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ORIGINAL RESEARCH

A comparative study of the analgesic effect of pericapsular nerve group block and iliofascial gap block in proximal femoral nail antrotation in elderly patients

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Abstract

Analgesic effects of the above two block modalities in this procedure are still unclear. This study aimed to compare the analgesic efficacy of pericapsular nerve group block (PENG) and Fascial iliaca compartment block (FICB) in proximal femoral nailing anti-rotation in elderly patients. This study retrospectively analyzed the clinical data of 80 elderly patients who underwent anti-rotational proximal femoral nailing after trochanteric fracture from May 2023 to March 2024. The researchers were divided into two groups: PENG group and FICB group with 40 cases in each group. Changes in relevant indexes before nerve block (T0), 10 min after block (T1), 20 min after block (T2), at the time of over-bed placement (T3), 24 h after surgery (T4), and 48 h after surgery (T5) were recorded and compared between both groups. The visual analog scale (VAS) scores of T3 and T4 in the PENG group were 4 (3, 5) and 3 (2, 3), respectively, which were significantly lower than those of 5 (4, 6) and 3 (3, 4) in the FICB group ($p < 0.05$). Mean arterial pressure (MAP) and heart rhythm (HR) at T3 in the PENG group were significantly lower than in the FICB group ($p < 0.05$). The cumulative intraoperative and postoperative remifentanil dosage in the PENG group (443.58 $\pm$ 78.88 μg) was less than the FICB group (487.43 $\pm$ 79.72 μg) ($t = 2.473$, $p = 0.016$). PENG group had significantly higher Lovett muscle strength scores at T4 and T5 ($p < 0.05$). Postoperative complications incidence did not differ significantly between both groups ($p > 0.05$). Analgesic effect of PENG block on anti-rotation of the proximal femoral nail is superior to that of FICB in elderly patients. There was less opioid accrual before and after the procedure, less impact on lower extremity muscle strength, and no significant adverse effects.

Keywords

Pericapsular nerve group block; Fascia iliaca compartment block; Proximal femoral nail anti-rotation; Analgesic effect

1. Introduction

A proximal femoral nail anti-rotation is widely used to stabilize elderly patients with proximal femoral fractures because it is effective and stable at the fracture site by a small incision and the use of an intramedullary nail into the femoral marrow cavity and fixing the distal end of the fracture with a proximal locking nail [1]. This procedure, however, is commonly accompanied by moderate to severe pain in the perioperative period, which makes it difficult for patients to cooperate during surgery and to recover afterward [2]. To reduce patients' intraoperative pain and promote postoperative recovery, a scientific and reasonable nerve block protocol is crucial. Currently, fascia iliaca compartment block (FICB) is widely used in clinical practice for analgesia in lower extremity surgery, and it can provide analgesia in the surgical area to a certain extent. However, FICB has some limitations, including that the block range may not be precise enough and the analgesia around the hip joint is incomplete, which may result in more obvious pain for some patients during surgery [3]. Periarticular capsule nerve block (PENG) is a new regional analgesic technique that blocks the nerves around the hip joint with relative precision, theoretically providing improved analgesia, effective perioperative analgesia for patients, and favorable postoperative recovery [4]. It is still necessary to further verify aspects such as the specific effects and safety of both techniques in clinical applications. This study aims to investigate the analgesic effect of PENG and FICB on proximal femoral nail anti-rotation in elderly patients. With this study, a basis for intraoperative analgesia in patients with femoral fractures should be established.

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2. Materials and methods

2.1 Patients

We retrospectively analyzed the clinical data of elderly patients who underwent anti-rotational proximal femoral nailing after trochanteric fracture between May 2023 and March 2024 at our institution. Inclusion criteria: (1) Patients meet surgery indications; (2) The American Society of Anesthesiologists (ASA) classification [5] was grade II–III; (3) Age >60 years. Exclusion criteria: (1) Mental disorders and abnormal coagulation function; (2) Allergies to anesthesia drugs; (3) Combined malignant tumors; (4) Motor sensory dysfunction of the lower limbs immediately before fractures; (5) Infection at the puncture site; and (6) Insufficiency of the heart, liver, kidneys and other important organs.

Ninety-four patients were screened for eligibility, and 80 patients were enrolled in this study (Fig. 1). Among them, there were 40 cases in the hip capsule peripheral nerve block group (PENG group) and 40 cases in the iliofascial gap block group (FICB group). Ethics approval was obtained from the hospital ethics committee, and all participants and their families gave informed consent to participate in the study.

2.2 Methods

Before surgery, patients were fasted and abstained from food and drink, and intravenous access was opened after admission to the room. The mean arterial pressure (MAP), heart rhythm (HR), blood oxygen saturation (SpO_2), and electroencephalographic dual frequency index (BIS) were routinely measured. Skin around the affected hip joint was exposed.

Experimental protocols were registered before the operation. (1) PENG group: Patients were positioned supine. After disinfecting the skin, a high-frequency ultrasound probe (6–13 MHz) was used to locate the anterior inferior iliac spine in the transverse plane, and then rotated counterclockwise by 45° to align with the pubic branch parallel to the superior inguinal ligament, identifying the anterior inferior iliac spine, ilio-pubic augmentation and iliopsoas tendon. A 100 mm 19G nerve block puncture needle was inserted using an in-plane technique after local anesthesia infiltration at the puncture point. After the tip of the needle penetrated the myofascial space between the anterior part of the psoas tendon and the posterior part of the pubic symphysis branch, saline was experimentally injected after retracting to confirm the absence of blood and gas. Floating the iliopsoas tendon was followed by placing a catheter under the tendon through the puncture needle, 3~5 cm anterior to the needle, and administering 20 mL of 0.33% ropivacaine was injected through the catheter. While injecting the drug, observe whether the drug spreads anteriorly under the iliopsoas tendon. If not, adjust the catheter's position. After drug injection, the catheter was properly fixed. (2) FICB group: Patients were positioned supine. Following disinfection, insert

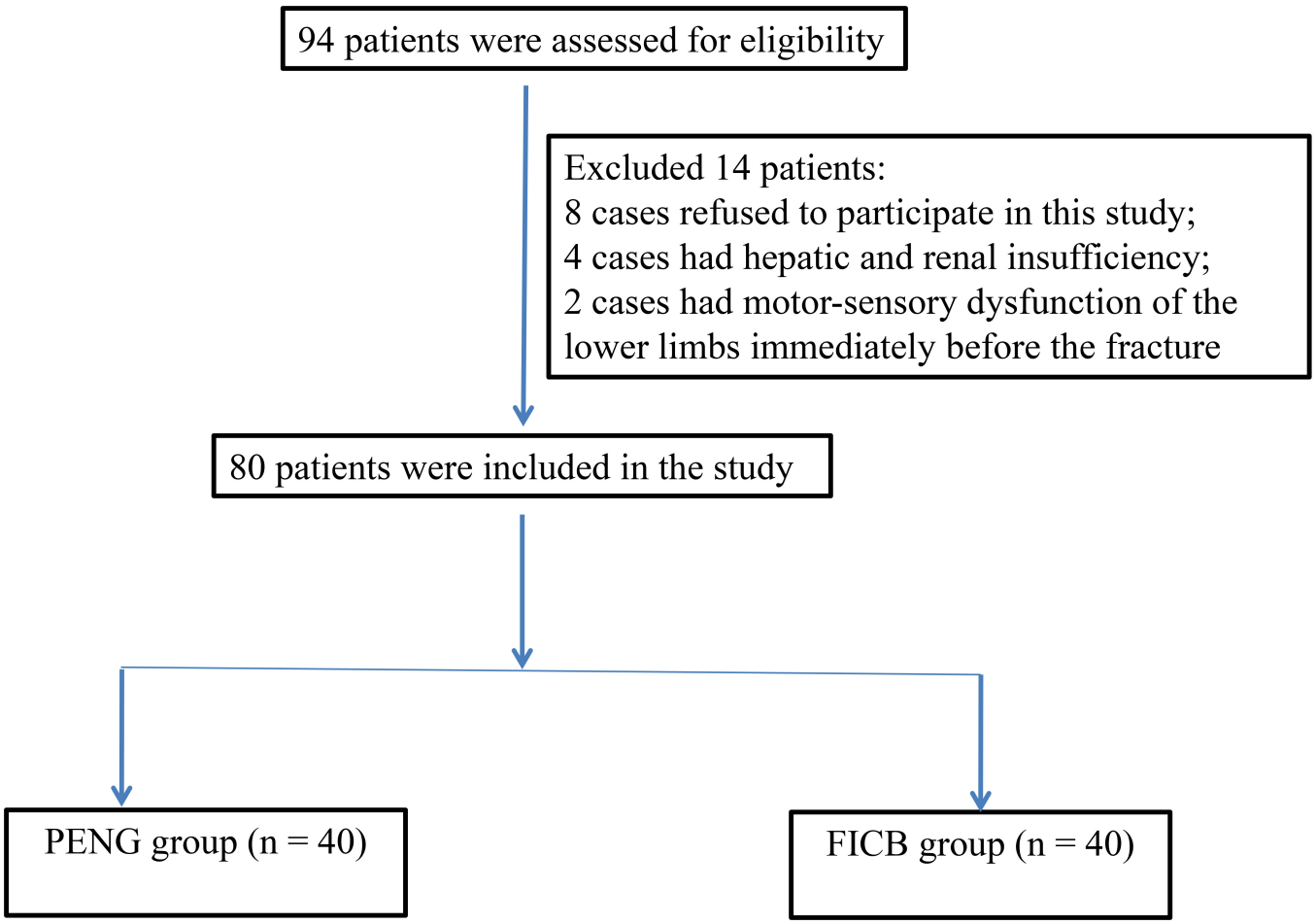

FIGURE 1. The diagram flow of the trial. PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block.

1 transverse finger inside the anterior superior iliac spine, parallel to the physiological long axis. Using a high-frequency ultrasound probe (6–13 MHz), the anterior inferior iliac spine, iliacus muscle, and iliac fascia were identified. A 100 mm 19G nerve block puncture needle was inserted using an in-plane technique after local anesthesia infiltration at the puncture point. Saline was injected experimentally after the needle tip reached the fascial space and withdrawn to confirm the absence of blood and gas. After the fascial space was widened, 30 mL of 0.33% ropivacaine was injected, and the catheter was placed 5–10 cm in front of the needle and properly fixed.

Anesthesia induction was performed 20 min after the nerve block was completed: Intravenous midazolam (Jiangsu Enhua Pharmaceutical; State Drug License H19990027; specification: 1 mL:5 mg, Xuzhou, Jiangsu, China) 0.05 mg/kg, remifentanil (Jiangsu Enhua Pharmaceutical; State Drug License H20143315; specification 2 mg, Xuzhou, Jiangsu, China) 1 μg/kg, propofol (Guangdong Jiabo Pharmaceutical; State Drug License H20051843; specification: 10 mL:100 mg, Qingyuan, Guangdon, China) 92.0 mg/kg and cis-atracurium (Jiangsu Hengrui Pharmaceuticals; State Pharmaceutical License H20183042; specification: 5 mL:10 mg, Lianyungang, Jiangsu, China) 0.3 mg/kg. After inotropic relaxation onset, mechanical ventilation was performed. The tidal volume was set at 6–10 mL/kg, respiratory rate at 10–15 breaths/min, and inspiratory/expiratory ratio of 1:2, maintenance of an end-tidal carbon dioxide ($PETCO_2$) of 230~40 mmHg (1 mmHg = 0.133 kPa), inhaled oxygen concentration 40%~60%, and oxygen flow 1.0~1.5 L/min.

Anesthesia maintenance: Propofol 2–5 mg/(kg.h), remifentanil 0.25 μg/(kg.h), and cis-atracurium 0.1 mg/(kg.h) were injected by an intravenous pump. Intraoperatively, the anesthetic dose was regulated according to the BIS value, and the BIS value was maintained at 40~60.

Anesthesia maintenance drugs were discontinued at the end of the operation, and all patients were given intravenous self-controlled analgesia after the operation. Injection of remifentanil 100 μg + oxycodone hydrochloride (Beijing Huasu Pharmaceuticals; State Drug Permit H20213987; specification 1 mL:10 mg, Beijing, China) 30 mg dissolved in 100 mL saline, background dose 2 mL/h, single dose 2 mL, locking time 15 min. Both groups of patients were anesthetized and had nerve blocks performed by the same group of physicians.

2.3 Observation indicators

(1) A visual analog scale [6] (VAS) was used to assess their pain before nerve block (T0), 10 min after block (T1), 20 min after block (T2), when crossing the bed and placing the body in position (T3), 24 h after operation (T4), and 48 h after operation (T5). (2) Record patients' MAP, HR and SpO_2 at T0~T3, and compare hemodynamic changes between both groups. (3) Record the cumulative dosage of remifentanil in patients after surgery and postoperatively. (4) Lovett muscle strength grading standard scale [7] was used to assess lower limb muscle strength of patients at T4 and T5 after surgery. No visible or palpable muscle contraction was scored as "0"; slight contraction but not able to cause joint movement was scored as "1"; being able to do full range of joint movement under weight loss was scored as "2"; being able to do full range of joint movement against gravity but not resistance was scored as "3"; being able to do full range of joint movement against gravity and resistance was scored as "4"; being able to do full range of joint movement against gravity and resistance was scored as "4"; and being able to do joint movement against gravity and resistance was scored as "4"; and being able to do joint movement against gravity and resistance was scored as "4". The ability to perform full range of motion against gravity but not against resistance was scored as 3 points; the ability to perform full range of motion against gravity and some resistance was scored as 4 points; the ability to perform full range of motion against gravity and resistance was scored as 5 points.

2.4 Statistical analyses

Data analysis was performed using SPSS 26.0 (IBM Corp., SPSS Statistics, Armonk, NY, USA). Count data were presented as examples and compared using the χ^2 test. All measures were assessed for normality using the Shapiro-Wilk test. Continuous variables were presented as mean $\pm$ standard deviation and compared using Students' *t*-test. When it differed from normal distribution, it was classified as M (Q1, Q3) and subjected to Mann-Whitney U test. Repeated-measures data were compared using repeated-measures one-way analysis of variance (ANOVA) and least significant difference (LSD)-*t* test. $p < 0.05$ indicates statistically significant differences. Multiple comparisons were not corrected in this study. It focuses primarily on the comparison of analgesic effect of two blocking modalities in intramedullary nailing internal fixation of the proximal femur in elderly patients, and it has an established purpose. Analyzing data involves some comparisons of multiple time points or indicators, but these comparisons are centered around the main research question and have strong internal logical connections. In addition, the study sample size is relatively small, so when multiple comparisons are corrected, some originally statistically significant results may become insignificant, affecting the reliability and validity of the study's conclusions.

3. Results

3.1 Comparison of general data of patients in the PENG and FICB groups

Comparing general data between both groups revealed no statistically significant difference ($p > 0.05$, Table 1).

3.2 Comparison of VAS scores at different time points before and after nerve block in both groups

The VAS scores of T0, T2 and T5 did not differ significantly between both groups ($p > 0.05$), but the VAS scores of T3, and T4 were lower in the PENG group ($p < 0.05$, Fig. 2).

TABLE 1. Comparison of general data of patients in the PENG and FICB groups.

Group	PENG group (n = 40)	FICB group (n = 40)	t/χ^2	p
Male/Female (cases)	16/24	19/21	0.457	0.499
Age (yr)	72 ± 6.21	74 ± 7.70	0.882	0.380
BMI (kg/m^2)	23.65 ± 1.34	23.14 ± 1.65	1.556	0.124
Hypertension	14	11	0.524	0.469
Diabetes	10	12	0.251	0.617
ASA grade II/III (cases)	27/13	31/9	1.003	0.317
Surgical time (min)	104.23 ± 14.19	109.20 ± 11.66	1.713	0.091
Past medical history				
Cardiovascular disease	13	15	0.220	0.639
Bone-related diseases	10	9	0.069	0.793
Current medications				
Antiplatelet agents	12	13	0.058	0.809
Antihypertensives	14	11	0.524	0.469
Oral hypoglycemic agents	7	11	1.147	0.284
Insulin	3	1	0.263	0.608

PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block; BMI: body mass index; ASA: American Society of Anesthesiologists.

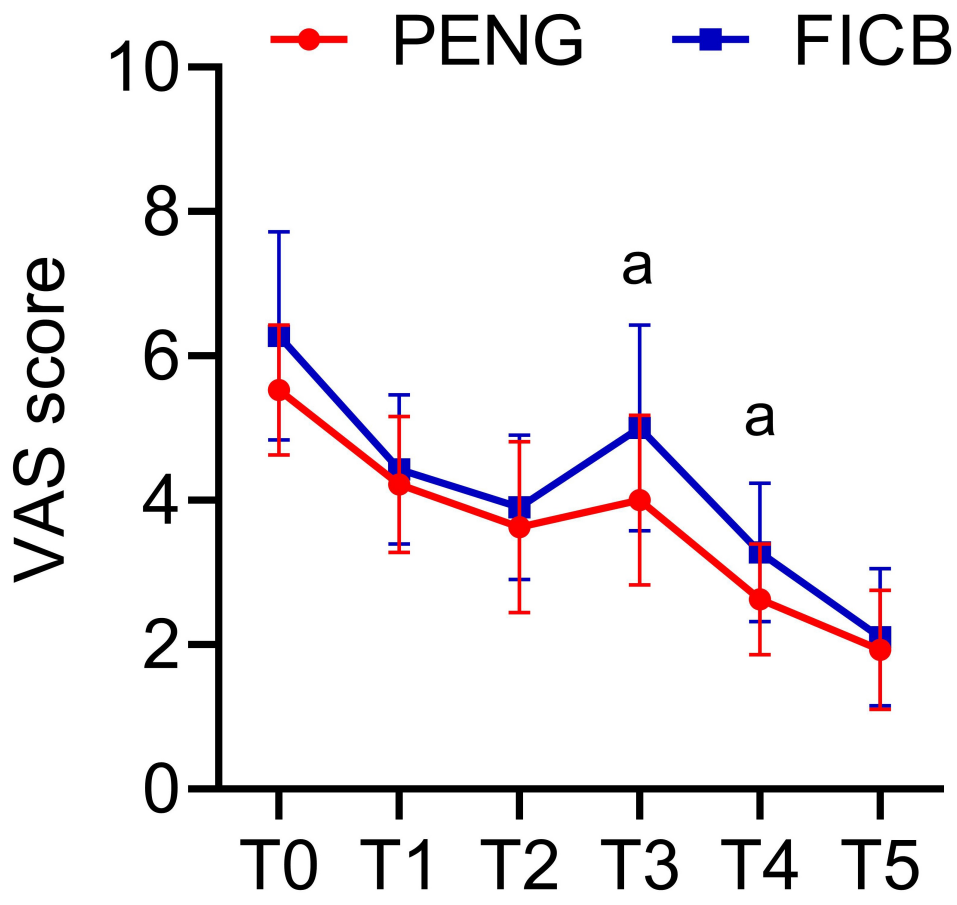

FIGURE 2. Comparison of VAS scores at different time points before and after nerve block. Compared with the PENG group, $^a p < 0.05$. PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block; VAS: visual analog scale.

3.3 Comparison of MAP, HR and SpO_2 at different time points before and after nerve block in both groups

A statistically significant difference was not found between the two groups for MAP, HR and SpO_2 between both groups at T0, T1 and T2 ($p > 0.05$). At T3, patients in the PENG group had lower MAP and HR than those in the FICB group ($t_{MAP} = 2.815$, $p = 0.006$; $t_{HR} = 4.997$, $p = 0.001$, Fig. 3).

3.4 Comparison of intraoperative and postoperative opioid use between both groups

The cumulative intraoperative and postoperative remifentanil use was significantly lower in the PENG group compared to the FICB group ($t = 2.473$, $p = 0.016$, Fig. 4).

3.5 Comparison of postoperative Lovett muscle strength scores between both groups

The PENG group scored higher on Lovett muscle strength at T4 and T5 than the FICB group ($p < 0.05$, Fig. 5).

3.6 Comparison of postoperative anesthesia-related complications between both groups

The PENG group experienced 3 anesthesia-related complications after surgery, while the FICB group experienced 5, but the difference was not statistically significant ($p > 0.05$, Table 2). Both groups did not experience any severe adverse reactions such as respiratory depression and hypotension after surgery.

4. Discussion

Increasing aging rates and a growing elderly population are both influencing the incidence of femoral fractures [8]. Currently, proximal femoral nail anti-rotation it the preferred surgical method for elderly patients with femoral fractures due to its stable effect and few postoperative complications. In addition to reducing surgical trauma and intraoperative bleeding, proximal femoral nail anti-rotation promotes fracture healing and protects periprosthetic blood flow [9, 10]. Due to the fact that it requires special positioning, proximal femoral nail anti-rotation is prone to severe pain during movement, not only affecting elderly patients' postoperative cooperation, but also increasing their risk of cardiovascular complications [11]. Therefore, the choice of a reasonable and safe nerve block is crucial to ensure the analgesic effect of surgery and promote the rapid recovery of elderly patients after surgery in proximal femoral nail anti-rotation.

Falling and proximal femur fractures are common among elderly patients with osteoporosis and decreased balance, which not only cause severe pain to patients but can endanger their lives as well [12]. There is no escaping the fact that pain management is an integral part of surgical treatment, and PENG and FICB have both shown good analgesic effects in clinical applications [13, 14]. To provide a more reasonable analgesic program for the clinic, this study compares the analgesic effects of these two techniques in proximal femoral nail anti-rotation in elderly patients. In this study, the PENG group had lower VAS scores for T3 and T4, and lower cumulative remifentanil dose than the FICB group, suggesting the PENG block may be more effective in analgesia and patients are less likely to consume opioids postoperatively. FICB is the injection of local anesthetic into the iliac fascia subglottic space, which is rich in sensory nerve endings and is an important channel for pain signaling in the anterolateral region of the hip and thigh, and achieves regional analgesic effects by blocking the conduction of the relevant nerves [15]. PENG block has a direct analgesic effect by effectively reducing the direct pain of the surgical incision as well as reducing the pain reflection caused by the pulling and stimulation of surrounding tissues during surgery [16]. PENG block can also significantly relieve patients' pain in the early postoperative period by blocking pain signaling and reducing pain sensitivity of the central nervous system [17]. Similarly, this study confirms the advan-

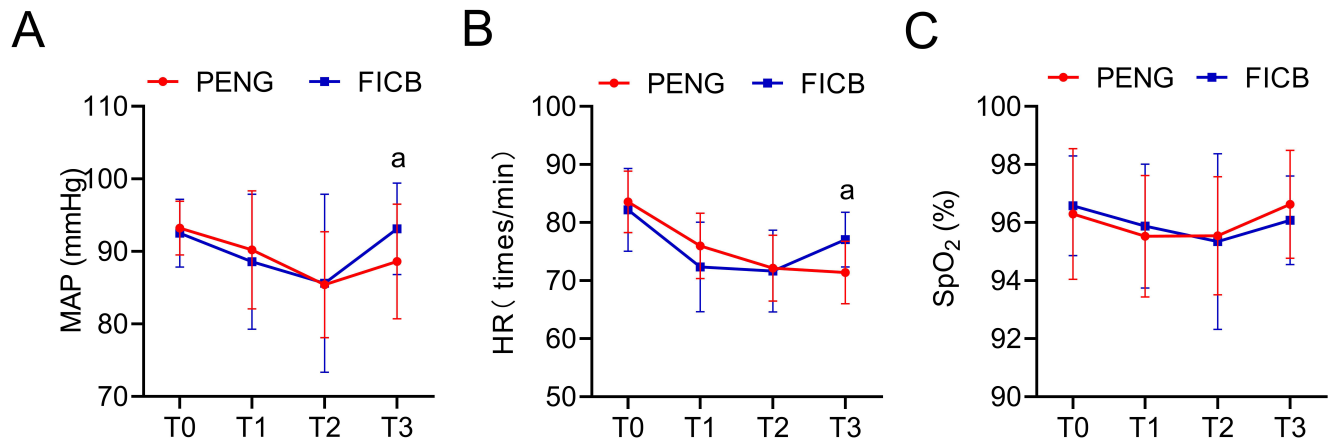

FIGURE 3. Comparison of hemodynamics. (A) MAP. (B) HR. (C) SpO_2. Compared with the PENG group, $^a p < 0.05$. PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block; MAP: Mean arterial pressure; HR: heart rhythm; SpO_2: blood oxygen saturation.

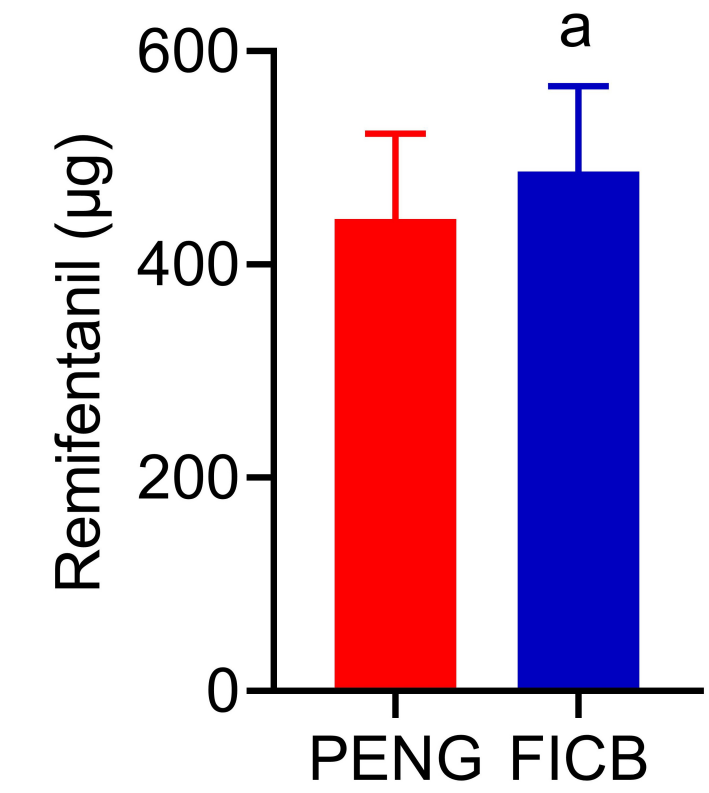

FIGURE 4. Comparison of opioid use. Compared with the PENG group, $^{a}p < 0.05$. PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block.

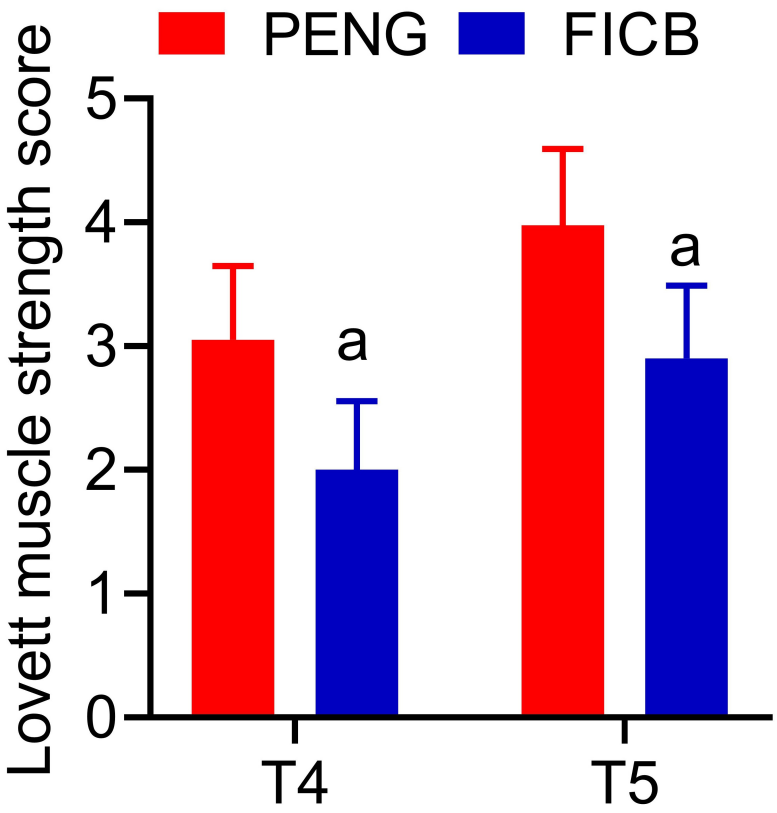

FIGURE 5. Comparison of Lovett muscle strength scores after surgery. Compared with the PENG group, $^{a}p < 0.05$. PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block.

TABLE 2. Comparison of postoperative anesthesia-related complications between both groups.

Group	PENG group (n = 40)	FICB group (n = 40)	χ^2	p
Nausea and vomiting	2 (5.00)	4 (10.00)	0.180	0.671
Hematoma at puncture site	1 (2.50)	1 (2.50)	0.513	0.474
Respiratory depression	0 (0.00)	0 (0.00)	-	-
Overall complication rate	3 (7.50)	5 (12.50)	0.139	0.709

PENG: Periarticular capsule nerve block; FICB: Fascial iliaca compartment block.

tages of PENG in proximal femoral surgery in elderly patients. PENG blockade has been shown to block femoral, obturator and para-obturator nerve branches innervating the anterior hip capsule in previous studies. A number of hip-related surgeries, including bone fractures and hip replacements, have been shown to relieve pain effectively when PENG blockade is used [18]. Pascarella *et al.* [19] found that PENG block significantly improved analgesia after total hip arthroplasty, reducing patients' pain scores and opioid consumption within 48 h after surgery. According to this study, the PENG block had superior analgesic effects during certain specific time periods, which clearly shows the superiority of the PENG block during this time period. A possible reason for this is that the present study used more intensive evaluation time points and different sample characteristics than previous studies. This study also demonstrated that the PENG group had lower MAP and HR at T3 and higher Lovett muscle strength scores at T4 and T5 than the FICB group, suggesting that the PENG block is more conducive to hemodynamic stabilization of the patients as well as the promotion of postoperative recovery of lower limb muscle strength of the patients. Perioperative hemodynamic status is directly correlated with surgical safety and recovery quality [20]. When changing positions during surgery, due to pain stimulation, patients will experience changes such as increased heart rate and elevated blood pressure, causing hemodynamic fluctuations. PENG reduces pain-induced stress by blocking nerve conduction in the surgical area, which maintains hemodynamic stability [21]. Lovett muscle strength score is a simple and practical method of muscle strength assessment, which evaluates the force and range of muscle contraction through the patient's active movement. An important indicator of treatment success in elderly patients with proximal femur fractures is the recovery of postoperative muscle strength [22]. As a classical method of lower limb nerve block, FICB primarily blocks the conduction of the femoral nerve to reduce lower limb pain, which is often accompanied by the impact on muscle strength of the lower limbs, which restricts the patient's early mobility [23]. Duan *et al.* [24] reported that among patients who underwent total hip arthroplasty during the same period, the PENG group demonstrated stronger quadriceps strength on the affected side postoperatively compared with the FICB group, and the patients had earlier postoperative mobility. Likewise, this study indicated that PENG block had less effect on lower limb muscle strength, which was favorable to postoperative muscle strength recovery. Neither group experienced serious adverse reactions, such as respiratory depression or hypotension, and there was no significant difference in the incidence of postoperative nausea and vomiting, indicating a favorable clinical safety profile for FICB and PENG.

A few limitations remain in this study. There may be some bias in the results of this study due to the relatively small number of cases selected. This study focused mainly on analgesic effects during the operation and in the short term after the operation, without long-term follow-up data. It was not possible to evaluate some long-term complications, such as chronic pain and long-term joint function recovery. Towards a comprehensive evaluation of the analgesic effects of intramedullary nailing internal fixation of the proximal femur in elderly patients, it will be necessary to expand the sample size and extend the observation period, as well as to consider more possible influencing factors.

5. Conclusions

In conclusion, PENG provided better analgesia in for elderly patients undergoing proximal femoral nail anti-rotation than FICB and demonstrated superior intraoperative hemodynamic stability, opioid use and postoperative muscle strength scores.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

THC—designed the study and carried them out; prepared the manuscript for publication and reviewed the draft of the manuscript. DSX and YFW—supervised the data collection. MHL and XFC—analyzed the data. OJ—interpreted the data. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of the Affiliated Hospital of Beihua University (Approval no. 20240013). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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