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A modified hip pericapsular nerve block on postoperative pain and functional outcome after total hip arthroplasty: a prospective, double-blind, randomized controlled study

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Background: This study aimed to explore the efficacy and safety of the hip pericapsular nerve block (hip-PNB), which combines the anterior pericapsular nerve group (PENG) and posterior pericapsular deep-gluteal (PPD) blocks, on postoperative pain and functional outcomes after total hip arthroplasty (THA) via the posterolateral approach.

Methods: Seventy patients undergoing THA were allocated to either the nerve block group (Group N, hip-PNB + sham local infiltration analgesia [LIA]) or the control group (Group C, sham hip-PNB + LIA). The primary outcome was cumulative morphine consumption in the first 24 h postoperatively. Secondary outcomes included visual analog scale pain scores at rest and during movement postoperatively, time to first rescue analgesia, cumulative morphine consumption during hospitalization, opioid consumption during surgery, postoperative recovery, and postoperative complications.

Results: Compared with Group C, Group N consumed significantly less morphine in the first 24 h (10 [0, 10] mg vs. 10 [10, 20] mg; $P < 0.001$) and throughout hospitalization (10 [0, 20] mg vs. 20 [20, 30] mg; $P < 0.001$) and had less opioid consumption perioperatively. Group N also had significantly lower pain scores at rest and during movement in the first 24 h, required rescue analgesia later, and had faster recovery postoperatively than Group C. No significant intergroup differences were observed in quadriceps muscle strength or postoperative complication rates.

Conclusions: Compared to LIA, hip-PNB has better postoperative analgesia and enhances recovery in patients undergoing THA.

Keywords: Analgesia; Nerve block; Pain; Rehabilitation; Ropivacaine; Total hip arthroplasty.

Introduction

Total hip arthroplasty (THA) is a common joint surgery that is often associated with moderate to severe postoperative pain. Local infiltration analgesia (LIA), which acts on the sensory nerve endings around the hip joint while sparing motor function, is typically used to control perioperative pain [1,2]. However, despite the use of LIA, some patients may experience pain for several days [3].

Previous studies have recommended peripheral nerve blocks be used as the core analgesic approach for enhancing recovery after THA [4]. This approach improves postoperative recovery, increases patient satisfaction, and reduces postoperative complications [5,6].

Most previous studies on postoperative analgesia after THA have focused on the anterior capsule of the hip joint [7], with many employing the pericapsular nerve group (PENG) block [8,9]. However, little attention has been paid to pain relief in the posterior part of the hip joint even though postoperative pain can be exacerbated by damage to the posterior hip joint structure during THA.

In a retrospective review, the authors found that posterior hip pericapsular neurolysis improved analgesia in patients with inoperable hip fractures [10]. This suggests that the posterior hip pericapsular block, termed the posterior pericapsular deep-gluteal (PPD) block [11], can cover the branches of the superior gluteal and sciatic nerves, providing postoperative pain relief.

Thus, we combined the PENG and PPD blocks to create a modified hip pericapsular nerve block (hip-PNB) and hypothesized that hip-PNB could be a promising analgesic strategy after THA. To test this hypothesis, we conducted a double-blind study to assess the feasibility and safety of administering the hip-PNB as part of multimodal analgesia following THA.

Materials and Methods

This study was approved by the Clinical Trials and Biomedical Ethics Committee of West China Hospital of Sichuan University (No. 2022-1425) and registered in the Chinese Clinical Trial Registry on November 22, 2022 (No. ChiCTR2200066032; https://www.chictr.org.cn). Written informed consent was obtained from all patients before enrollment. All the procedures were conducted in accordance with the principles of the 2013 Declaration of Helsinki.

Between November 28, 2022, and January 28, 2023, patients aged between 18 and 80 years with normal quadriceps strength who were diagnosed with hip osteoarthritis, osteonecrosis of the femoral head (Ficat IIIB or IV), or hip dysplasia (Crowe I or II) and scheduled for primary unilateral THA via the posterolateral approach under general anesthesia were enrolled in this study. Patients were also required to have American Society of Anesthesiologists (ASA) functional status I–III.

Patients were excluded if they had any of the following conditions: (1) hip ankylosis, (2) known allergies to the drugs used in the study, (3) opioid addiction or dependence, (4) alcohol addiction or dependence, (5) cognitive impairment, (6) psychiatric illness, (7) recognized neuromuscular disorders, (8) previous open hip surgery, (9) other neuropathic diseases affecting the target hip, or (10) an inability to communicate verbally.

The patients were randomized into two groups using a computer-generated list of random numbers (Excel, Microsoft). Based on this list, Investigator 1 prepared sealed opaque envelopes for each patient. On the morning of surgery, Investigator 2 opened the envelopes and assigned the patients to either the nerve block group (Group N, hip-PNB + sham LIA) or the control group (Group C, sham hip-PNB + LIA).

Before surgery, Investigator 2 prepared the analgesic drugs in the central pharmacy, and Anesthesiologist 1 performed the nerve blocks in the preparation room. After the nerve blocks, the patients were administered general anesthesia by Anesthesiologist 2. The two anesthesiologists, surgeon, statistical analyst (Investigator 4), and outcome assessor (Investigator 3) were all blinded to the group allocation. All patients were informed at their group allocation at discharge.

Age, sex, body mass index (BMI), preoperative pain scores, and ASA functional status were recorded upon admission. Prior to surgery, the patients received oral celecoxib (200 mg) twice daily as a preemptive analgesic. All patients fasted for 8 h and consumed 100 ml of a clear, pure carbohydrate solution 2 h before surgery [12].

The hip-PNB, which included administration of ropivacaine (0.33%, 80 ml) and epinephrine (1:200,000) or an equal volume of isotonic saline solution for sham blocks, was performed 30 min before general anesthesia. All nerve blocks were performed after subcutaneous infiltration of 1 ml 2% lidocaine. LIA was administered to both groups before wound closure (50 ml 0.33% ropivacaine + 1:200,000 epinephrine for Group C and 50 ml 0.9% saline for Group N).

Pericapsular nerve group block

All patients were placed in the anesthesia preparation room approximately 30 min before surgery, and the PENG block was performed with the patient in the supine position. A low-frequency convex array probe (Anesus ME7; Mindray) was placed parallel to the anterior superior iliac spine and rotated 45° counterclockwise to visualize the iliopsoas muscle, femoral artery, and pectineus muscle. A 21-gauge nerve block needle (UniPlex Nanoline, 100 mm) was inserted lateromedially until the plane under the iliopsoas tendon was reached. Local anesthetics (20 ml 0.33% ropivacaine + 1:200,000 epinephrine) were injected in 5-ml increments after negative aspiration (Fig. 1). Group C received 20 ml 0.9% saline as a mock PENG block.

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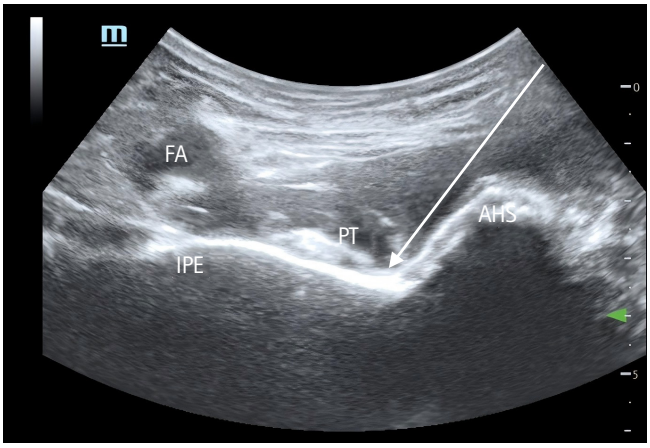

Fig. 1. Ultrasound-guided pericapsular nerve group (PENG) block. The white arrow indicates the trajectory of the needle. AIIS: anterior inferior iliac spine, FA: femoral artery, IPE: iliopubic eminence, PT: psoas tendon.

Posterior pericapsular deep-gluteal block

The PPD block was performed with the patient in the lateral decubitus position with the target side up and both the hip and knee flexed at a 70°–90° angle (Figs. 2A–B). A low-frequency curvilinear ultrasound transducer was used to identify the greater trochanter and superolateral part of the posterior hip capsule. After subcutaneous infiltration with 1 ml 2% lidocaine, a nerve block needle was inserted in a lateral-to-medial direction until the ischiofemoral ligament between the piriformis and posterior hip capsule was reached (Fig. 2C). Local anesthetics (30 ml 0.33% ropivacaine + 1:200,000 epinephrine) were injected in 5-ml increments after negative aspiration (Fig. 2D). Group C received 30 ml 0.9% saline as a mock PPD block.

The THA surgeries were performed by two senior surgeons

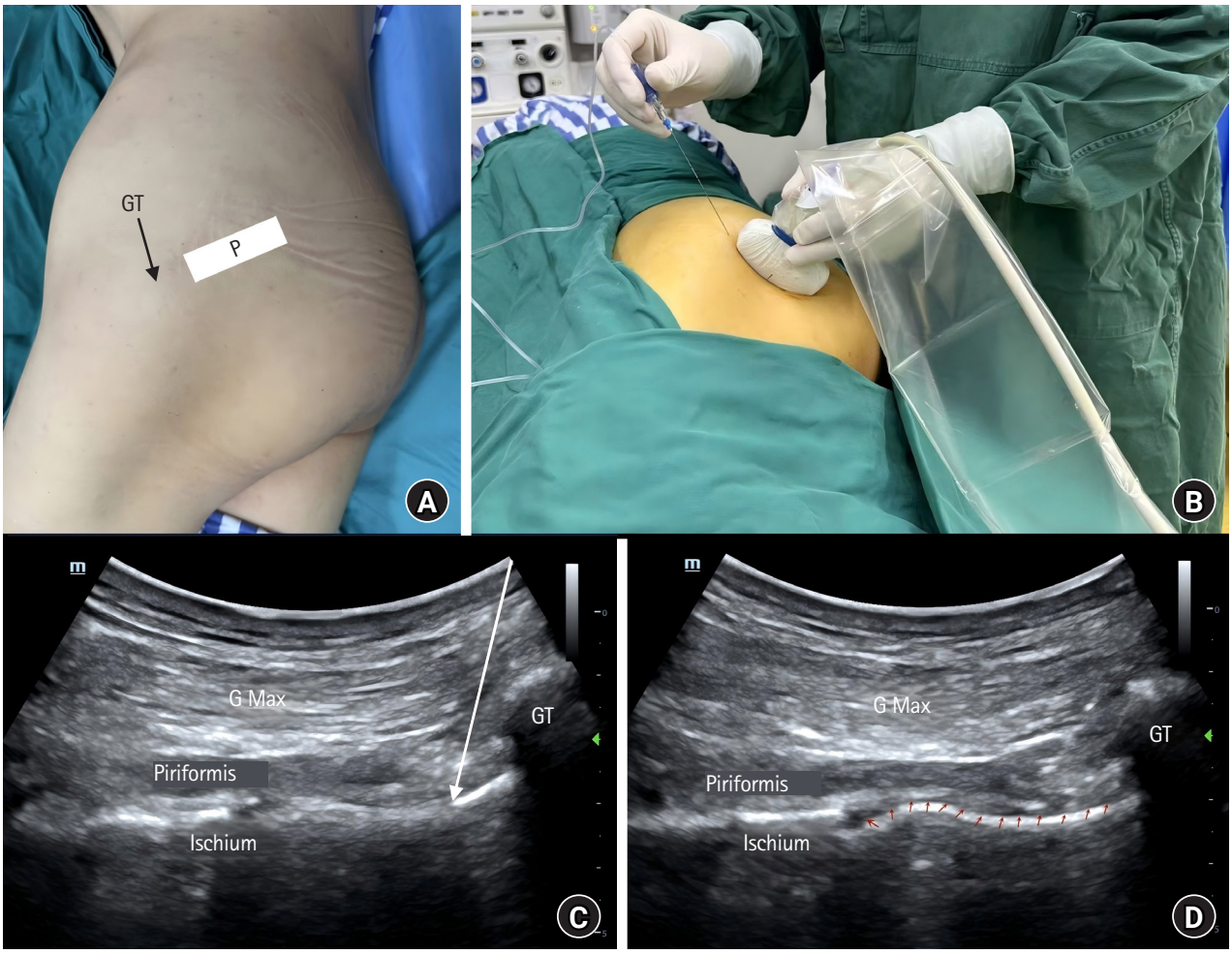

Fig. 2. Ultrasound-guided posterior pericapsular deep-gluteal (PPD) block. The white arrow indicates the trajectory of the needle. (A) Body surface markers, P shows the position of probe. (B) Set up of the probe, needle, and patient for the PPD block. (C) Ultrasound image of the needle trajectory. (D) Red arrows indicate the spread of local anesthetic below the piriformis muscle and the posterior capsule of the hip joint. G Max: gluteus maximus, GT: greater trochanter.

who had undergone training to ensure consistency in surgical technique and periarticular infiltration analgesia.

After 5 min of inhalation of pure oxygen, intravenous anesthesia was administered as follows: midazolam (2 mg), propofol (2 mg/kg), sufentanil (0.3 μg/kg), and cis-atracurium (0.2 mg/kg). Patients were then intubated and administered inhaled anesthetics (sevoflurane, 1–1.5 minimum alveolar concentration and remifentanil [0.1–0.2 μg/kg/min]). If the heart rate or blood pressure increased by more than 20% compared to pre-anesthesia values, 2.5 μg sufentanil was administered to suppress the surgical stress response. Before the completion of surgery, flurbiprofen (50 mg) was administered intravenously to prevent postoperative pain, and tropisetron (5 mg) was administered to prevent nausea and vomiting.

After recovery from general anesthesia, the patients were transferred to the ward, and ice compression was applied to the incision area. Postoperative pain was managed with oral celecoxib (200 mg twice daily). If pain scores (visual analog scale, VAS) were ≥ 4 or the pain was unbearable, 10 mg of morphine hydrochloride was administered subcutaneously as a rescue analgesia.

Outcomes

The primary outcome was cumulative morphine consumption within 24 h postoperatively. Secondary outcomes included postoperative pain scores on a VAS, time to first rescue analgesia (from surgery completion to the first pain score ≥ 4 [at rest or with movement] or analgesia request), cumulative morphine consumption during hospitalization, opioid consumption during surgery (sufentanil and remifentanil), postoperative recovery, and postoperative complications.

During hospitalization, the following were collected: VAS scores, time to first rescue analgesia, opioid consumption, postoperative recovery, and complications. At the 3-month follow-up, VAS scores, postoperative chronic pain, quadriceps strength, and 3-month readmission status were collected.

Discharge criteria included adequate pain control with oral medications, independent transfer, ambulation of at least 200 feet, and demonstration of ability to climb stairs. Postoperative complications included dizziness, nausea, vomiting, wound complications, urinary retention, 3-month readmission, venous thromboembolism, local anesthetic toxicity, and incidence of falls.

Postoperative pain was assessed using VAS scores ranging from 0 to 10 (1–3 was considered mild pain) [13] measured at 3, 6, 12, 24, and 48 h and 3 months postoperatively. Postoperative recovery included Quality of Recovery (QoR)-15 scores [14], postoperative quadriceps strength, frequency of sleep interruption due to pain on the first night, time to first ambulation post-surgery, time to hospital discharge, daily ambulation distance, and postoperative chronic pain (defined as moderate pain, i.e., VAS score ≥ 4 during daily activities at the 3-month follow-up). Quadriceps strength was evaluated before the block (baseline), 30 min after the block, and 0, 1, and 2 days and 3 months postoperatively. Patients were asked to flex their hip at 45° and knee at 90° while supine and extend the knee against gravity and resistance. Strength was scored as follows: no muscle contraction (0), contraction without joint movement (1), joint movement without gravity resistance (2), gravity resistance (3), gravity with partial counterforce (4), and normal function (5) [15]. The scores were assessed independently by Investigator 3. Quadriceps strength < 3 was classified as quadriceps weakness.

Sample size calculation and statistical analysis

The sample size was based on the power analysis from a pilot study involving 30 patients who were not enrolled in the main study. In the pilot, 24-h morphine consumption was 13.0 ± 9.5 mg in Group C and 5.0 ± 5.3 mg in Group N. Based on these results, a minimum of 31 patients per group was required, assuming a two-sided alpha level of 0.05 and 90% power. To account for dropouts, 35 patients were recruited in each group.

Data were analyzed using the Statistical Package for Social Sciences (version 26.0; IBM Corp.). Data normality was evaluated using the Shapiro-Wilk test. Continuous data following a normal distribution are presented as mean ± standard deviation and non-normally distributed continuous data are presented as median (Q1, Q3). Categorical data are presented as numbers or percentages. Intergroup differences in normally distributed continuous data were assessed using Student's t-test, while non-normally distributed data were analyzed using the Mann-Whitney *U* test. The time to first rescue analgesia was analyzed using the Kaplan-Meier survival analysis with the log-rank test. Categorical data were analyzed using Pearson's chi-squared or Fisher's exact test. Differences were considered statistically significant at $P < 0.05$.

Results

Patient characteristics

A total of 102 patients were assessed for eligibility, 20 of which did not meet the inclusion criteria and 12 declined to participate. Data were thus collected from 70 eligible patients who were randomly divided into two groups (Fig. 3). Age, sex, BMI, surgical side, ASA status, duration of surgery (defined as the time from

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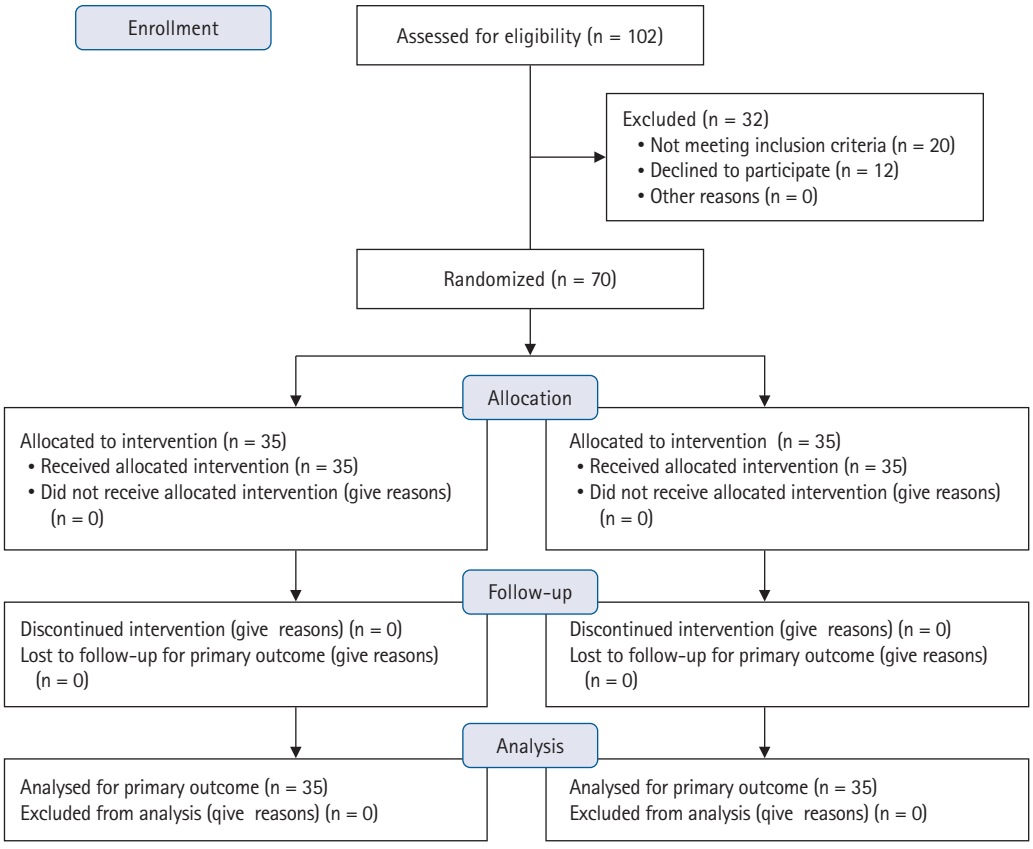

Fig. 3. CONSORT flow diagram of patient selection and exclusion.

the start of the skin incision to wound suture completion), and duration of anesthesia for both groups are shown in Table 1.

The two groups showed similar changes in quadriceps strength from baseline to 30 min after the hip-PNB (5 [5–5] vs. 5 [5–5], median difference 0 [95% CI: 0–0; P = 0.744]) and sham hip-PNB (5 [5–5] vs. 5 [5–5], median difference 0 [95% CI: 0–0; P = 0.208]).

Primary outcome

At 24 h post-operation, Group N consumed significantly less morphine than Group C (10 [0–10] mg vs. 10 [10–20] mg, median difference 0 mg [95% CI: 0–20; P < 0.001]) (Table 2).

Secondary outcomes

Postoperative pain scores

Group N had significantly lower pain scores at rest and during movement in the first 24 h postoperatively (P < 0.001). However, no significant differences in pain scores were found at 48 h or 3 months postoperatively (Figs. 4A–B).

Table 1. Clinical and Demographic Characteristics of Patients Undergoing Total Hip Arthroplasty, Stratified Based on Analgesic Treatment

Characteristic	Group C (n = 35)	Group N (n = 35)
Age (yr)	53.97 ± 10.91	55.18 ± 13.23
Sex (M/F)	19/16	17/18
Height (cm)	158 (153, 167)	160 (155, 167)
Weight (kg)	60 (55, 70)	60 (57, 70)
BMI (kg/m^2)	23.78 (22.07, 26.63)	23.42 (21.64, 26.31)
ASA-PS (I/II/III)	6/26/3	3/28/4
Duration of surgery (min)	60 (56, 71)	60 (48, 69)
Duration of anesthesia (min)	112 (108, 120)	110 (100, 122)
Surgery side (L/R)	17/18	20/15

Values are presented as mean ± SD, number or median (Q1, Q3). BMI: body mass index, ASA-PS: American Society of Anesthesiologists physical status.

For pain scores at rest, the effect sizes (median differences with 95% CIs) were 2 (1–2), 1 (1–2), 1 (1–2), 2 (1–2), 2 (1–2), 0 (0–0), and 0 (0–0) at arrival in the PACU and 3 h, 6 h, 12 h, 24 h, 48 h, and 3 months postoperatively, respectively. During movement, the effect sizes of the pain scores were 1 (1–1), 2 (1–2), 1 (1–2), 1

Table 2. Perioperative and Postoperative Analgesia

Outcome	Group C (n = 35)	Group N (n = 35)	P value
Morphine consumption (mg)			
First 24 h after surgery	10 (10, 20)	10 (0, 10)	< 0.001
Cumulative during hospitalization	20 (20, 30)	10 (0, 20)	< 0.001
Time to first rescue analgesia (h)	12 (6, 15)	19 (15, 49)	< 0.001
No rescue analgesia during hospitalization	3 (8.6)	12 (34.3)	< 0.001
Sufentanil consumption (μg)	25 (25, 30)	22.5 (20, 25)	< 0.001
Remifentanil consumption (μg)	846 (686, 946)	540 (468, 589)	< 0.001

Values are presented as median (Q1, Q3) or number (%).

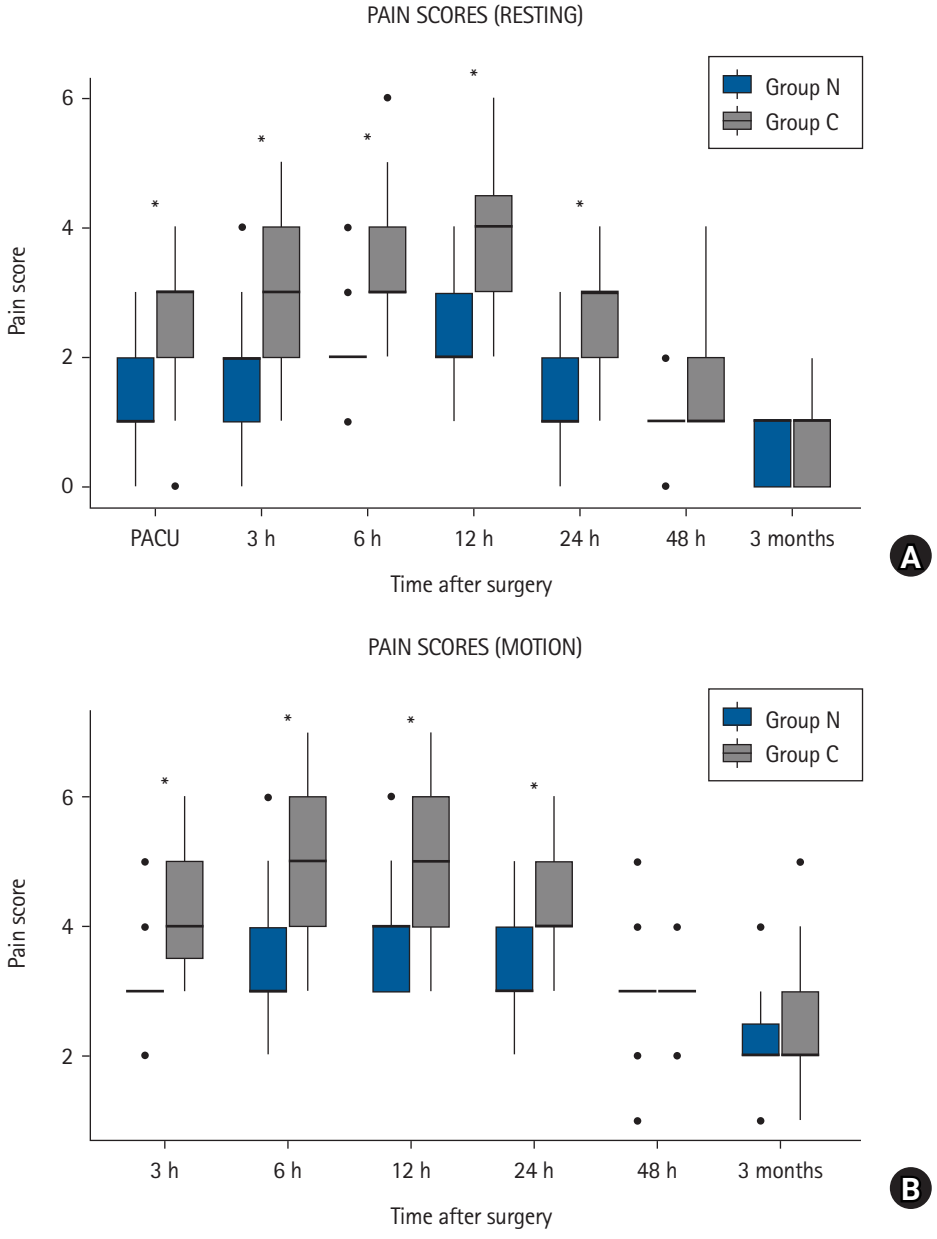

Fig. 4. Postoperative pain scores of THA patients in Group C (patients received sham hip-PNB + LIA) and Group N (patients received hip-PNB + sham LIA) at rest (A) and during movement (B). *Indicates a significant difference from the control group (P < 0.05).

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(1–1), 0 (0–0), and 0 (0–1) at 3 h, 6 h, 12 h, 24 h, 48 h, and 3 months postoperatively, respectively.

Time to first rescue analgesia

The time to first rescue analgesia in Group N was significantly longer than that in Group C (19 [15–49] h vs. 12 [6–15] h, median difference 7 h [95% CI: 6–17; P < 0.001]) (Table 2; Supplementary Fig. 1).

Cumulative morphine consumption during hospitalization

Group N required significantly less cumulative morphine during hospitalization than Group C (10 [0–20] mg vs. 20 [20–30] mg, median difference 10 mg [95% CI: 10–20; P < 0.001]) (Table 2).

Intraoperative opioid consumption

Group N showed significantly less opioid consumption than Group C (sufentanil: 22.5 [20–25] μg vs. 25 [25–30] μg, median difference 2.5 μg [95% CI: 2.5–7.5; P < 0.001]; remifentanil: 540 [468–589] μg vs. 846 [686–946] μg, median difference 306 μg [95% CI: 214–370; P < 0.001]) (Table 2).

Postoperative recovery

Group N scored higher on the QoR-15 scores than Group C on day 0 (106 [99–109] vs. 94 [90–99], median difference 12 [95% CI: 6–13; P < 0.001]) and day 1 (116 [109–119] vs. 104 [102–112], median difference 12 [95% CI: 5–13; P < 0.001]). No significant difference in postoperative quadriceps strength during movement was found between the two groups. Group N showed a lower frequency of sleep interruption due to pain on the first night postoperatively (0 [0–2] vs. 3 [1–4], median difference 3 [95% CI: 1–3; P < 0.001]) and a shorter time to hospital discharge (4 [3–4] vs. 5 [4–6], median difference 1 [95% CI: 1–2; P < 0.001]) compared to Group C. Group N also ambulated for a significantly longer distance on postoperative days 0 (16 [12–18] vs. 10 [6–12], median difference 6 [95% CI: 3–7; P < 0.001]) and 1 (29 [25–32] vs. 25 [22–27], median difference 4 [95% CI: 1–6; P = 0.003]) and showed a shorter time to first ambulation (7 [6–9] vs. 9 [7–12], median difference 2 [95% CI: 1–3; P = 0.006]). Additionally, the incidence of postoperative chronic pain was lower in Group N (Table 3).

Occurrence of complications

No significant differences were found in the incidences of postoperative dizziness, nausea, vomiting, wound complications, urinary retention, 3-month readmission, venous thromboembolic events, local anesthetic intoxication, or falls postoperatively between the two groups (Table 4).

Discussion

To the best of our knowledge, this is the first study of the hip-PNB conducted in patients undergoing THA. Its most important contribution is providing evidence that including the hip-PNB in

Table 3. Postoperative Recovery

Outcome	Group C (n = 35)	Group N (n = 35)	P value
Quadriceps strength			
Day 0	3 (3, 4)	4 (3, 4)	0.342
Day 1	4 (4, 4)	4 (4, 4)	0.130
Day 2	5 (4, 5)	5 (4, 5)	0.228
3 months	5 (5, 5)	5 (5, 5)	0.553
Daily ambulation distance (m)			
Day 0	10 (6, 12)	16 (12, 18)	< 0.001
Day 1	25 (22, 27)	29 (25, 32)	0.003
Day 2	45 (40, 49)	47 (41, 55)	0.161
Quality of Recovery-15 score			
Day 0	94 (90, 99)	106 (99, 109)	< 0.001
Day 1	104 (102, 112)	116 (109, 119)	< 0.001
Day 2	126 (120, 130)	128 (123, 132)	0.201
Frequency of sleep interruption (no.)	3 (1, 4)	0 (0, 2)	< 0.001
Time to first ambulation (h)	9 (7, 12)	7 (6, 9)	0.006
Time to hospital discharge (d)	5 (4, 6)	4 (3, 4)	< 0.001
Postoperative chronic pain	5 (14.3)	1 (2.8)	0.020

Values are presented as median (Q1, Q3) or number (%).

Table 4. Differences in Postoperative Complications after Total Hip Arthroplasty

Adverse event	Group C (n = 35)	Group N (n = 35)	P value
Postoperative dizziness	10 (28.6)	8 (22.9)	0.490
Nausea	9 (25.7)	6 (17.1)	0.262
Vomiting	5 (14.3)	3 (8.6)	0.314
Wound complication	4 (11.4)	3 (8.6)	0.591
Urinary retention	1 (2.8)	2 (5.7)	0.414
3-month readmission	1 (2.8)	0 (0)	0.157
Venous thrombotic events	0 (0)	0 (0)	
Local anesthetic intoxication	0 (0)	0 (0)	
Falls after surgery	0 (0)	0 (0)	

Values are presented as number (%).

multimodal analgesia can result in statistically significant improvements in opioid consumption and postoperative recovery, lower VAS pain scores, and a longer time to first rescue analgesia. These findings suggest that the hip-PNB can provide satisfactory analgesia and enhance recovery in patients undergoing THA, thereby confirming our hypothesis.

In this study, morphine consumption was appropriately chosen as the primary outcome as it reflects the need for analgesics to treat pain. The secondary outcomes associated with analgesic efficacy, including postoperative pain scores, time to first rescue analgesia, intraoperative opioid consumption, and frequency of sleep interruption due to pain on the first night postoperatively reflected the patient's response to postoperative pain. These outcomes are consistent with those of other studies on postoperative pain relief in patients undergoing THA [3]. Our results demonstrated that patients in Group N consumed significantly less morphine than those in Group C in the first 24 h postoperatively, and the differences in pain scores were mainly observed during the same period. No significant differences in pain scores were found between the two groups after 24 h (all pain scores were < 4, indicating mild pain). In addition, no statistically significant differences were found in other pain-related outcomes after 24 h, such as cumulative morphine consumption.

The secondary outcomes of our study also included patient rehabilitation outcomes such as time to first postoperative ambulation, daily ambulation distance, and QoR-15 scores. The QoR-15 consists of 15 recovery quality indicators [16], wherein the investigator asks the patients how they feel after surgery and scores them based on their descriptions. Among the QoR-15 items, postoperative pain and sleep quality were particularly important. In the present study, the QoR-15 scores in Group N were significantly higher than those in Group C, suggesting that the nerve block could enhance postoperative rehabilitation quality. The differences in the QoR-15 scores between the two groups were mainly reflected in appetite, sleep quality, postoperative pain, and presence of energy owing to proper rest. Thus, the hip-PNB not only reduced postoperative pain scores, but also improved appetite and sleep quality, increased QoR-15 scores, and enhanced recovery after surgery.

Our results also demonstrated that the hip-PNB showed motor-sparing effects, as no significant differences in quadriceps strength were found between the two groups. For postoperative analgesia of the anterior capsule using the PENG block in our study, we observed a motor-sparing benefit similar to that seen in our previous study using the same dose of 0.5% ropivacaine (20 ml) [17] and in other studies using 20 ml 0.375% or 0.5% ropivacaine [18,19]. The low concentration of ropivacaine used in this study provides further credence to our findings. The ultrasound-guided PPD block was also motor-sparing. Future research and cadaveric studies are needed to explore the motor-sparing effect of the PPD block in more detail, considering factors such as patient characteristics, injection volume, and other variables.

We selected LIA as the control group to align with a previous study [20]. LIA is the most commonly used postoperative analgesia method for THA in other previous studies as well [21,22]. Most have compared LIA with a type of peripheral nerve block [20,22], while another previous study directly compared the analgesic effects of two types of peripheral nerve blocks (femoral nerve block vs. PENG block) to determine which was more effective [23]. Further studies are required to compare the hip-PNB with other nerve blocks.

In this study, we used 20 ml 0.33% ropivacaine for the PENG block, which is consistent with a previous study [8]. We administered 30 ml of 0.33% ropivacaine for the PPD block to relieve pain in the posterior capsule of the hip joint. Group C received the same dose of local anesthetic (50 ml 0.33% ropivacaine), allowing us to effectively compare the analgesic effects of the two methods. In previous studies on patients undergoing THA, LIA was used

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for postoperative analgesia at doses ranging from 30 to 150 ml and at concentrations ranging from 0.2% to 0.5% [17,24–28], all of which achieved good analgesic effects. Based on this literature, we administered a 50-ml dose [25], and none of the patients experienced dose-related side effects.

Our study has some limitations. First, no adverse events were observed in our study, including those related to motor effects, possibly because of the low incidence of such events. As the sample size calculations in our study were based on the primary outcome, more patients may have been required to observe adverse events. Second, the block plane was not assessed to maintain blinding; thus, patients receiving combination blocks may have experienced weak or incomplete analgesia. Third, manual testing of quadriceps strength may not be effective at detecting clinical differences, and more accurate measurements (such as straight leg lift test and resistance test) should be used in future studies. Finally, all patients in our study underwent general anesthesia; therefore, these results may not be directly applicable to patients receiving regional anesthesia blocks such as spinal or epidural anesthesia.

In conclusion, this study highlights that the hip-PNB can improve postoperative pain relief and enhance recovery in patients undergoing THA without compromising quadriceps strength. The hip-PNB is thus a feasible and promising technique for patients undergoing THA. However, further clinical trials are needed to confirm its efficacy and establish it as a standard of care.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

Data Availability

The datasets generated during and/or analyzed during the current study are not publicly available due [personal privacy protection, data security, data integrity, data ownership and confidentiality of academic research] but are available from the corresponding author on reasonable request.

Author Contributions

Jian Hu (Conceptualization; Software; Writing – original draft)
Qiuru Wang (Data curation; Resources; Visualization)
Jie Hu (Formal analysis; Software; Supervision; Validation; Writing – original draft)
Chunyu Gong (Formal analysis; Writing – review & editing)
Jing Yang (Conceptualization; Software; Writing – review & editing)

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Supplementary Material

Supplementary Fig. 1. Survival analysis function of the time to first rescue analgesia.

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