Journal of Pain Research

Dovepress
open access to scientific and medical research

Open Access Full Text Article

CLINICAL TRIAL REPORT

Comparison of the Effect of Pericapsular Nerve Group Block Combined with Lateral Femoral Cutaneous Nerve Block and Fascia Iliaca Compartment Block in Patients Undergoing Hip Arthroscopy Under General Anesthesia: A Randomized, Double-Blind Trial

Menglin Liu[1], Mingyang Gao[1], Yufei Hu[1], Xiaoqin Ren[1], Yanan Li[1], Fang Gao[1], Jianglong Dong[1], Jiangtao Dong[2], Qiujun Wang[1]

[1]Department of Anesthesiology, The Third Hospital of Hebei Medical University, Shijiazhuang, Hebei Province, People's Republic of China; [2]Department of Orthopaedic Surgery, The Third Hospital of Hebei Medical University, Shijiazhuang, Hebei Province, People's Republic of China

Correspondence: Qiujun Wang, Third Hospital of Hebei Medical University, No. 139, Ziqiang Road, Shijiazhuang City, Hebei, People's Republic of China, Tel/Fax +86-311-8860-2072, Email wangqiujunsy@163.com

Purpose: Patients undergoing arthroscopic hip surgery (AHS) require good analgesia and early rehabilitation after surgery, and there is no consensus on the optimal nerve block. We aimed to compare the efficacy of the pericapsular nerve group (PENG) block with lateral femoral cutaneous nerve (LFCN) block compared to fascia iliaca compartment block (FICB) in patients with AHS.

Patients and Methods: A total of 80 patients receiving AHS under general anesthesia were randomized to receive either FICB (group F) or PENG block in combination with LFCN block (group P). The primary outcomes were the rate of quadriceps weakness after block on the afflicted side, as well as muscle strength grading and pain score after block, and the quality of recovery on the second postoperative day.

Results: Compared with group F, group P had a lower incidence of quadriceps weakness 48 h after block (76.9% vs 28.2%, $P < 0.001$), and had less impact on muscle strength grade and lower static pain score at 6, 12, 18, 24, 36, and 48 h after block ($P < 0.001$), and a lower dynamic pain score at 6 and 12 h after block in group P ($p < 0.05$). The quality of recovery on the second postoperative day improved ($p < 0.05$).

Conclusion: In comparison to FICB, PENG block in combination with LFCN block can affect less quadriceps muscle strength and reduce the use of postoperative analgesics, which is beneficial for the postoperative recovery of AHS patients.

Keywords: analgesia, fascia iliaca compartment block, hip arthroscopy, nerve group block, pericapsular, postoperative pain

Introduction

Arthroscopic hip surgery (AHS) is becoming more popular for the treatment of hip diseases.[1] Early postoperative mobilization interventions for inpatients undergoing orthopedic surgery have been of great interest based on the concept of enhanced recovery after surgery (ERAS). AHS allows the patient to get out of bed on the first postoperative day for rehabilitation.[2] Thus, postoperative mobilization is very important. Early out-of-bed mobilization is a safe early mobilization intervention that reduces the risk of thrombosis, urinary retention, and lung infections.[3] Second, due to the inherent operational characteristics of AHS, surgical patients often experience severe pain postoperatively.[4] Therefore, patients with AHS require effective analgesia. Effective analgesia avoids the overdose of opioids and reduces their adverse effects.[5] The sensory nerve of the hip capsule is mainly distributed in the anterior capsule and consists of

Received: 3 January 2024
Accepted: 1 May 2024
Published: 6 May 2024

the obturator nerve, accessory obturator nerve, and femoral nerve.[6] Peripheral nerve block is known as an important adjunctive measure for multimodal pain management, and its positive results suggest that it can bring benefits to the perioperative management of AHS patients.[7]

In recent years, fascia iliaca compartment block (FICB) with ultrasound guidance has emerged as a dominant block method in hip surgery. However, FICB often fails to block the obturator nerve sufficiently, which can lead to an inadequate analgesic effect on the medial side of the hip joint.[8] Moreover, FICB may lead to reduced mobilization of the affected limb postoperatively, which prevents patients from early postoperative activity, increases the risk of falls after surgery, and delays discharge from the hospital.[9] Pericapsular nerve group (PENG) block is a new type of planar interfascial block designed to block the joint branches provided by the femoral, obturator, and accessory obturator nerve.[10] Because the PENG block covers more of the anterior hip capsule region, the technique appears to produce better analgesia compared with FICB. More importantly, the PENG block blocks only the joint branches of the nerves, causing no motor impairment, and promotes early postoperative ambulation, lowering the likelihood of serious problems such as thrombosis of the deep veins and enhancing postoperative recovery quality.[11]

Incisional pain is also a significant source of postoperative pain in patients with AHS. The lateral femoral cutaneous nerve block (LFCN) provides most of the cutaneous innervation to the surgical site. It has been shown that PENG block combined with LFCN block provides better analgesia for hip surgery compared with PENG block alone.[12] Therefore, PENG block and LFCN block should be used in combination in patients with AHS.

Current studies have paid less attention to the effect of nerve block on early ambulation in patients with AHS. The study aimed to investigate the effectiveness of PENG block combined with LFCN block in AHS patients compared to FICB.

Materials and Methods

Ethics

The Third Hospital of Hebei Medical University's Ethics Committee accepted this clinical investigation (No. 2021-004-1), which was also registered with the Chinese Clinical Trial Registration Center under the registration number ChiCTR2100053001 and the registration date of November 7, 2021. All subjects provided their informed consent before the study was carried out in compliance with the Declaration of Helsinki (October 2013) and clinical Practice guidelines.

Inclusion of Patients

From November 8, 2021, to November 6, 2022, an amount of 80 patients having AHS received registration after signing the informed consent. The following criteria were used for inclusion: American Society of Anesthesiologists (ASA) physical status I–II, age ≥ 18 years. Exclusion criteria were (1) refusal to sign the informed consent, (2) preoperative comorbid peripheral nerve injury or lesion, (3) long-term oral pain medication, (4) severe compound trauma, (5) lactating and pregnant women, (6) history of steroid use within two weeks of the study, (7) presence of contraindications to local anesthesia or nerve block, (8) history of allergy to the study medication in the patient, (9) Sensory-motor abnormalities of the lower extremities, (10) Presence of infection in the wound, (11) Mental, speech, and hearing impairments.

Randomization and Blinding

Random sequences were generated in a 1:1 ratio using RESEARCH-RANDOMIZE (https://www.randomizer.org/) according to the order of patient admission, and all patients were assigned to group F (FICB) or group P (PENG block combined with LFCN block). A researcher who did not participate in the postoperative assessment assigned the patients. The assignment was unknown to the patients and the remaining researchers. An investigator for the blinded study collected the outcome information.

Nerve Block Regimen

The patient was given oxygen inhalation under a mask after entering the room, and peripheral venous access was opened. Peripheral capillary oxygen saturation (SpO_2), electrocardiography (ECG), non-invasive blood pressure (NIBP), and heart rate (HR) were monitored. The affected limb's contralateral radial artery was catheterized, invasive arterial blood

pressure (ABP) was monitored, and the same skilled anesthesiologist conducted all of the nerve blocks during the same procedure. The nerve block process ensures that the patient will not see the ultrasound image.

Group P: An inguinal ligament-parallel plane was chosen for the placement of a low-frequency ultrasonic probe with a curved tip (frequency 3–5 MHz, Mindray, China). Then, it was turned 45 degrees to show the iliopubic eminence, the psoas tendon, and the anterior inferior iliac spine. With the tip situated in the muscle fascia plane between the posterior pubic branch and the anterior psoas tendon, a 22-gauge, 80 mm nerve stimulation needle (Braun, Germany) was inserted in an in-plane approach. After following negative aspiration, 35 mL of 0.375% ropivacaine (lot number: LCCU, AstraZeneca AB, Sweden) were administered (Figure 1).

Following that, an LFCN block was conducted using a linear ultrasound probe (frequency 6–12 MHz, Mindray, China) utilizing the femoral artery and vein as markers to visualize the lateral region of the sartorius muscle and the tensor fascia lata. The lateral femoral cutaneous nerve was visible between the sartorius muscle and the tensor fascia lata. The needle was inserted at a shallow angle and reached the nerve area. Following negative aspiration, 5 mL of 0.375% ropivacaine was given (Figure 2).

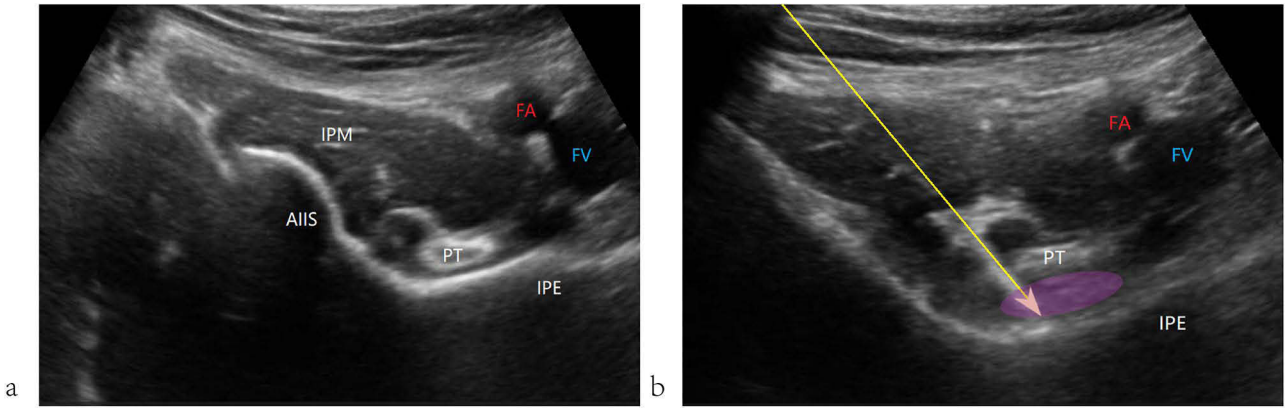

Figure 1 Sonoanatomy of PENG block. The ultrasonic anatomy of a PENG block (**a**); Ultrasound anatomy of PENG block after local anesthetic injection (**b**). Arrow, needle pathway; Area outlined by an ellipse, local anesthetic dissemination.
Abbreviations: FV, femoral vein; FA, femoral artery; PT, psoas tendon; IPE, iliopubic eminence; IPM, iliopsoas muscle; AIIS, anterior inferior iliac spine.

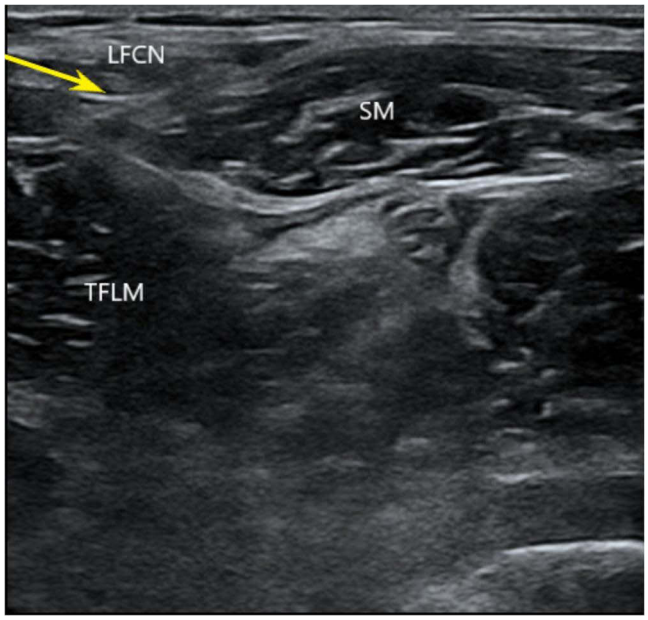

Figure 2 Sonoanatomy of LFCN block. The needle tip was inserted into the fascia tunnel produced by the sartorius and tensor fascia lata. Arrow, needle pathway.
Abbreviations: SM, sartorius muscle; TFIM, tensor fascia lata; IPM, iliopsoas muscle.

In Group F, an ultrasonic probe (line array) was inserted in the sagittal plane of the inguinal ligament. The probe was rotated and slid medially to identify the "bow-tie sign" formed by the internal oblique muscle and the sartorius muscle together. Then a neurostimulation needle (22-gauge, 80 mm) was inserted cephalad, with the needle tip placed in the gap between the iliopsoas muscle and the internal oblique muscle. Following negative aspiration, 0.375% ropivacaine (40 mL) was given (Figure 3).

After 30 min, the sensory nerve block was evaluated by pinpricking the skin with the wooden stick end of a cotton swab on the anterior, medial, and lateral thighs, as well as at the incision site, and was classified as 0, 1, or 2 based on no sensation, touch alone, or acupuncturist sensation. The effective block was defined as the detection of a pinprick sensation graded as 0 or 1 within 30 min of the injection's completion. Patients who failed the block were removed from the study.

Anesthesia and Perioperative Management

Induction of anesthesia: After 3 minutes of oxygen denitrification, midazolam 0.05 mg/kg, propofol 2 mg/kg, sufentanil 0.3 μg/kg, and cisatracurium 0.2 mg/kg were given intravenously, mechanical ventilation was performed after placing a laryngeal mask.

Continuous infusions of the vein of propofol (3–6 mg/kg/h) and remifentanil (0.1–0.4 μg/kg/h) for anesthesia maintenance. Maintain a Bispectral Index (BIS) range of 40 to 60. The range of fluctuation in blood pressure (BP) and HR remains within 20% of preoperative levels. To prevent postoperative nausea and vomiting (PONV), palonosetron hydrochloride 0.25 mg was administered 30 minutes before the conclusion of the operation.

After the operation, patients had self-controlled intravenous analgesia (PCIA). The medication formulation was sufentanil 1.5 μg/kg + palonosetron hydrochloride 0.25 mg + saline 100 mL, the background rate of infusion remained 2 mL/h, the PCA volume remained 0.5 mL, and the lockout duration remained 15 min. Through the education, patients were instructed to press the analgesia pump by themselves after they felt pain at the surgical site after surgery. If the pain score (VAS) ≥ 5, the rescue analgesic regimen was intravenous injection of ketorolac tromethamine 30 mg. All patients in the hospital's ward received 200 mg of oral celecoxib every 12 hours, and those who experienced severe vomiting or nausea also received 10 mg of metoclopramide. Postoperatively, lower extremity pneumatic compression devices were frequently employed. Patients were urged to use direct factor Xa inhibitors and conduct intermittent ankle pumping

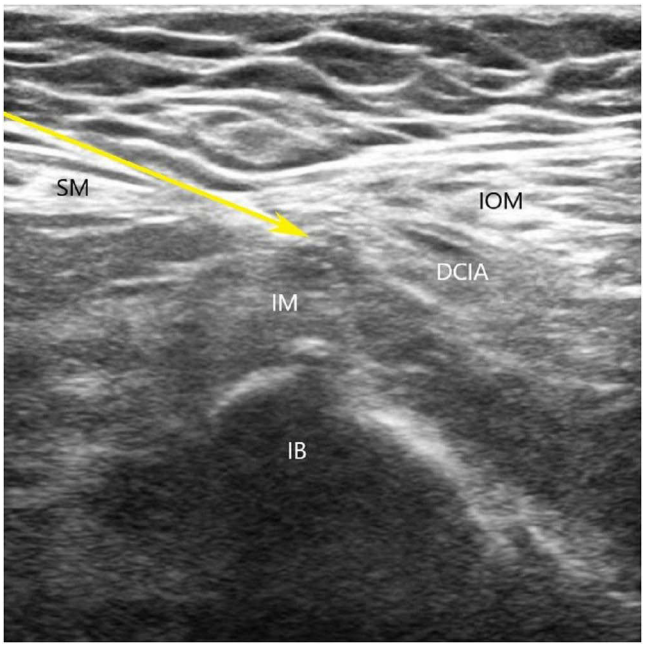

Figure 3 Sonoanatomy of FICB. Arrow, needle pathway.
Abbreviations: DCIA, deep circumflex iliac artery; IB, iliac bone; IM, iliac muscle; IOM, internal oblique muscle; SM, sartorius muscle.

exercises to prevent thrombosis. Patients were told to do quadriceps exercises, and they were reminded to walk as soon as possible after surgery.

Outcome Variables

The main outcomes were the rate of quadriceps weakness after blockage on the afflicted side, as well as muscle strength grading and pain score after 6, 12, 18, 24, 36, and 48 h after nerve block, and the quality of recovery on the second postoperative day. The muscular strength grading was evaluated with a manual muscle test (MMT). MMT was defined as grade 0, there is no muscular contraction; grade 1, only minor quadriceps contraction, not enough to generate joint movement; grade 2, muscle contraction could only induce horizontal joint movement; grade 3, capable of lifting the leg and extending the knee under gravity but unable to resist resistance; grade 4, capable of performing leg lifts and knee extensions against gravity and partial resistance; grade 5, capable of lifting the leg and extending knee with full resistance to gravity and resistance.[13] The rate of quadriceps muscle weakness (defining hemiplegia or knee extension paralysis, ie, MMT muscle strength grade <3) within 48 h after the blockade. In this study, the visual analog scale (VAS) score (0–10) was used to evaluate the postoperative analgesia effect, with 0 indicating no pain and 10 indicating the most severe pain possible. The VAS pain scores (static and dynamic) at 6, 12, 18, 24, 36, 48 h after nerve block (static state: measured after the patient rested in bed for 15 min; dynamic state: measured when the hip joint was flexed to 45°). The quality of recovery scale (QoR-15 scores) was utilized to assess early recuperation on the second day following the operation.

The secondary outcomes were the number of analgesic pump compression, the number of rescue analgesics, and the duration of sensory blockade (defined as the duration of time when pain at the surgical site was not existent). The time and duration of the patient's first time out of bed (the time and duration of the patient's first walk with a walker under the direction of a rehabilitation physician) were also recorded, and the Richards Campbell Sleepiness Scale (RCSQ) was used to describe the quality of sleep on the night of surgery and the second night after surgery. RCSQ measures five domains of sleep quality: (1) depth, (2) latency (time to fall asleep), (3) number of awakenings, (4) efficiency (percentage of time awake), and (5) quality. On the 100 mm line, the visual simulation scale for each item is 0–100. The higher scores represent better rest and the mean of all five questions reflects the overall quality of sleep (main sleep result.[14] Patients were additionally requested to report any site of puncture infections, hematomas, nerve damage, vomiting, nausea, or lower extremity deep vein thrombosis.

Sample Size Estimation and Statistical Analysis

According to previous studies, the incidence of quadriceps weakness after fascia iliaca compartment block was 61%.[15] The goal was to reduce the occurrence of quadriceps weakness by 50% in group P than group F, and with 37 patients in each team, 80% of the test's efficacy could be employed to detect a 0.05 (two-tailed) level of significance for such a difference. This study included 80 patients accounting for a 10% loss to follow-up.

We used IBM SPSS version 25.0.0.0 software (IBM, NY, USA) for statistical analysis. The Student's *t*-test or Mann–Whitney *U*-test was utilized according to the results of the normality test of continuous variables. The χ^2 test or Fisher's exact test probability was used to compare categorical variables expressed as occurrences. Hodges-Lehmann estimation at 95% CI was used to measure pain scores and QoR-15 scores 24 h after block. Differences were judged statistically significant at $P < 0.05$.

Results

Written informed consent was obtained from a total of 80 patients in this study, and one patient in each group did not complete the follow-up. Therefore, 39 patients were eventually included in each group (Figure 4). There was no significant difference in the basic parameters between the two groups ($p > 0.05$) (Table 1).

Compared with group F, the level of muscle strength was higher in group P after blockade ($p < 0.001$) (Figure 5a), and the static VAS scores were lower in group P than in group F after blockade ($p < 0.001$) (Figure 5b). Dynamic VAS scores were lower in group P at 6 and 12 h after block compared to group F ($p < 0.05$) (Figure 5c). The sleep quality of group P only on the second night following the operation was higher than that of group F ($p < 0.05$) (Figure 5d). Compared with group F, group P exhibited a lower incidence of quadriceps weakness (76.9% vs 28.2%, $p < 0.001$) and

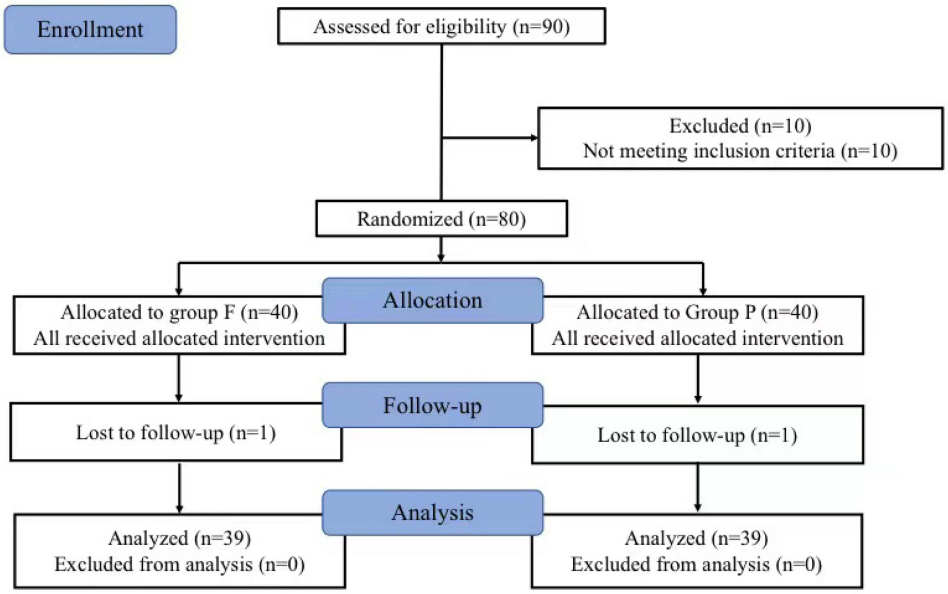

Figure 4 The CONSORT flow diagram.

a lower incidence of standing instability (43.6% vs 10.3%, $p < 0.05$). The first time for patients in group P to get out of bed was earlier and longer than that in group F, and the dosage of ketorolac tromethamine and the number of analgesic pump compression were significantly reduced compared with group F ($p < 0.05$). On the second day after surgery, QoR-15 scores increased in group P compared to group F ($p < 0.05$), with a median (95% CI) difference of 8 (1–12) (Table 2).

Every patient in both groups had a successful nerve block. No infection, itching, or nerve damage occurred in the postoperative period in either group. There was no statistical difference in the occurrence of adverse reactions such as vomiting, nausea, and deep vein thrombosis of the lower extremities between the two groups (Table 3).

Discussion

Effective analgesia as well as early postoperative rehabilitation is necessary for patients with AHS. Early postoperative mobilization not only improves the mobilization of patients' joints but also reduces soft-tissue swelling in the surgical

Table 1 Patients' Demographic Characteristics

	Group F (n=39)	Group P (n=39)	*P*-value
Age, years	39.3 (17.7)	44.1 (13.7)	0.129
Sex, n (%)			0.645
Male	24 (61.5)	22 (56.4)	
Female	15 (38.5)	17 (43.6)	
ASA physical status, n (%)			0.821
I	19 (48.7)	20 (51.3)	
II	20 (51.3)	19 (48.7)	
BMI, kg/m^2	23.5 (3.9)	24.6 (3.7)	0.223
Operation duration, h	2.0 (2.0–2.5)	2.0 (1.5–2.5)	0.815
Duration of anesthesia, h	3.5 (3.0–4.0)	3.5 (3.0–4.0)	0.779
Preoperative muscle strength (MMT)	5.0 (5.0–5.0)	5.0 (5.0–5.0)	1.000
Preoperative pain score (VAS)	2.0 (2.0–2.0)	2.0 (2.0–2.0)	0.611
Preoperative sleep quality (RCSQ)	480.0 (450.0–500.0)	480.0 (460.0–500.0)	0.624

Note: Data are presented as mean and standard deviation (SD), number (percentage), or median and interquartile range (IQR).

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists. MMT, the manual muscle test; VAS, visual analog scale; RCSQ, Richards Campbell Sleepiness Scale.

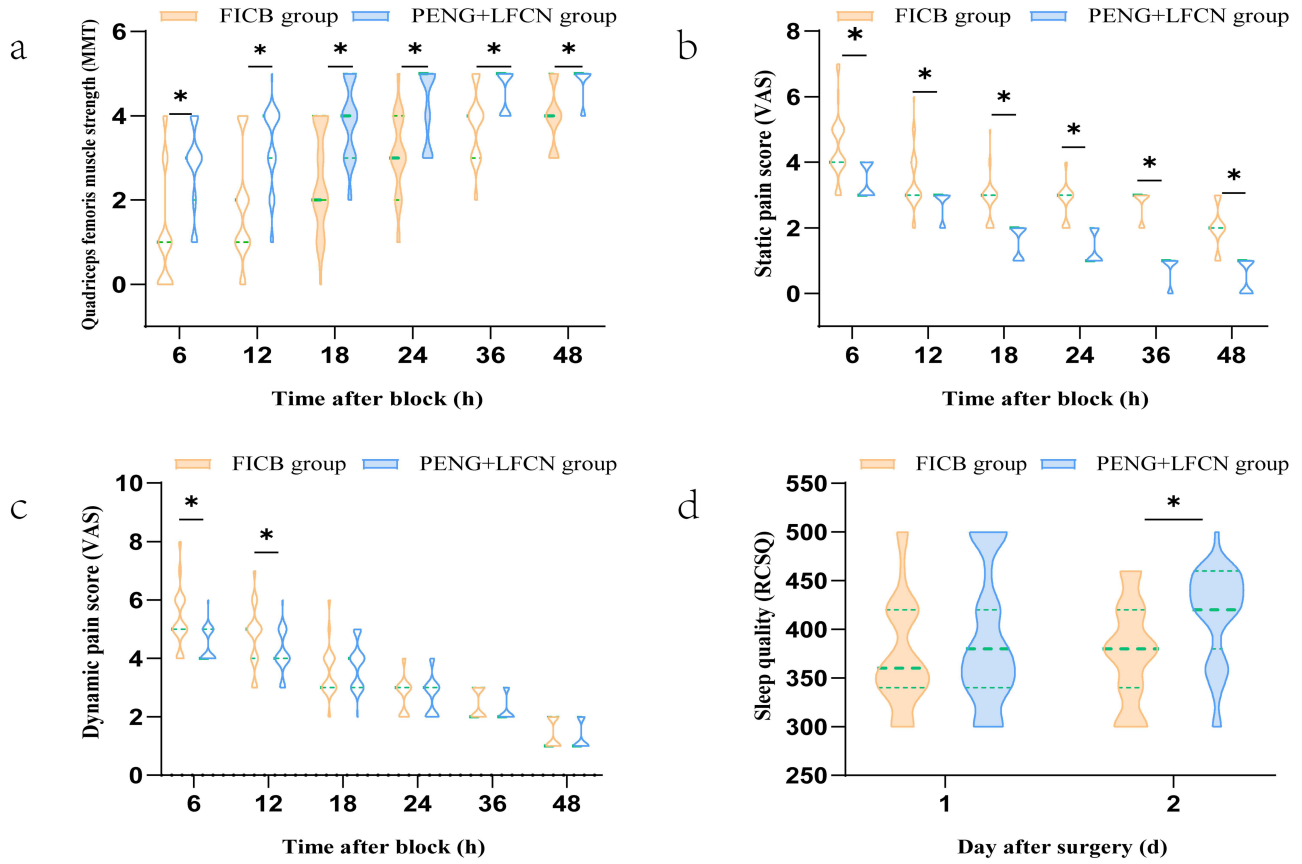

Figure 5 Comparison of the muscular strength grading (MMT) (**a**), the VAS pain score (**b**) at static and (**c**) at dynamic, and (**d**) the quality of sleep (RCSQ) between the two groups. *P <0.05. The violin plots show medians and interquartile ranges. For group P in comparison with group F, the median (95% CI) difference in Pain static at 24 h after block (VAS) was 1 (1–2). For group P in comparison with group F, the median (95% CI) difference in Pain dynamic at 24 h after block (VAS) was 0 (0–0).

area[16] and decreases the use of postoperative analgesic medications.[17] Peripheral nerve blocks, as one of the commonly used perioperative pain management methods, can be beneficial for pain management in patients with AHS, but they must be used with caution to minimize the risk of patient falls.[5] Since less attention has been paid to the efficacy of nerve blocks in AHS patients, there is a need to investigate the efficacy of different blocking techniques in AHS patients.

FICB is often used in hip surgery by blocking the femoral nerve, the obturator nerve, and the lateral femoral cutaneous nerve. It has the advantage of being easy to perform, covering most of the nerves responsible for the hip joint,[18] and is effective in the treatment of hip fractures[19] and total hip arthroplasty.[20] However, quadriceps weakness and limb numbness caused by FICB tend to increase the probability of postoperative falls in AHS patients, which greatly

Table 2 Perioperative Medications and Recovery Indicator

	Group F (n=39)	Group P (n=39)	*P*-value
The incidence of quadriceps femoris muscle weakness, n (%)	30.0 (76.9)	11.0 (28.2)	< 0.001
Incidence of standing instability, n (%)	17.0 (43.6)	4.0 (10.3)	< 0.001
First time out of bed, h	24.0 (19.0–27.0)	18.00 (15.0–22.0)	< 0.001
Duration of initial walk out of bed, min	5.0 (3.0–6.0)	5.00 (5.0–7.0)	0.008
Duration of sensory blockade, h	12.0 (9.0–13.0)	12.00 (9.0–14.0)	0.604
The number of analgesic pump compression	1.0 (0.0–2.0)	0.0 (0.0–1.0)	< 0.001
Postoperative ketorolac tromethamine consumption (mg)	30.0 (0.0–30.0)	0.0 (0.0–30.0)	0.035
QoR-15 scores	112.0 (109.0–123.0)	123.0 (112.0–134.0)	0.008

Notes: The median (IQR) or a number (percentage) are used to present data. The median (95% CI) difference in QoR-15 scores between group P and group F was 8 (1–12).

Table 3 Postoperative Adverse Events in Two Group

	Group F (n=39)	Group P (n=39)	*P*-value
The incidence of lower limb deep vein thrombosis, n (%)	2 (5.1)	0 (0.0)	0.064
PONV, n (%)	2 (5.1)	2 (5.1)	1.000
Pruritus, n (%)	0 (0)	0 (0)	-
Nerve damage, n (%)	0 (0)	0 (0)	-
Infection, n (%)	0 (0)	0 (0)	-

Note: Data is number (percentage).
Abbreviation: PONV, postoperative nausea and vomiting.

increases the risk of glenoid labral repair failure as well as hip dislocation, and affects the patient's postoperative rehabilitation.[5,9] This is consistent with the results of the present study. According to the study's findings, the incidence of quadriceps weakness in group F was 76.9% and the incidence of standing instability was 43.6%. This confirms the negative effect of FICB on postoperative quadriceps muscle strength in AHS patients. The effectiveness of PENG block as a new regional block technique in hip arthroplasty as well as hip fracture surgery has shown its ability to provide analgesia as well as preservation of postoperative muscle strength.[21–23] The anterior hip capsule is the main source of hip pain.[6] Postoperative incision pain in AHS patients is also of concern, and the skin sensation there is dominated by LFCN. PENG blocks the sensory branches of the femoral, obturator, and accessory obturator nerve that innervate the anterior hip capsule. Since FICB includes LFCN block, PENG block combined with LFCN block can provide a more comprehensive analgesic effect for AHS patients. In addition, AHS requires patients to undergo various rehabilitation activities immediately after surgery,[24] so AHS requires high postoperative muscle strength, and the PENG block has the property of preserving the ability to exercise, which is in line with the clinical needs of AHS. According to the study's findings, the incidence of quadriceps weakness and standing instability in group P was 28.2% and 10.3%, respectively, suggesting that PENG blockade reduces the negative effect on postoperative muscle strength in AHS patients. Moreover, in comparison to FICB, the PENG block paired with the LFCN block significantly reduced static pain scores at all measured time points (6, 12, 18, 24, 36, and 48 h) and motor pain scores at 6 and 12 h after block in AHS patients. In comparison to FICB, the PENG block paired with the LFCN block provided a superior analgesic effect. The findings of this study also showed that PENG block in combination with LFCN block, when compared to FICB, more effectively retained postoperative muscular strength at all measured time points, decreased the time to get out of bed, and increased the duration of ambulation. Our findings were validated to some extent by Eppel et al who showed that PENG block had a better analgesic effect in AHS patients compared to FICB.[25] Similar to the results obtained by Noaman et al using 0.5% bupivacaine 20 mL for PENG block versus FICB, although the nerve block anesthetic used was different, the results showed that PENG block had a better ability to preserve motor function and analgesia in AHS patients.[26] However, Liang et al's results of nerve block using 0.33% ropivacaine 30 mL in hip arthroplasty patients showed that compared to FICB, although PENG block combined with LFCN block shortened the time to a first postoperative activity, muscle strength levels were higher only at 6 h postoperatively and pain scores were higher only at 48 h postoperatively.[27] This is different from our findings, and we hypothesize that the reason for this is that, in addition to the effect of nerve block, different types of surgery have different effects on postoperative pain and muscle strength levels. Postoperative pain in patients with AHS is divided into two parts: intra-articular pain caused by surgical procedures such as capsulotomy and glenoid labral repair, and extra-articular pain caused by intraoperative traction and extrusion, which may result in nerve and soft-tissue damage, and by fluid irrigation, which may result in soft-tissue swelling. Extra-articular pain due to soft tissue swelling.[28] The postoperative neuropathy that may result from traction can cause changes such as numbness in the limb.[29] Therefore, despite using the same nerve block technique the clinical outcome is different. In the present study, we used higher concentration and volume of ropivacaine for nerve block. This may have improved the effectiveness of the block and prolonged the duration of action, making the ability of the PENG block to preserve motor function more prominent is also one of the reasons.

In addition, a study claimed that PENG block using 0.5% ropivacaine 20 mL did not improve postoperative analgesia in patients with AHS compared to placebo.[30] The reasons for this are that intraoperative fluid flushing dilutes the anesthetic

causing insufficient block effect, and fluid extravasation as well as surgical incisions increase pain in areas outside the hip joint capsule that are beyond the range of action of the PENG block. In addition, one study showed that 20 mL PENG block with 0.5% ropivacaine did not improve postoperative analgesia in AHS patients compared to placebo. The reason is that intraoperative liquid irrigation dilutes the anesthetic, resulting in insufficient blocking effect, and fluid extravasation and surgical incision increase the pain outside the hip capsule beyond the scope of PENG block. Therefore, high dose nerve block may be more suitable for AHS. At present, the optimal dose of PENG block that does not affect postoperative muscle strength remains to be determined, although studies have shown that PENG block with a dose of > 20mL May block the femoral nerve and lead to quadriceps muscle weakness.[31] However, this study is more concerned about whether PENG block can have less impact on postoperative muscle strength when meeting the analgesic requirements of AHS. Therefore, based on previous study showing that FICB requires 40 mL of ropivacaine to block the obturator nerve,[32] we used a nerve block dose of 40 mL per set. In addition, we measured the block effect on the patients 30 min after the block was completed and confirmed that the block was effective before including them in this study. The entire process from confirmation of block effectiveness to intraoperative fluid flushing will provide time for the nerve block to work and for the LFCN block to be performed to improve pain at the incision in patients with AHS. In addition to this, reducing the flush pressure, traction force, and duration of traction can prevent extra-articular pain and nerve injury. We can assist these preventive measures by ensuring adequate muscle relaxation to reduce traction force and controlled intraoperative hypotension to reduce bleeding in the operative field. Intra-articular pain, on the other hand, is associated with the necessary surgical maneuvers and is therefore difficult to control. Therefore, in our study, the PENG block paired with the LFCN block could provide good analgesia for AHS patients. Although we increased the anesthetic dose of the nerve block, the PENG block still better preserved postoperative muscle strength, and none of the patients experienced any nerve block-related complications after surgery, which indicated that the anesthetic dose of the nerve block we used was safe and effective.

We performed a study of the minimal clinically relevant difference (MCID) to more accurately reflect the variance in pain levels between the two groups. It allows evaluation of the degree of clinical benefit of the intervention for the patients rather than just statistical differences.[33] Studies have shown a change in the MCID threshold defined as 1.1 for VAS pain scores in AHS patients at 24 hours postoperatively.[25] In our study, although the difference in VAS pain scores between the two groups did not reach the MCID, the amount of postoperative analgesic medication used and the number of analgesic pump presses were significantly less in group P than in group F. Therefore, the PENG block paired with the LFCN block brought benefits to postoperative analgesic management in AHS patients. The quality of sleep and QOR-15 scores on the second postoperative night in group P were significantly higher than those in group F, and the variance in QOR-15 scores among the two groups reached the MCID (MCID>8),[34] which was clinically significant. We attribute the improvement in the quality of recovery and sleep quality in group P to the patients' enhanced postoperative muscle strength and improved analgesia. The findings of this study suggest that PENG block in combination with LFCN block is more beneficial to the recovery of AHS patients than FICB.

The study still has some limitations. Although the incidence of quadriceps weakness in AHS patients in group P was significantly reduced, 28.2% of patients still had quadriceps weakness within 48 h after blockade. The use of higher doses of PENG block may aggravate the decline in quadriceps muscle strength, so further studies are needed to determine a more precise dose and range of action of PENG block. This is our future research direction. In addition, this experiment has the problem of insufficient sample size. The sample size was calculated based on the rate of quadriceps weakness, so measurements of other indicators may lack accuracy. Therefore, it is our future research direction to explore the optimal anesthesia dose and puncture method for larger samples of PENG block.

Conclusion

In comparison to FICB, PENG block in combination with LFCN block can affect less muscle strength and reduce the use of postoperative analgesics, which is favorable to the postoperative recovery of AHS patients.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Acknowledgments

The authors would like to express their gratitude to the Joint Surgery Department of the Third Hospital of Hebei Medical University for their assistance and support.

Disclosure

The authors report no conflicts of interest in this work.

References

1. Bedi A, Kelly BT, Khanduja V. Arthroscopic Hip preservation surgery: current concepts and perspective. *Bone Joint J*. 2013;95-B(1):10–19. doi:10.1302/0301-620X.95B1.29608
2. Domb BG, Sgroi TA, VanDevender JC. Physical therapy protocol after hip arthroscopy: clinical guidelines supported by 2-year outcomes. *Sports Health*. 2016;8(4):347–354. doi:10.1177/1941738116647920
3. Lei YT, Xie JW, Huang Q, Huang W, Pei FX. Benefits of early ambulation within 24 h after total knee arthroplasty: a multicenter retrospective cohort study in China. *Mil Med Res*. 2021;8(1):17. doi:10.1186/s40779-021-00310-x
4. Shin JJ, de Sa DL, Burnham JM, Mauro CS. Refractory pain following Hip arthroscopy: evaluation and management. *J Hip Preserv Surg*. 2018;5(1):3–14. doi:10.1093/jhps/hnx047
5. Shin JJ, McCrum CL, Mauro CS, Vyas D. pain management after hip arthroscopy: systematic review of randomized controlled trials and cohort studies. *Am J Sports Med*. 2018;46(13):3288–3298. doi:10.1177/0363546517734518
6. Short AJ, Barnett JJG, Gofeld M, et al. Anatomic study of innervation of the anterior hip capsule: implication for image-guided intervention. *Reg Anesth Pain Med*. 2018;43(2):186–192. doi:10.1097/AAP.0000000000000701
7. Kay J, de Sa D, Memon M, Simunovic N, Paul J, Ayeni OR. Examining the role of perioperative nerve blocks in hip arthroscopy: a systematic review. *Arthroscopy*. 2016;32(4):704–715. doi:10.1016/j.arthro.2015.12.022
8. Bendtsen TF, Pedersen EM, Peng P. Course of the obturator nerve. *Reg Anesth Pain Med*. 2019;44(11):1039–1040. doi:10.1136/rapm-2019-100655
9. Behrends M, Yap EN, Zhang AL, et al. Preoperative fascia iliaca block does not improve analgesia after arthroscopic hip surgery, but causes quadriceps muscles weakness: a randomized, double-blind trial. *Anesthesiology*. 2018;129(3):536–543. doi:10.1097/ALN.0000000000002321
10. Kukreja P, Avila A, Northern T, Dangle J, Kolli S, Kalagara H. A retrospective case series of Pericapsular Nerve Group (PENG) Block for primary versus revision total hip arthroplasty analgesia. *Cureus*. 2020;12(5):e8200.
11. Chung CJ, Eom DW, Lee TY, Park SY, Rakhshan V. Reduced opioid consumption with pericapsular nerve group block for hip surgery: a randomized, double-blind, placebo-controlled trial. *Pain Res Manag*. 2022;2022:6022380. doi:10.1155/2022/6022380
12. Roy R, Agarwal G, Pradhan C, Kuanar D. Total postoperative analgesia for hip surgeries, PENG block with LFCN block. *Reg Anesth Pain Med*. 2019;44(6):684.1–684. doi:10.1136/rapm-2019-100454
13. Sions JM, Beisheim EH, Hoggarth MA, et al. Trunk muscle characteristics: differences between sedentary adults with and without unilateral lower limb amputation. *Arch Phys Med Rehabil*. 2021;102(7):1331–1339. doi:10.1016/j.apmr.2021.02.008
14. Ritmala-Castren M, Axelin A, Richards KC, Mitchell ML, Vahlberg T, Leino-Kilpi H. Investigating the construct and concurrent validity of the Richards-Campbell Sleep Questionnaire with intensive care unit patients and home sleepers. *Aust Crit Care*. 2022;35(2):130–135. doi:10.1016/j.aucc.2021.04.001
15. Yin H, Zhang W, Shan T, et al. Comparison of efficacy of pericapsular nerve group block combined with lateral femoral cutaneous nerve block versus fascia iliaca compartment block in elderly patients undergoing total Hip arthroplasty under general anesthesia. *Chin J Anesthesiol*. 2021;41(05):567–570.
16. Radulovic TN, Lazovic M, Jandric S, Bucma T, Cvjetkovic DD, Manojlovic S. The effects of continued rehabilitation after primary knee replacement. *Med Arch*. 2016;70(2):131–134. doi:10.5455/medarh.2016.131-134
17. Pearse EO, Caldwell BF, Lockwood RJ, Hollard J. Early mobilisation after conventional knee replacement may reduce the risk of postoperative venous thromboembolism. *J Bone Joint Surg Br*. 2007;89(3):316–322. doi:10.1302/0301-620X.89B3.18196
18. Capdevila X, Biboulet P, Bouregba M, Barthelet Y, Rubenovitch J, d'Athis F. Comparison of the three-in-one and fascia iliaca compartment blocks in adults: clinical and radiographic analysis. *Anesth Analg*. 1998;86(5):1039–1044. doi:10.1213/00000539-199805000-00025
19. Hao C, Li C, Cao R, et al. Effects of perioperative fascia iliaca compartment block on postoperative pain and hip function in elderly patients with hip fracture. *Geriatr Orthop Surg Rehabil*. 2022;13:21514593221092883. doi:10.1177/21514593221092883
20. Bang S, Chung J, Jeong J, Bak H, Kim D. Efficacy of ultrasound-guided fascia iliaca compartment block after Hip hemiarthroplasty: a prospective, randomized trial. *Medicine*. 2016;95(39):e5018. doi:10.1097/MD.0000000000005018
21. Senthil KS, Kumar P, Ramakrishnan L. Comparison of pericapsular nerve group block versus fascia iliaca compartment block as postoperative pain management in hip fracture surgeries. *Anesth Essays Res*. 2021;15(4):352–356. doi:10.4103/aer.aer_119_21
22. Lin DY, Brown B, Morrison C, et al. The Pericapsular Nerve Group (PENG) block combined with Local Infiltration Analgesia (LIA) compared to placebo and LIA in Hip arthroplasty surgery: a multi-center double-blinded randomized-controlled trial. *BMC Anesthesiol*. 2022;22(1):252. doi:10.1186/s12871-022-01787-2
23. Hu J, Wang Q, Hu J, Kang P, Yang J. Efficacy of Ultrasound-Guided Pericapsular Nerve Group (PENG) Block combined with local infiltration analgesia on postoperative pain after total hip arthroplasty: a prospective, double-blind, randomized controlled trial. *J Arthroplasty*. 2023;38(6):1096–1103. doi:10.1016/j.arth.2022.12.023
24. McCarthy JC, Jarrett BT, Ojeifo O, Lee JA, Bragdon CR. What factors influence long-term survivorship after hip arthroscopy? *Clin Orthop Relat Res*. 2011;469(2):362–371. doi:10.1007/s11999-010-1559-2
25. Eppel B, Schneider MM, Gebhardt S, et al. Pericapsular nerve group block leads to small but consistent reductions in pain between 18 and 24 hours' postoperatively in hip arthroscopy for femoroacetabular impingement surgery: a prospective, randomized controlled clinical trial. *Arthroscopy*. 2023;22:S0749.

26. Noaman SS, Abdallah ES, Elsawy SMA, Abd El-Radi M, Kamel MM. The efficacy of pericapsular nerve group block versus facia iliaca block on immediate postoperative pain and opioid consumption after hip arthroscopy randomized trial. *Pain Physician*. 2023;26(4):357–367.
27. Liang L, Zhang C, Dai W, He K. Comparison between pericapsular nerve group (PENG) block with lateral femoral cutaneous nerve block and supra-inguinal fascia iliaca compartment block (S-FICB) for total Hip arthroplasty: a randomized controlled trial. *J Anesth*. 2023;37(4):503–510. doi:10.1007/s00540-023-03192-6
28. Bech NH, Hulst AH, Spuijbroek JA, van Leuken LL, Haverkamp D. Perioperative pain management in Hip arthroscopy; what options are there? *J Hip Preserv Surg*. 2016;3(3):181–189. doi:10.1093/jhps/hnw015
29. Bailey TL, Stephens AR, Adeyemi TF, et al. Traction time, force and postoperative nerve block significantly influence the development and duration of neuropathy following hip arthroscopy. *Arthroscopy*. 2019;35(10):2825–2831. doi:10.1016/j.arthro.2019.03.062
30. Amato PE, Coleman JR, Dobrzanski TP, et al. Pericapsular nerve group (PENG) block for Hip arthroscopy: a randomized, double-blinded, placebo-controlled trial. *Reg Anesth Pain Med*. 2022;47(12):728–732. doi:10.1136/rapm-2022-103907
31. Kim JY, Kim J, Kim DH, et al. Anatomical and radiological assessments of injectate spread stratified by the volume of the pericapsular nerve group block. *Anesthesia Analg*. 2023;136(3):597–604. doi:10.1213/ANE.0000000000006364
32. Vermeylen K, Desmet M, Leunen I, et al. Supra-inguinal injection for fascia iliaca compartment block results in more consistent spread towards the lumbar plexus than an infra-inguinal injection: a volunteer study. *Reg Anesth Pain Med*. 2019;44(4):483–491.
33. Copay AG, Subach BR, Glassman SD, Polly DW, Schuler TC. Understanding the minimum clinically important difference: a review of concepts and methods. *Spine J*. 2007;7(5):541–546. doi:10.1016/j.spinee.2007.01.008
34. Myles PS, Myles DB, Galagher W, Chew C, MacDonald N, Dennis A. Minimal clinically important difference for three quality of recovery scales. *Anesthesiology*. 2016;125(1):39–45. doi:10.1097/ALN.0000000000001158