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Posterior Hip Pericapsular Block (PHPB) with pericapsular nerve group (PENG) block for hip fracture: a case series

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Abstract

Background Pain after total hip arthroplasty (THA) for femoral neck fracture (FNF) can be severe, potentially leading to serious complications. PENG block has become an optional local analgesic strategy in hip fracture surgery, but it cannot provide effective pain relief for the posterior capsule of the hip joint. Therefore, we modified the traditional sacral plexus nerve block and named it Posterior Hip Pericapsule Block (PHPB) to complement the blockade of the relevant nerves innervating the posterior hip capsule region. Thereby, we detail the analgesic effect of PHPB combined with PENG block on five hip fracture patients and the effect on their hip motor function.

Methods This case series was conducted from December 2023 to February 2024. We performed ultrasound-guided PHPB combined with PENG block on five patients with hip fractures. Numerical Rating Scale (NRS) pain scores at rest and maximum NRS pain scores during limb movement of the five patients were recorded within 48 h after surgery. Their hip flexion, abduction, adduction, keen flexion and quadriceps muscle strength were also recorded. Serious postoperative complications, including wound infection, hematoma formation, or nerve injury, were recorded.

Results They experienced effective pain control within 48 h postoperatively, with NRS pain scores at rest decreasing from 3.0 (3.0, 4.5) to 0.0 (0.0, 1.0) and maximum NRS pain scores during limb movement from 8.0 (7.5, 8.5) to 1.0 (0.5, 2.0). They can autonomously perform hip flexion, abduction, adduction, and knee flexion within 48 h postoperatively without any signs of movement disorders or quadriceps muscle weakness. No severe postoperative complications, such as wound infections, hematoma formation or nerve damage, were observed in any of the patients.

Conclusions Ultrasound-guided PENG block combined with PHPB provided effective analgesia for hip fracture patients in the perioperative period. It maintained hip joint motor function and quadriceps muscle strength within 24 h after THA.

Keywords Posterior hip pericapsular block, Pericapsular nerve group block, Hip fracture, Total hip arthroplasty, Regional anesthesia

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Introduction

Hip fractures are a common injury among the elderly. They are associated with a significant mortality rate, with crude mortality rates within 12 months of the fracture being 15.9% for women and 38.0% for men [1]. About half the people who have a hip fracture aren't able to regain the ability to live independently. When hip fractures prevent movement for a long time, complications can include blood clots in the legs or lungs, bedsores, pneumonia, further loss of muscle mass and death [2]. Treatment for hip fractures in the elderly typically involves surgery, and pain after total hip arthroplasty (THA) can be severe, potentially leading to serious complications in the cardiovascular and respiratory systems [3]. The procedure-specific postoperative pain management (PROSPECT) guidelines recommended fascia iliaca compartment block (FICB) as the preferred nerve block when a nerve block is indicated for total hip arthroplasty [4]. However, FICB may not fully block the obturator nerve and can cause decreased quadriceps muscle strength [5]. Therefore, Girón-Arango et al. proposed the pericapsular nerve group (PENG) block in 2018 [6]. As a novel targeted nerve block technique for the sensory nerves of the anterior hip capsule, PENG block can selectively target the articular branches of the femoral nerve, obturator nerve, and accessory obturator nerves, thereby providing potential motor-sparing analgesia for hip surgery [7]. Duan et al. found that continuous PENG block can reduce exercise VAS pain scores within 48 h after THA and preserve quadriceps muscle strength in the affected limb [8]. However, pain in the posterior hip capsule remains unaddressed [8].

Pain in the hip primarily originates from nociceptors in the anterior hip capsule, but nociceptors in the posterior hip capsule derive from branches of the sacral plexus, making it impossible for FICB or PENG block to block these branches [9]. Tung et al. reported that some patients who underwent chemical denervation of the anterior hip capsule still did not achieve sufficient analgesia, indicating that pain in the posterior hip capsule region still warrants attention [10]. Therefore, our teamnamed "Posterior Hip Pericapsular Block (PHPB)" technique is a modification of the traditional sacral plexus nerve block technique, which could selectively target and block the articular branches of the nerve to the quadratus femoris (NQF), superior gluteal nerve (SGN), and inferior gluteal nerve (IGN). Therefore, we propose the hypothesis that PHPB could provide analgesia in the posterior hip capsule region and potential motor-sparing. PHPB with PENG block could provide complete analgesia for the entire hip capsule and preserving motor function of the lower limbs.This approach was applied and evaluated in this five case reports.

Methods

Ethics

This study was approved by the Medical Ethics Committee of Xi'an Aerospace General Hospital (Approval Number: XHTZYY-2020-LL-02). Patients signed written informed consent forms after explaining the treatment procedures, risks, and benefits. This case series was conducted from December 2023 to February 2024.

Patients

This case series included five patients with unilateral hip fractures caused by trauma, none of whom had contraindications to regional block (such as coagulation dysfunction, skin breakage or infection at the puncture site). Before the regional block procedures, patients were intravenously administered parecoxib sodium 40 mg and betamethasone 5 mg, followed by general anesthesia with a laryngeal mask after PENG block combined with PHPB. The surgical approach for all patients was the posterior lateral approach for THA, where the operative area was innervated by the superior cuneal (dorsal branch) nerve, the iliohypogastric nerve, the subcostal nerve, and the lateral femoral cutaneous nerve [11], which could not be completely blocked by both PENG block and PHPB. Therefore, in this study, regarding the findings of Fusco [12], 10 ml of 0.25% ropivacaine incisional subcutaneous infiltration was performed before the end of the procedure to eliminate the confounding factors caused by superficial wounds. After meeting the criteria for laryngeal mask removal, patients were transferred to the Post Anesthesia Care Unit (PACU) and returned to the ward once vital signs stabilized.

Pericapsular nerve group (PENG) block

The PENG block was performed according to the study by Girón [6]. The patient was placed in a supine position, the skin over the puncture site was disinfected, and the position of the ipsilateral anterior superior iliac spine was determined. A 5 MHz convex probe (Sonosite Inc., model: S-series) was placed transversely at the edge of the anterior superior iliac spine plane, then rotated 45° towards the tail end to align with the rami ossis pubis (Fig. 1A). The probe was used to identify the anterior inferior iliac spine (AIIS), then shifted to identify the iliopubic eminence (IPE), where a bright oval structure above it represents the psoas tendon (PT). Using an in-plane technique, a puncture needle (18G×100 mm, Contiplex type D, Braun Melsungen, Germany) was inserted from lateral to medial (Fig. 1B), penetrating from the AIIS to the space between the IPE and the PT after ensuring no abnormalities on negative aspiration, 15 ml of 0.25% ropivacaine was injected between the IPE and the PT, and the local anesthetic (LA) spread in a hypoechoic shape between the PT and the IPE (Fig. 1C).

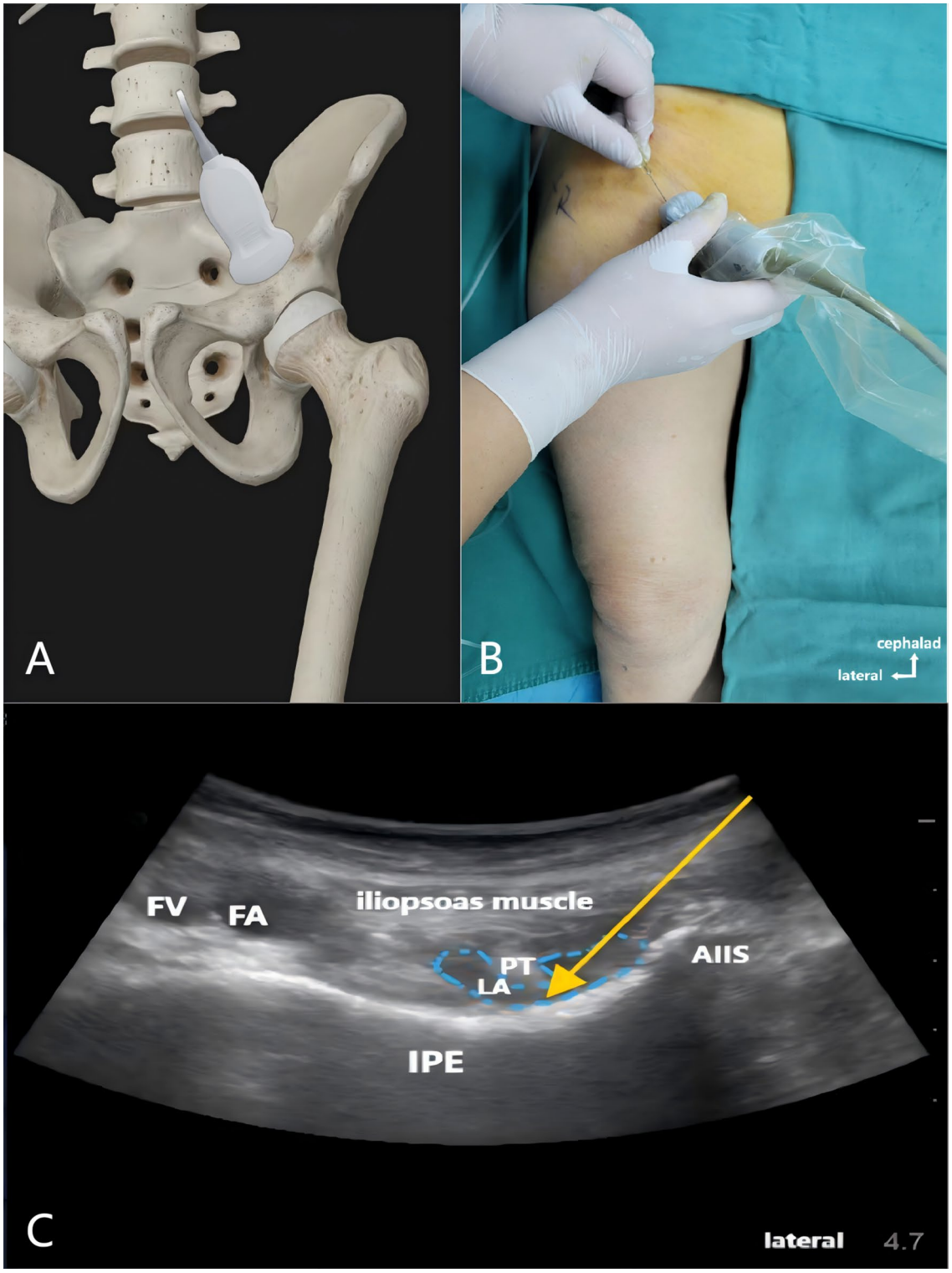

Fig. 1 Schematic diagram of PENG block (**A**), image of the block process (**B**), and ultrasound image (**C**). Yellow arrow, needle trajectory; FV, femoral vein; FA, femoral artery; PT, psoas tendon; IPE, iliopubic eminence; AIIS, anterior inferior iliac spine; LA, local anesthetic

Posterior hip pericapsular block (PHPB)

Five minutes after completing the PENG block, the patient was positioned with the affected side up and the healthy side slightly flexed at the hip. A low-frequency convex probe was placed vertically at the midpoint of the line connecting the posterior superior iliac spine to the greater trochanter on the affected side, moving slowly towards the greater trochanter. The movement was stopped when the image of the greater trochanter, piriformis, and ischiofemoral ligament appeared (Fig. 2A). Using in-plane needle advancement, the needle was directed from medial to lateral towards the direction of the ischiofemoral ligament in the posterior hip capsule (Fig. 2B). Once the needle tip passed between the piriformis and the ischiofemoral ligament, with no abnormalities found on negative aspiration, 15 ml of 0.25% ropivacaine was injected. Ultrasound showed a hypoechoic shuttle-shaped image of the spread between the piriformis and the ischiofemoral ligament (Fig. 2C).

Post-intervention assessment

On the day before surgery, the anesthesiologist explained the meaning of the NRS scale and how it was assessed, and all five patients were able to accurately understand and provide feedback on their NRS scores for hip fracture pain. Patients were evaluated for Numerical Rating Scale (NRS) pain scores at rest (NRS_{rest}) and maximum NRS pain scores during limb movement (NRS_{max}) before the block, 30 min after the block, 6 h, 12 h, 24 h, and 48 h postoperatively. The NRS was assessed as follows: patients were asked to choose between 4 categories with a total of 11 scores (0–10): no pain (0), mild pain (1–3), moderate pain (4–6), and severe pain (7–10).

Perioperative maximum voluntary angles of hip flexion, hip abduction, hip adduction, and knee flexion with autonomy and quadriceps muscle strength were assessed. Quadriceps muscle strength was measured using an OE-210 tonometer (model number: OE-210, manufactured by Ito Corporation, Japan). The maximum quadriceps muscle strength (Quadriceps muscle $strength_{MAX}$) of the healthy lower limb was measured in the ward one day before surgery. The maximum quadriceps muscle strength (Quadriceps muscle $strength_{MAX}$) of the affected limb was measured at 24 h postoperatively and 48 h postoperatively in the ward. The quadriceps muscle strength was measured by the following method [8]. The patient was placed in the supine position, the hip was fixed, the straight leg was elevated at 15° for 5 s, and the myograph was placed at the ankle with a slightly downward resistance to determine the maximum muscle strength of the quadriceps muscle during isometric contraction. The maximum value of hip adduction (Hip $adduction_{MAX}$) and maximum value of knee flexion angle (Knee $flexion_{MAX}$) of the healthy limb were measured on the ward on the day before surgery. The maximum value of hip adduction (Hip $adduction_{MAX}$) and maximum value of knee flexion angle (Knee $flexion_{MAX}$) of the affected limb were measured in the ward at 24 h postoperatively and 48 h postoperatively. The angle of the patient's hip and knee joints was measured using the WeChat applet "Ruler Angle Measurement." For the measurement of hip joint adduction angle, the patient lies in a supine position with the hip flexed, the axis of the electronic protractor is placed at the position of the greater trochanter of the femur, and the bottom edge of the protractor coincides with the anterior axillary line and the prolongation of the greater trochanter. Then, the adduction angle of the hip joint can be measured (Supplementary Fig. 1A, 1B, and 1C). For the measurement of knee flexion angle, the patient bends the knee in the supine position, the axis of the electronic protractor is placed at the lateral side of the knee joint, the bottom edge of the protractor coincides with the long axis of the femur, and the knee flexion angle can then be measured (Supplementary Fig. 1D).

Postoperative analgesia protocol

A postoperative oral celecoxib (200 mg/day) and a patient-controlled intravenous analgesia (PCIA) pump were administered. The PCIA formula consisted of oxycodone 40 mg+tropisetron 10 mg in 100 ml of 0.9% sodium chloride, with a bolus dose of 5 ml, no continuous infusion dose, and a lockout time of 15 min. Intravenous analgesic rescue remedy with hydromorphone, dose 0.1 mg/kg, was used if the NRS score was >3 and persisted for more than 30 min (Table 1).

Statistical analysis

The Kolmogorov-Smirnov normality test was conducted for continuous variables. Normally distributed variables were expressed as mean±standard deviation (SD), and comparisons between groups were made using one-way ANOVA. Non-normally distributed variables were expressed as median (interquartile range, IQR) [M (Q1, Q3)]. Count data were presented as the number of cases. The significance level was set at $\alpha=0.05$, and differences were considered statistically significant at $P<0.05$.

Results

In this case series, the five patients (demographic characteristics shown in Table 2) self-reported experiencing effective pain control within 48 h postoperatively, with NRS_{rest} scores decreasing from 3.0 (3.0, 4.5) to 0.0 (0.0, 1.0) and NRS_{max} scores from 8.0 (7.5, 8.5) to 1.0 (0.5, 2.0) (Table 3). Notably, all five patients could autonomously perform hip flexion, hip abduction, hip adduction, and knee flexion within 24 h postoperatively without any signs of movement disorders or quadriceps muscle weakness, and none of them showed statistical differences

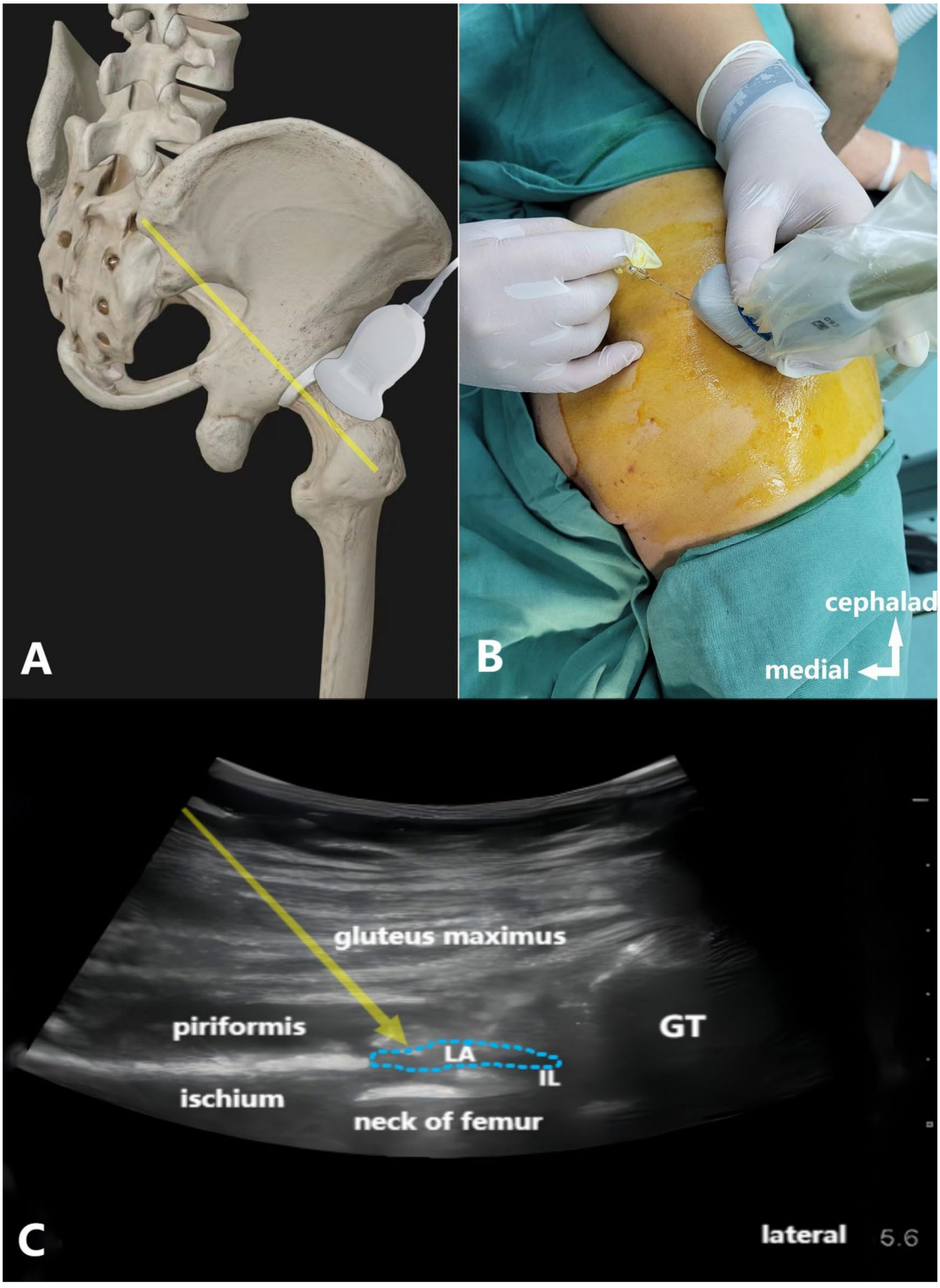

Fig. 2 Schematic diagram of PHPB (**A**), image of the block process (**B**), and ultrasound image (**C**). Yellow arrow, needle trajectory; GT, greater trochanter; IL, ischiofemoral ligament; LA, local anesthetic

Table 1 Postoperative analgesia for patients

Patient	Consumption of oxycodone (mg)		PCIA pump usage (times)		Analgesic rescue remedy (times)	
	0–24 h postoperatively	24–48 h postoperatively	0–24 h postoperatively	24–48 h postoperatively	0–24 h postoperatively	24–48 h postoperatively
Case 1	4.0	6.0	2	3	0	0
Case 2	0	4.0	0	2	0	0
Case 3	4.0	8.0	2	4	0	0
Case 4	0	4.0	0	2	0	0
Case 5	0	4.0	0	2	0	0
Median (IQR)	0.0 (0.0,4.0)	4.0 (4.0,7.0)	0.0 (0.0,2.0)	2.0 (2.0,3.5)	0 (0.0, 0.0)	0 (0.0, 0.0)

Table 2 Patient characteristics

Terms	Data
Sex (male/female, n)	3/2
Age [mean (SD), y]	68.3 (6.3)
BMI [mean (SD), kg/m^{2}]	23.8 (3.5)
ASA physical status [(I/II/III), n]	1/2/2
Fracture type [(Femur neck/Intertrochanteric), n]	4/1

Note BMI, body mass index; ASA, American Society of Anesthesiologists

compared with the healthy side (all $P>0.05$) (Table 4). Three of these patients did not use opioid analgesics for 24 postoperative hours, and analgesic rescue remedies did not occur in these five patients for 48 h postoperatively (Table 1). No severe postoperative complications, such as wound infections, hematoma formation or nerve damage, were observed in any of the patients.

Discussion

This case report demonstrates the successful application of ultrasound-guided PHPB combined with PENG block for perioperative analgesia in patients with hip fractures. The results showed that PHPB with PENG block balanced, controlling pain across the entire hip capsule and preserving motor function. Particularly notable was that five patients showed no difference in the angle of voluntary hip movement or quadriceps muscle strength on the operated side compared to the healthy side, with median NRS_{MAX} scores ≤ 3 within 48 h after THA.

According to previous anatomical studies, the anterior hip capsule is innervated by joint branches from the obturator nerve (ON), accessory obturator nerve (AON), and femoral nerve (FN) with a high density of nociceptors, making it the primary analgesic target for THA surgery, leading to the development of FICB, femoral nerve 3-in-1 block, and PENG block techniques [13, 14]. Laumonerie et al. found that the sciatic nerve innervates the posterior hip capsule, NQF, SGN, and IGN [15], with nociceptors found in the upper lateral and lower parts of the posterior hip capsule [13]. Nagpal's cadaver study found that the NQF forms the main branch of the joint nerve supply to the posterior hip capsule [16]. Therefore, our team modified the traditional sacral plexus nerve block technique to develop the PHPB technique, targeting the NQF, SGN, and IGN on the surface of the ischiofemoral ligament of the posterior hip capsule. Both the "parasacral interfascial plane block (PIPB)" described by Tulgar et al. [17] and the "Deep posterior gluteal compartment (PPD) block" described by Vermeylen et al. [18] represent modifications of the traditional sacral plexus block techniques. In the study by Tulgar et al., patients undergoing transfemoral knee amputation required only postoperative pain management without concerns regarding lower limb muscle strength [17]. Therefore, within the context of Enhanced Recovery After Surgery (ERAS), the PIPB technique may not be suitable for facilitating the rapid recovery of lower limb motor function in patients undergoing THA. Furthermore, although our PHPB technique appears similar to Vermeylen's PPD block, clinical practice has significant differences. First, the PPD block necessitates hip and knee flexion of 90° on the affected limb [18], a position nearly impossible to achieve in patients with hip fractures, whereas PHPB can be performed with only mild hip flexion on the affected side. Second, the injection site for the PPD block is closer to the sacral plexus [18]. In contrast, PHPB more closely resembles the PENG block. We found that injecting local anesthetics in the region between the piriformis and the ischiofemoral ligament. The barrier of the piriformis could keep the local anesthetics away from the sciatic nerve, avoiding lower limb weakness after block, which are the advantages of PHPB. In this study, none of the five patients reported any sensory or motor abnormalities in the lower leg within 24 h postoperatively. One of the patients (Case 4) could walk a distance of 5 m using a stand-up walker at the time of transfer out of the PACU. Consequently, we believe that both PHPB and PPD blocks represent modifications of the sacral plexus block, with differences in ultrasound probe positioning and preservation of lower leg muscle strength. Therefore, retaining the PHPB name helps to distinguish it from other sacral plexus block techniques. The use of 15 ml of local anesthetic for the PENG block in our study center was informed by the studies of Tran et al. and Leurcharusmee et al., aiming to ensure the effectiveness of the PENG block while minimizing the impact on the femoral nerve [19, 20]. Additionally, considering that elderly

Table 3 NRS pain scores of each patient at different points

Patient	Before block		30 min after the block		6 h postoperatively		12 h postoperatively		24 h postoperatively		48 h postoperatively	
	NRS_{rest}	NRS_{MAX}	NRS_{rest}	NRS_{MAX}	NRS_{rest}	NRS_{MAX}	NRS_{rest}	NRS_{MAX}	NRS_{rest}	NRS_{MAX}	NRS_{rest}	NRS_{MAX}
Case 1	4	8	2	3	2	1	0	1	1	2	0	1
Case 2	3	8	1	3	1	2	1	2	1	2	1	0
Case 3	5	9	2	3	1	2	1	2	1	2	1	2
Case 4	3	7	1	1	1	1	0	1	1	1	0	1
Case 5	3	8	1	2	1	2	1	2	1	2	0	2
Median (IQR)	3.0 (3.0, 4.5)	8.0 (7.5, 8.5)	1.0 (1.0, 2.0)	3.0 (1.5, 3.0)	1.0 (1.0, 1.0)	2.0 (1.0, 2.0)	1.0 (0.0, 1.0)	2.0 (1.0, 2.0)	1.0 (1.0, 1.0)	2.0 (1.5, 2.0)	0.0 (0.0, 1.0)	1.0 (0.5, 2.0)

patients in the northwest region of mainland China generally have a lean and frail physique, and based on our medical center's experience, we reduced the volume of local anesthetic for PENG to 15 ml. Tran's study demonstrated that both 10 ml and 20 ml of methylene blue could fully stain the entire anterior capsule of the hip joint and completely cover the nociceptive nerve fibers in that area [19]. Leurcharusmee's study indicated that, for the PENG block, the MEV90 of methylene blue required to spare the femoral nerve in a cadaveric model is 13.2 ml [20]. In this study, the total dose of ropivacaine used was 100 mg (37.5 mg of ropivacaine for the PENG block, 37.5 mg of ropivacaine for the PHPB, and 25 mg of ropivacaine for the SC infiltrated), which is approximately 1.5 mg/kg of ropivacaine for the regional block and the total amount of ropivacaine used was less than the 200 mg of the maximum dose.

Hip pain is often localized to one of three locations: anterior, lateral, or posterior [21]. In adult patients, anterior hip pain is evaluated by hip flexion [22]. The patient flexes the hip at 90 degrees, and the examiner extends the knee and passively moves the hip into adduction and internal rotation while palpating just lateral to the ischium. The result is positive if the pain is reproduced at posterior hip pain [23]. Therefore, the results of this study showed that the patients could move the hip flexion/adduction/abduction independently at 24 h and 48 h postoperatively and did not trigger pain in the corresponding areas of the hip. This result suggests that PENG block and PHPB can produce analgesic effects on the anterior and posterior parts of the hip joint, respectively. In addition, although no case-control was set up in this study, the results of this study showed that the NRS_{MAX} of these five patients at the same observation time points (6 h/12 h/24 h/48 h postoperatively) was lower than that in the previous study with our team [8]. Also, the opioid consumption aspect of the results of this study was lower than that of the study using FICB alone [24]. This result suggests that the addition of PHPB may be responsible for further decreasing NRS scores and reducing opioid consumption.

This case series has the following limitations. First, we did not assess the sensory and motor block dermatome levels at 24 h postoperatively. Given that both the PENG block and PHPB target the articular branch nerves, which primarily affect the nociceptors around the joint capsule and not those in the skin, due to that these blocks do not produce a sensory block at the skin level in the surgical area. Since these blocks theoretically do not affect the femoral or sciatic nerves, patients may not experience motor block postoperatively. Second, we could not determine the optimal concentration and volume of local anesthetics and the impact of the anesthetic dose on the range of PHPB. Although none of the five

Table 4 Patient's perioperative hip range of motion and muscle strength status

	Hip flexion$_{MAX}$ (°)	Hip abduction$_{MAX}$ (°)	Hip adduction$_{MAX}$ (°)	Knee flexion$_{MAX}$ (°)	Quadriceps muscle strength-$_{MAX}$ (kg)
Healthy side	103.72 ± 7.11	40.64 ± 1.35	14.69 ± 1.66	112.04 ± 3.28	8.14 ± 0.71
Affected side					
24 h postoperatively	94.11 ± 5.21	37.14 ± 2.56	12.62 ± 0.77	106.92 ± 2.60	7.36 ± 0.46
48 h postoperatively	97.97 ± 3.89	38.87 ± 2.20	13.15 ± 0.73	107.43 ± 4.34	7.36 ± 0.39
F	3.788	3.480	2.983	3.662	3.613
P	0.053	0.064	0.111	0.076	0.059

patients reported lower limb movement disorders within 48 h postoperatively, we cannot confirm whether 15 ml of ropivacaine could spread to the surrounding area of the sciatic nerve and affect lower limb movement, especially in the calf. Future studies may need to use contrast agents in cadaver studies to determine the spread range of local anesthetics in PHPB. Third, due to the inherent limitations of the case series report, we could not include a control group to provide more direct comparative data. However, when compared with previous studies that utilized the PENG block alone [25], our study showed that three patients were able to maintain an NRS score of less than 3/10 during hip abduction and adduction movements within 24 h post-THA without the need for opioid analgesics. This result indirectly suggests the efficacy of PHPB for postoperative pain management. Nonetheless, further research with more direct evidence is needed to confirm the effectiveness of PHPB.

Conclusions

In summary, ultrasound-guided PENG block combined with PHPB provided effective analgesia for patients with hip fractures during the perioperative period, especially enabling patients to autonomously perform movements such as hip flexion /abduction/adduction and knee flexion with lower pain scores after THA, thereby achieving early recovery of hip joint function. However, larger patient cohorts and randomized clinical trials (RCTs) are needed to validate its efficacy, safety, and potential risks in THA.

Abbreviations

THA	Total hip arthroplasty
FICB	Fascia iliaca compartment block
PENG	Pericapsular nerve group
PHPB	Posterior hip pericapsular block
PACU	Post-anesthesia care unit
AIIS	Anterior inferior iliac spine
IPE	Iliopubic eminence
PT	Psoas tendon
ERAS	Enhanced recovery after surgery
NRS	Numerical rating scale
NRS_{rest}	NRS pain scores at rest
NRS_{max}	Maximum NRS pain scores during limb movement
PCIA	Patient-controlled intravenous analgesia
ON	Obturator nerve
AON	Accessory obturator nerve
FN	Femoral nerve
NQF	Nerve to quadratus femoris muscle
RCTs	Randomized clinical trials

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12871-024-02731-2.

Supplementary Material 1

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Not applicable.

Author contributions

All authors contributed to this case report, navigating the clinical decisions described and the research putting it into the context of the current literature. All provided input and critique on the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This case series was conducted from December 2023 to February 2024. This study was approved by the Medical Ethics Committee of Xi'an Aerospace General Hospital (Approval Number: XHTZYY-2020-LL-02). All participating patients signed an informed consent regarding the procedure, possible complications, and alternative treatment modalities. All experiments were performed following relevant guidelines and regulations. No experiments on animals were conducted.

Consent for publication

Written informed consent was obtained from the patient for publication of this Case report and any accompanying images.

Competing interests

The authors declare no competing interests.

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