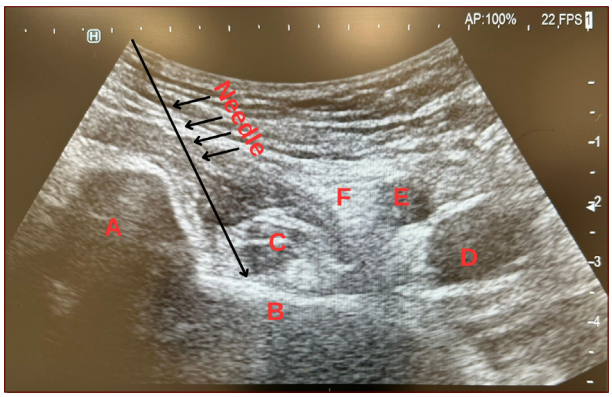


Figure 1. Ultrasound view of PENG Block
A. Anterior Inferior Iliac Spine
B. Iliopubic Eminence
C. Psoas Tendon
D. Femoral Artery
E. Femoral Vein
F. Femoral Nerve

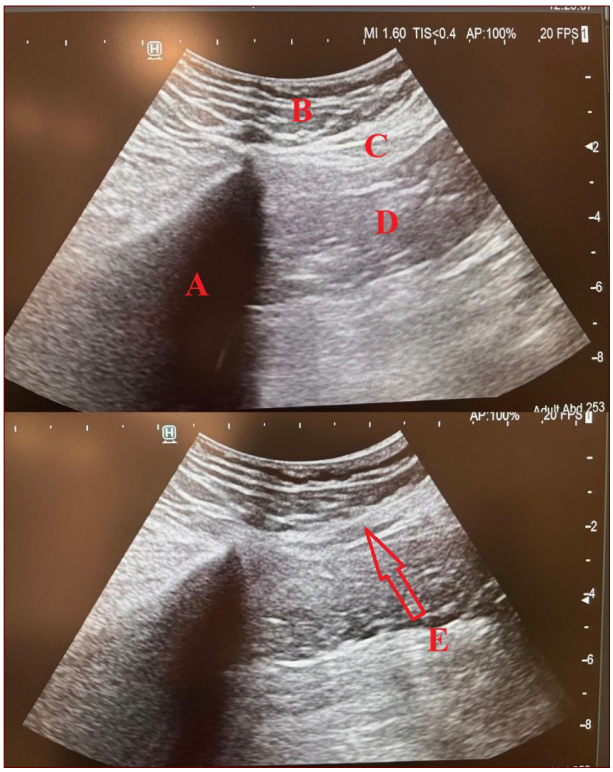


Figure 2. Ultrasound view of QIPB
A. Iliac Crest
B. Erector Spinae Muscle
C. Quadratus Lumborum Muscle
D. Psoas Major Muscle
E. Local anesthetic

The local anesthetic volume and total dose were selected according to the anatomical target and commonly used technical requirements of each block rather than to create an identical-dose comparison. The PENG block is performed in a relatively confined anterior pericapsular plane adjacent to the iliopubic eminence and psoas tendon, where a lower volume is generally sufficient to cover the articular branches supplying the anterior hip capsule. In contrast, QIPB is a fascial plane block performed at the quadratus lumborum–iliac crest interface, where adequate cranio-caudal and mediolateral spread within a deeper fascial compartment is expected to require a larger injectate volume. Therefore, 20 mL of 0.25% bupivacaine was used for PENG block and 30 mL of 0.25% bupivacaine was used for QIPB, corresponding to total bupivacaine doses of 50 mg and 75 mg, respectively. This dosing strategy was defined a priori and was intended to reflect anatomically appropriate clinical application of each technique.

Randomization

Eligible participants were allocated to the PENG or QIPB group based on a computer-generated randomization list produced in Microsoft Excel using the RAND() function (Microsoft Corp., Redmond, WA, USA) (Figure 3). This allocation sequence was generated by an independent investigator who did

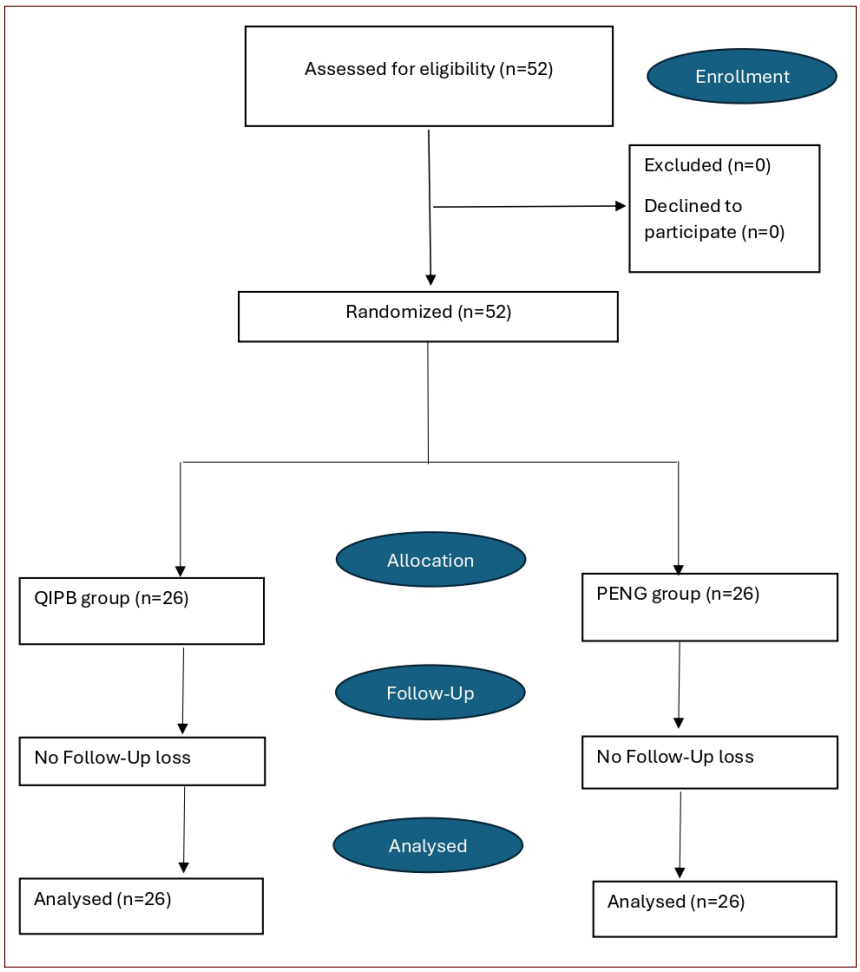


Figure 3. Flow chart of the patients



not participate in enrollment, block administration, perioperative care, or outcome evaluation.

To maintain allocation concealment, group assignments were placed in sequentially numbered, sealed, opaque envelopes. These envelopes were prepared and kept by the same independent investigator. Each envelope was opened only after the surgical procedure had been completed and immediately before the regional block was performed by the attending anesthesiologist.

Blinding

Because of the distinct technical approaches and different patient positioning required for QIPB and PENG block, blinding of the anesthesiologist performing the intervention was not possible. Postoperative pain scores and motor function were assessed at predefined time points by a postoperative assessor who did not perform the blocks and was not involved in the randomization or allocation concealment process. However, complete assessor blinding could not be guaranteed because the block technique, patient positioning, and possible postoperative sensory findings could have suggested group allocation. Therefore, the study should be considered an open-label randomized trial with limited blinding of outcome assessment rather than a fully assessor-blinded trial. To minimize potential detection and performance bias, patients were not informed of the specific block name, allocation was concealed until the end of surgery immediately before block application, postoperative analgesic management was standardized in both groups, and the primary endpoint of 24-hour tramadol consumption was obtained objectively from PCA device records.

Statistical Analysis

Statistical analyses were carried out with IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean ± standard deviation or median and interquartile range, as appropriate based on data distribution, whereas categorical variables were described using frequencies and percentages.The Shapiro–Wilk test was used to evaluate whether continuous variables followed a normal distribution.

The primary outcome was total tramadol consumption during the first 24 hours after surgery. Since the study was planned as a non-inferiority trial and the sample size estimation was based on mean values, the main analysis focused on the mean difference in 24-hour tramadol consumption between the two groups, calculated as QIPB minus PENG. Given the relatively small sample size and the possibility of non-normal data distribution, bias-corrected and accelerated bootstrap 95% confidence intervals were calculated using 2,000 resampling iterations. QIPB was considered non-inferior to PENG if the upper limit of the confidence interval for the mean difference remained below the predefined non-inferiority margin of 32 mg.

Although the initial sample size calculation was performed using a one-sided alpha level of 0.05, the primary non-inferiority analysis was presented with a two-sided 95% confidence interval to provide a more conservative estimate. As an additional sensitivity analysis, 24-hour tramadol consumption was compared between groups using the Mann–Whitney U test.

Postoperative NRS scores measured repeatedly over time were analyzed using an ordinal logistic generalized estimating equations model, which allowed adjustment for the correlation among repeated observations within the same patient. Treatment group, time, and their interaction were included in the model as fixed effects.An exchangeable working correlation structure was selected, and robust standard errors were applied. Model effects were assessed using Wald chi-square statistics.

Between-group comparisons of QoR-15 total scores were performed using the Mann–Whitney

U test. Categorical secondary outcomes were assessed with either the chi-square test or Fisher's exact test, depending on the expected frequencies within cells.

Because the study was powered only for the primary non-inferiority outcome and not for detecting superiority in secondary endpoints, all secondary outcome analyses were regarded as exploratory and interpreted with caution. For these exploratory analyses, a two-sided p value below 0.05 was considered statistically significant.

Sample size

Sample size was determined a priori based on the primary non-inferiority endpoint of 24-hour cumulative tramadol consumption. Pilot data suggested a mean 24-hour tramadol consumption of 80 ± 31.6 mg in the control group and 72 ± 17.9 mg in the intervention group. Because no established minimal clinically important difference or accepted non-inferiority margin exists for 24-hour tramadol consumption after proximal femoral nail surgery, the non-inferiority margin was prespecified as 32 mg . This corresponded to 40% of the mean opioid consumption in the control group and was informed by the clinician-perceived minimal clinically important difference of approximately 40% reported by Laigaard et al. for postoperative opioid consumption in hip and knee arthroplasty trials (10).

With equal allocation, a one-sided α of 0.05, and a power of 95%, the required sample size was estimated as 52 patients in total (26 per group). This target sample size was reached, and all randomized patients completed the study.

RESULTS

Fifty-two patients were randomized and completed the study without any loss to follow-up. All randomized participants underwent the allocated intervention and were included in the final analysis. The baseline demographic and clinical characteristics of patients in the QIPB and PENG groups are shown in Table 1.

Primary Endpoint: 24-hour Tramadol Consumption

Mean 24-hour tramadol consumption was 67.7 mg (bootstrap BCa 95% confidence interval [CI], 54.6 to 80.7) in the QIPB group and 81.5 mg (bootstrap BCa 95% CI, 66.8 to 97.6) in the PENG group. The mean difference (QIPB − PENG) was -13.8 mg (BCa 95%

Table 1. Baseline demographic and clinical profile of patients who underwent PFN surgery under spinal anesthesia.

	QIPB (n=26)	PENG (n=26)	p value
Gender (M/F)	10/16	13/13	0.577*
Age	77.85±10.43	75.62±9.10	0.415†
HT (n)	23(%88.4)	20(%76.9)	0.465*
CHF (n)	2(%7.6)	0(%0)	0.490*
CRF (n)	5(%19.2)	2(%7.6)	0.419*
COPD (n)	4(%15.2)	3(%11.5)	1.000*
CAD (n)	9(%34.6)	6(%23.0)	0.541*

HT: Hypertension, CHF: Congestive Heart Failure, CRF: Chronic Renal Failure, COPD: Chronic Obstructive Pulmonary Disease, CAD: Coronary Artery Disease

Data are presented as mean ± standard deviation for continuous variables and number (%) for categorical variables.

* Fisher's exact test. †Welch's independent-samples t-test.



CI, -33.7 to 6.0). The upper limit of the confidence interval remained below the predefined 32 mg non-inferiority threshold, supporting the non-inferiority of QIPB for the primary outcome. In an additional sensitivity analysis, 24-hour tramadol use was evaluated by comparing median values with the Mann–Whitney U test. This analysis showed no statistically significant difference between the QIPB and PENG groups: 70 [40–100] mg versus 80 [55–120] mg, respectively; p = 0.235.

Secondary Outcomes

Postoperative analgesic outcomes are summarized in Table 2. Median NRS scores at 1 and 6 hours were lower in the QIPB group than in the PENG group, whereas no statistically significant differences were observed at 12 and 24 hours. However, in the repeated-measures ordinal generalized estimating equations analysis, although there was a significant effect of time on postoperative pain scores (Wald χ^2 = 27.314, df = 3, p < 0.001), the overall group effect was not statistically significant (β = -0.80; 95% CI, -1.70 to 0.10; p = 0.080), and the group × time interaction was also not significant (Wald χ^2 = 4.517, df = 3, p = 0.211). These findings indicate that, although early between-group differences were observed at individual time points, overall postoperative pain trajectories were similar between groups.

Median QoR-15 scores at 24 hours were 134 (127.75–136.25) in the QIPB group and 129.5 (116.5–135.5) in the PENG group, with no statistically significant between-group difference (p = 0.134). Given the limited sample size and the exploratory nature of this secondary endpoint, this finding should be interpreted cautiously.

Postoperative nausea and vomiting occurred in 2 patients (7.6%) in the QIPB group and 8 patients (30.7%) in the PENG group (p = 0.035). Rescue analgesia was required in 7 patients (26.9%) in the QIPB group and 6 patients (23.0%) in the PENG group (p = 0.749). No block-related adverse events, including hematoma, pruritus, or signs of local anesthetic systemic toxicity, were observed in either group. No cases of postoperative motor weakness were detected during serial motor assessments performed at the same time points as NRS evaluation.

Individual NRS comparisons at each time point are descriptive/exploratory; the primary repeated-measures analysis of postoperative pain scores was performed using an ordinal generalized estimating equations model.

Table 2. Comparison of postoperative analgesic outcomes between the QIPB and PENG groups.

	QIPB (Median [Q1–Q3])	PENG (Median [Q1–Q3])	p value
NRS 1 hour	1 (1–2)	2 (1–2.25)	**0.009***
NRS 6 hour	2 (1–3)	3 (2–3)	**0.023***
NRS 12 hour	2 (1–3)	2 (2–3)	0.106*
NRS 24 hour	2 (2–3)	2 (2–3)	0.230*
Tramadol consumption (mg)	70 (40–100)	80 (55–120)	0.235*
QoR-15 total score	134 (127.75–136.25)	129.5 (116.5–135.5)	0.134*
PONV (n)	2(%7.6)	8(%30.7)	**0.035†**
Rescue Analgesia need (n)	7(%26.9)	6(%23.0)	0.749†

NRS: Numeric Rating Scale QoR-15: Quality of Recovery-15 PONV: Postoperative nausea and vomiting.

Data are presented as median (Q1–Q3) for continuous variables and number (%) for categorical variables. * Mann–Whitney U test. † Chi-square test or Fisher's exact test, as appropriate.

DISCUSSION

This prospective randomized trial demonstrated that the QIPB met the prespecified criterion for non-inferiority compared with the PENG block with respect to 24-hour postoperative tramadol consumption after PFN surgery under spinal anesthesia. The mean between-group difference numerically favored QIPB, and the upper bound of the confidence interval remained below the prespecified non-inferiority margin. These results indicate that QIPB provided a comparable early postoperative opioid-sparing effect to PENG, without exceeding the predefined clinically acceptable difference in tramadol requirement during the first 24 hours after surgery.

For the secondary endpoints, the QIPB group demonstrated a trend toward improved early pain control and fewer episodes of postoperative nausea and vomiting. However, because these outcomes were secondary in nature, these observations should be interpreted carefully and should not be overemphasized. In the repeated-measures analysis, there was no statistically significant overall group effect and no significant group × time interaction, indicating that overall postoperative pain trajectories were similar between groups.

The anatomical and dermatomal distribution of pain after PFN surgery may also help interpret the early postoperative findings. The PENG block primarily targets the articular branches of the femoral, obturator, and accessory obturator nerves, which contribute to sensory innervation of the anterior hip capsule. Therefore, its analgesic effect is expected to be more closely related to deep anterior capsular pain. However, postoperative pain after PFN surgery may also originate from the skin incision, subcutaneous tissue dissection, muscle retraction, periosteal irritation, proximal femoral manipulation, and the cephalomedullary nail entry site. These pain generators may involve anterior, lateral, gluteal, and proximal thigh sensory territories. In contrast, QIPB is performed at the quadratus lumborum–iliac crest interface and may provide a broader field of analgesia through spread within the thoracolumbar fascial system and possible involvement of upper lumbar and proximal lumbosacral sensory territories. In their case series of frail patients undergoing hip fracture surgery, Marrone et al. emphasized that QIPB may provide broad dermatomal coverage extending approximately from T11 to L3, which is anatomically relevant for hip fracture surgery and peri-incisional pain distribution. This anatomical rationale may partly explain the lower early NRS scores observed in the QIPB group; however, this interpretation remains exploratory and should be considered together with the open-label design, possible residual spinal anesthesia, and unequal local anesthetic volumes between groups (11).

QoR-15 scores were numerically higher in the QIPB group; however, no statistically significant between-group difference was observed, and this secondary finding should be interpreted cautiously.

Existing evidence suggests that the PENG block can improve early postoperative pain control in hip fracture and arthroplasty populations; however, findings regarding its opioid-sparing effect have been inconsistent (12–16). Andrade et al. reported favorable analgesic effects of PENG in hip surgery, while Mosaffa et al. demonstrated meaningful early analgesia in femoral neck fracture surgery, despite a more limited effect on total opioid consumption (12,13). Similarly, studies by Kukreja et al. and Pascarella et al. in total hip arthroplasty suggested beneficial effects on recovery-related outcomes, whereas Elshall et al. reported reductions in both pain scores and opioid consumption in elderly patients undergoing hip replacement surgery (14–16). Taken together with previous evidence, our results further suggest that PENG block may continue to have a useful role within multimodal analgesic strategies for proximal femoral procedures.

From a clinical perspective, even modest reductions in early postoperative pain may be



relevant in older patients with hip fracture, as improved early analgesia may facilitate positioning, nursing care, respiratory effort, and early participation in rehabilitation. However, the lower NRS scores observed at 1 and 6 postoperative hours should not be interpreted as definitive evidence of analgesic superiority, because the repeated-measures ordinal GEE analysis did not show a significant overall group effect or group × time interaction.

The lower incidence of postoperative nausea and vomiting in the QIPB group may also be clinically relevant, particularly in frail older patients, in whom PONV may delay oral intake, reduce comfort, impair mobilization, and increase the risk of dehydration or aspiration. This finding may be related to better early pain control and possibly fewer patient-triggered opioid boluses during the early postoperative period. Nevertheless, because total 24-hour tramadol consumption did not differ significantly between groups in the secondary analysis, the lower PONV rate cannot be attributed solely to reduced opioid exposure. Other factors, including individual susceptibility, perioperative conditions, residual spinal anesthesia, and the small sample size, may also have contributed. Therefore, both the early NRS differences and the PONV finding should be considered exploratory and interpreted cautiously.

The available clinical literature on QIPB is still limited but growing. Marrone et al. described QIPB as a feasible perioperative analgesic option in frail patients with hip fracture and reported favorable early analgesic findings without major complications (11). In addition, Satici et al. showed that QIPB was associated with improved recovery-related outcomes, lower pain scores, and reduced opioid consumption after total hip arthroplasty (17). Although the present study differs in surgical population and comparative design, our findings are broadly consistent with these reports in suggesting that QIPB may be incorporated into multimodal analgesia strategies for hip and proximal femoral surgery.

From a practical perspective, each technique may offer different advantages. The PENG block may be attractive because of its familiar anterior pericapsular target and ease of application in the supine position (3). In contrast, QIPB may represent a reasonable alternative in selected patients because of its distinct fascial plane target and potentially broader analgesic field (4,11,17). Rather than suggesting clear superiority of one technique over the other, the present findings indicate that both techniques may be clinically useful, and the choice between them may reasonably depend on patient characteristics, surgical factors, operator experience, and institutional practice.

Limitations

The findings of this study need to be viewed within the context of certain limitations. First, the sample size calculation was based on the primary non-inferiority outcome, and consequently, the study may not have had sufficient statistical power to detect relatively small between-group differences in secondary endpoints, including postoperative pain scores, quality of recovery, and adverse events. Second, full blinding could not be achieved because QIPB and PENG differ in their technical application and may produce different postoperative sensory or motor findings. Although allocation concealment was maintained until block administration, postoperative care was standardized, and the primary outcome was obtained objectively from PCA records, some degree of bias in secondary outcome assessment cannot be ruled out. A further important limitation is that both blocks were performed postoperatively, immediately after completion of surgery, at a time when residual spinal anesthesia may still have influenced early postoperative pain assessments; therefore, the 1-hour and 6-hour NRS findings should be interpreted with caution. Another important limitation is that the volume and total dose of bupivacaine were not identical

between the two groups. Although this difference was planned a priori and reflected the anatomical and practical requirements of each block, it may have influenced the observed analgesic outcomes. In particular, the lower early NRS scores and lower incidence of postoperative nausea and vomiting observed in the QIPB group cannot be attributed solely to the block technique, because the larger injectate volume and higher total bupivacaine dose may also have contributed to broader sensory spread and improved early analgesia. Therefore, the present study should be interpreted as a comparison of two clinically applied block protocols rather than a pure equal-dose block-to-block comparison. Future studies using dose-equivalent or volume-controlled designs are needed to determine whether the observed differences are primarily related to block anatomy, injectate volume, or local anesthetic dose. Finally, the non-inferiority margin may be considered relatively wide, as no validated threshold has been established for 24-hour tramadol consumption after PFN surgery. This margin was therefore based on pilot observations and indirect evidence from the literature. Moreover, the assessment period covered only the initial 24 hours after surgery, and functional recovery parameters, including mobilization and ambulation, were not evaluated in a structured manner.

CONCLUSION

QIPB met the prespecified non-inferiority criterion compared with PENG block for the primary outcome of 24-hour postoperative tramadol consumption in patients undergoing PFN surgery under spinal anesthesia. From a clinical perspective, this suggests that QIPB can achieve a similar opioid-sparing effect during the early postoperative period. While certain secondary outcomes numerically favored QIPB, these findings remain exploratory and should not be overinterpreted. Taken together, QIPB appears to be a feasible and effective alternative to PENG block as part of multimodal postoperative analgesia in this patient population. Larger multicenter trials with broader functional assessment are warranted to further define its clinical role.

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