Article

Effects of Different Ultrasound-Guided Nerve Block Modalities on Inflammatory Stress Response in Elderly Patients after Total Hip Arthroplasty

Ann. Ital. Chir., 2024 95, 5: 879–885
https://doi.org/10.62713/aic.3526

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AIM: This study aimed to evaluate the impact of different ultrasound-guided nerve blocks on the postoperative inflammatory and stress response in elderly patients undergoing total hip arthroplasty (THA), providing a theoretical foundation for clinical application.
METHODS: Elderly patients with THA who received ultrasound-guided nerve block combined with general anesthesia from June 2021 to June 2022 in the hospital were selected as a retrospective cohort study. Patients were divided into two groups based on the type of nerve block used. The observation group (n = 60) received ultrasound-guided pericapsular nerve group (PENG) block combined with femoral nerve block (FNB), while the control group (n = 60) received ultrasound-guided PENG block. The cortisol (Cor), tumor necrosis factor-α (TNF-α), interleukin-6 (IL-6), visual analogue scale (VAS) scores, and pain medication consumption in both groups were compared.
RESULTS: The observation group demonstrated significantly lower serum levels of Cor, TNF-α, and IL-6 at postoperative 1 day, 3 days and 7 days, as well as lower soluble protein-100β (S100β) levels at postoperative 1 day compared to the control group ($p < 0.001$). The VAS score in the observation group was significantly lower than that in the control group at postoperative 1 day, 3 days and 7 days ($p <$ 0.001), with no significant difference in preoperative VAS score between the two groups ($p >$ 0.05). Additionally, opioid consumption in the observation group was significantly lower than that in the control group at postoperative 48 h ($p < 0.001$).
CONCLUSIONS: The combination of ultrasound-guided PENG block and FNB effectively reduces postoperative pain and the inflammatory response in elderly patients undergoing THA, facilitating early recovery.

Keywords: hip capsule peripheral nerve block; femoral nerve block; geriatric hip arthroplasty; cognitive function; stress response; inflammatory response

Introduction

Total hip arthroplasty (THA) is a widely performed orthopedic procedure aimed at alleviating intractable pain and functional limitations associated with end-stage arthritis, especially osteoarthritis (OA) [1]. It significantly reduces pain and disability, improving the quality of life for millions of patients. THA provides effective analgesia with minimal side effects, enhancing early postoperative mobility, optimizing functional outcomes, and reducing the incidence of postoperative complications [2]. Despite its frequency, there is considerable variability in perioperative anesthesia and analgesia management across different clinical settings [3].

A key challenge in THA is the management of moderate-to-severe postoperative pain, which, if inadequately controlled, can hinder early postoperative healing, impair functional recovery, and increase the risk of postoperative complications, especially in elderly patients [4]. Current analgesic approaches for THA include systemic analgesics, intra-articular injections, intrathecal analgesics, and various peripheral nerve blocks. Several different types of peripheral nerve blocks have been used in THA in the clinic, such as femoral nerve block (FNB) and pericapsular nerve group (PENG) block.

In 2020, Mysore *et al.* [5] introduced PENG block, targeting the hip capsule branches of the femoral, obturator, and parafemoral nerves. The PENG block effectively alleviates hip fracture pain and provides robust postoperative analgesia in THA, while preserving quadriceps strength [6]. However, there is a lack in clinical research examining the combined use of PENG block and FNB under general anesthesia for THA. This retrospective study was initiated to investigate the effects of these two ultrasound-guided nerve blocks combined with general anesthesia on the inflammatory stress response in elderly patients undergoing THA.

Submitted: 24 June 2024 Revised: 23 August 2024 Accepted: 28 August 2024 Published: 20 October 2024
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Table 1. Comparison of clinical characteristics and surgery-related indices between the two groups [M (P25, P75), n (%)].

Characteristic		Control group (n = 60)	Observation group (n = 60)	χ^2/Z	p-value
Age (years)		65.00 (63.00, 68.00)	67.00 (64.00, 69.75)	–1.312	0.190
Sex	Male	39 (65.00)	45 (75.00)	1.429	0.232
	Female	21 (35.00)	15 (25.00)		
Weight (kg)		59.09 (54.91, 62.24)	57.73 (53.90, 62.96)	–0.527	0.598
ASA classification	I	28 (46.67)	25 (41.67)	0.348	0.840
	II	20 (33.33)	21 (35.00)		
	III	12 (20.00)	14 (23.33)		
Type of occupation	Physical labor	34 (56.67)	33 (55.00)	0.034	0.854
	Mental labor	26 (43.33)	27 (45.00)		
Methods of payment for medical expenses	Employee medical insurance	36 (60.00)	30 (50.00)	6.585	0.037
	Resident medical insurance	13 (21.67)	25 (41.67)		
	(Be) at one's own expense	11 (18.33)	5 (8.33)		
Educational level	High school and below	45 (75.00)	46 (76.67)	0.045	0.831
	High school and above	15 (25.00)	14 (23.33)		
Marital status	Married	55 (91.67)	54 (90.00)	0.100	0.752
	Unmarried	5 (8.33)	6 (10.00)		
Economic situation	$>$705 USD	40 (66.67)	38 (63.33)	0.147	0.702
	$\leq$705 USD	20 (33.33)	22 (36.67)		
Diagnosis	Osteoarthritis	21 (35.00)	20 (33.33)	1.582	0.454
	Femoral necrosis	23 (38.33)	18 (30.00)		
	Hip dysplasia	16 (26.67)	22 (36.67)		
Surgical site	Left side	39 (65.00)	37 (61.67)	0.144	0.705
	Right side	21 (35.00)	23 (38.33)		
Surgical time (min)		176.80 (158.33, 200.53)	179.10 (155.05, 202.35)	–0.118	0.906
Intraoperative bleeding (mL)		432.15 (409.65, 456.45)	456.87 (435.10, 468.30)	–0.312	0.755
Intraoperative urine output (mL)		475.20 (456.73, 496.00)	472.65 (459.08, 489.98)	–0.236	0.813

ASA, American Society of Anesthesiologists.
1 USD = 7.09 CNY.

Materials and Methods

Study Subjects

A retrospective cohort study was conducted on elderly patients with THA who underwent ultrasound-guided nerve block combined with general anesthesia from June 2021 to June 2022 at the hospital. The study complied with the principles of the Declaration of Helsinki (2013) [7] and was approved by the Medical Ethics Committee of Hebei Province Cangzhou Hospital of Integrated Traditional and Western Medicine (Approval No.: CZX2024-KY-038.1). Patient records were collected and organized through the electronic medical records systems with the informed consent of all participants. All personal information was securely and confidentially stored during data analysis.

Inclusion Criteria

Patients were included in the study based on the following criteria: (1) Age 60–75 years; (2) Classification of I–III by the American Society of Anesthesiologists (ASA) [8]; (3) Absence of contraindications to anesthesia; (4) Availability of complete clinical data; (5) Informed consent was obtained after patients were made aware of the purpose for the study.

Exclusion Criteria

Exclusion criteria included: (1) Severe cardiovascular, respiratory, and other systemic diseases; (2) History of allergy to local anesthetics; (3) Infection at the proposed puncture site; (4) Femoral nerve injury; (5) History of mental illness.

Study Grouping

A total of 127 elderly patients undergoing THA were selected and grouped based on the ultrasound-guided nerve block technique. The control group consisted of 60 patients who received ultrasound-guided PENG block after excluding two patients: one over 75 years old and one with heart failure. The observation group included 60 patients who received a combination of ultrasound-guided PENG and FNB after excluding five patients: two over 75 years old, two with infections at the puncture site, and one with femoral nerve injury.

Anesthesia Methods

All patients were instructed to fast and abstain from drinking before surgery. Upon admission, standard monitoring was initiated, including non-invasive blood pressure (NIBP), heart rate (HR), electrocardiogram (ECG), percuta-

Table 2. Comparison of inflammatory stress markers between the two groups [M (P25, P75)].

Marker	Timing	Control group (n = 60)	Observation group (n = 60)
Cor (nmol/L)	1 day preoperative	249.31 (239.01, 262.30)	254.77 (242.53, 263.81)
	1 day postoperative	409.15 (398.06, 423.12)	371.10 (364.97, 374.64)
	3 days postoperative	356.82 (351.58, 369.59)	341.73 (333.93, 350.63)
	7 days postoperative	337.95 (333.55, 342.03)	300.25 (296.10, 306.62)
TNF-α (μg/L)	1 day preoperative	5.00 (4.39, 5.48)	4.98 (4.44, 5.45)
	1 day postoperative	12.20 (11.80, 12.77)	10.59 (10.05, 11.13)
	3 days postoperative	10.59 (9.83, 11.28)	8.85 (8.50, 9.50)
	7 days postoperative	8.48 (8.25, 8.73)	6.97 (6.74, 7.66)
IL-6 (ng/L)	1 day preoperative	26.38 (24.43, 28.00)	27.26 (24.86, 28.99)
	1 day postoperative	52.04 (44.75, 58.58)	38.24 (31.88,43.49)
	3 days postoperative	74.15 (70.52, 76.94)	65.15 (59.09, 70.25)
	7 days postoperative	65.68 (60.64, 69.59)	41.10 (36.09, 44.91)

Cor, cortisol; TNF-α, tumor necrosis factor-α; IL-6, interleukin-6.

Table 3. Analysis of simple effect for Cor, TNF-α, and IL-6 levels.

Indicator	Simple effect between groups	OR	95% Wald CI (lower)	95% Wald CI (upper)	p-value
Cor (nmol/L)	Time (1 day preoperative) × group	1.495	0.189	8.189	0.225
	Time (1 day postoperative) × group	2.075	3.295	11.257	<0.001
	Time (3 days postoperative) × group	1.148	2.084	10.255	<0.001
	Time (7 days postoperative) × group	1.190	4.058	9.014	<0.001
TNF-α (μg/L)	Time (1 day preoperative) × group	2.135	2.514	14.248	0.794
	Time (1 day postoperative) × group	1.257	4.210	15.774	<0.001
	Time (3 days postoperative) × group	2.054	1.042	8.532	<0.001
	Time (7 days postoperative) × group	3.329	2.541	10.255	<0.001
IL-6 (ng/L)	Time (1 day preoperative) × group	2.821	2.398	9.132	0.102
	Time (1 day postoperative) × group	2.035	3.585	12.047	<0.001
	Time (3 days postoperative) × group	3.375	4.043	10.312	<0.001
	Time (7 days postoperative) × group	2.821	3.885	9.604	<0.001

OR, odds ratio; CI, confidence interval.

Table 4. S100β levels between the two groups [M (P25, P75), μg/L]

Group	n	1 day preoperative	1 day postoperative
Control group	60	0.12 (0.10, 0.13)	0.19 (0.17, 0.20)$^{\#}$
Observation group	60	0.11 (0.09, 0.13)	0.15 (0.14, 0.16)$^{\#}$
Z-score	-	–1.036	–7.112
p-value	-	0.300	< 0.001

Note: Comparison with preoperative within the same group; $^{\#}p < 0.05$. S100β, soluble protein-100β.

neous arterial oxygen saturation (SpO_2), and end-tidal carbon dioxide partial pressure ($PETCO_2$). An intravenous line was also established in the upper extremity.

In the control group, a PENG block was administered before the induction of general anesthesia. After routine sterilization, a 2–5 MHz ultrasound probe was positioned parallel to the inguinal ligament, with a coupling agent applied to facilitate imaging. The probe was moved to identify key anatomical structures, including the iliopubic ramus, femoral artery, pubococcygeus muscle, and psoas major tendon. The needle was inserted using an in-plane technique, targeting the surface of the pubic bone and the lower edge of the lumbaris major tendon. A small amount of normal saline (H20183173; Harbin Sanlian Pharmaceutical Co. Ltd.; Harbin, China) was injected to confirm diffusion at the target site, followed by administration of 20 mL of 0.25% ropivacaine (H20113463; Hebei Yipin Pharmaceutical Co. Ltd.; Shijiazhuang, China).

In the observation group, patients received a combination of PENG and FNB. The PENG block was performed as described in the control group. The FNB patients were placed in a supine position with the affected limb slightly externally rotated. The puncture site was disinfected, and the area was draped. A sterile cover was applied to the ultrasound probe, positioned parallel to the inguinal ligament and perpendicular to the skin. The probe was gently moved to the inner 1/3 of the line between the anterior superior iliac spine and the pubic tubercle. Hypoechoic broad fascia and iliac fascia acoustic images are visualized on ultrasound, while hypoechoic pike or foveal femoral nerve acoustic images can be demonstrated on the lateral aspect of the femoral artery. Using in-plane needle insertion, the puncture needle was inserted into the skin from the lateral end of the probe, and the needle was slowly advanced from the outside to the inside until the tip of the needle passed through the broad fascia and the iliac fascia close to the femoral nerve. After confirming that no blood was aspirated, 20 mL of 0.25% ropivacaine was injected.

Both groups received general anesthesia following the nerve blocks. Anesthesia was induced with intravenous injections of sufentanil citrate (H20237156; Yichang Renfu Pharmaceutical Co. Ltd.; Yichang, China) at 0.3–0.5 µg/kg, etomidate (H32022379; Jiangsu Hengrui Pharmaceutical Co. Ltd.; Lianyungang, China) at 0.2–0.5 mg/kg, and rocuronium bromide (H20244041; Shandong New Era Pharmaceutical Co. Ltd.; Heze, China) at 0.2–0.5 mg/kg. Following induction of anesthesia, a laryngeal mask airway was inserted, and mechanical ventilation was initiated with the following settings: FiO_2 at 50%, tidal volume (VT) at 6–8 mL/kg, respiratory rate (RR) at 10–12 breaths/minute, and $PETCO_2$ maintained between 35–45 mmHg. Anesthesia was maintained with a continuous infusion of propofol (H20123318; Xi'an Libang Pharmaceutical Co. Ltd.; Xi'an, China) at 4–6 mg/(kg-h) and remifentanil (H20123422; China National Pharmaceutical Industry Co. Ltd.; Langfang, China) at 0.2–0.5 µg/(kg-min). Dosage adjustments were made based on the vital signs of the patient and anesthesia depth, aiming to keep the Nactrend value between 40–60. Cis-atracurium (H20223233; North China Pharmaceutical Co. Ltd.; Shijiazhuang, China) was administered intermittently to maintain muscle relaxation. Mean arterial pressure (MAP) fluctuations were controlled within $\pm$20% of the baseline. If MAP decreased by more than 20%, 0.1 mg/kg of pseudoephedrine (H11020545; Huarun Shuanghe Pharmaceutical Co. Ltd.; Beijing, China) was administered. If the heart rate fell below 60 beats/min, 0.01 mg/kg atropine (H20237122; Hubei Xinghua Pharmaceutical Co. Ltd.; Wuhan, China) was given.

Postoperatively, both groups received patient-controlled intravenous analgesia (PCIA) with a solution of sufentanil 1 µg/kg, butorphanol (H20243407; Easton Biopharmaceuticals; Chengdu, China) 4 mg, and saline diluted to 100 mL. PCIA settings were: continuous background infusion at 3 mL/h, an additional dose of 2 mL, and a lockout interval of 20 minutes. An additional dose was administered if the postoperative visual analogue scale (VAS) was $\geq$4. If the VAS remained $\geq$4 after 2 consecutive doses, 50 mg of Tramadol was given intravenously for additional pain relief.

Observation Indicators and Evaluation Criteria

Demographic information: A self-developed questionnaire was used to collect general demographic information, including gender, age, weight, type and duration of surgery, crystalloid infusion volume, diagnosis, surgical site, ASA grading, intraoperative bleeding, urine output, and volumes of intraoperative crystalloid and colloid administered in postoperative THA patients.

Inflammatory stress indicators: Inflammatory stress markers were measured by drawing 5 mL of venous blood on the day before surgery and on postoperative days 1, 3, and 7. Cortisol (Cor) levels were assessed using a fully automated chemiluminescence analyzer (J853261; Beckman Coulter, Inc.; Brea, CA; USA), while tumor necrosis factor-α (TNF-α) and interleukin-6 (IL-6) levels were measured via enzyme-linked immunosorbent assay (ELISA) kits (TNF-α: ZKH064; Shenzhen Ziker Biological Technology Co. Ltd.; Shenzhen, China; IL-6: YT-H17195; Tianjin Yueteng Biotechnology Co. Ltd.; Tianjin, China). The normal reference ranges were as follows: Cor (140–630 nmol/L at 8 a.m. and 80–410 nmol/L at 4 p.m.), TNF-α (4.3 $\pm$ 2.8 µg/L), and IL-6 (0.373–0.463 ng/L) [9].

Soluble protein-100β (S100β) measurement: Fasting venous blood samples were taken on the day before surgery and on postoperative day 1 to determine S100β levels using an ELISA kit (Human S100β assay kit; LBK-H03010; Jiangxi Lianbokebio Co. Ltd.; Nanchang, China). The normal reference range for S100β was 0.068–0.728 µg/L [10].

Visual analogue scale (VAS): Pain levels were assessed us-

Table 5. VAS scores between the two groups [M (P25, P75), scores].

Group	n	Preoperative	6 h postoperative	12 h postoperative	24 h postoperative	48 h postoperative
Control group	60	7.00 (5.00, 8.00)	3.00 (2.00, 4.00)	4.00 (3.00, 4.00)	4.00 (3.00, 5.00)	5.00 (4.00, 5.00)
Observation group	60	7.00 (6.00, 8.00)	2.00 (2.00, 3.00)	3.00 (2.00, 4.00)	3.00 (3.00, 4.00)	4.00 (3.00, 5.00)
Z-score	-	–0.890	–3.928	–3.970	–5.263	–4.482
p-value	-	0.373	<0.001	<0.001	<0.001	<0.001

VAS, visual analogue scale.

Table 6. Analysis of simple effect for VAS scores.

Simple effect between groups	OR	95% Wald CI (lower)	95% Wald CI (upper)	*p*-value
Time (preoperative) × group	3.058	5.014	12.337	0.316
Time (6 h postoperative) × group	7.284	8.473	15.826	<0.001
Time (12 h postoperative) × group	5.381	9.243	16.005	<0.001
Time (24 h postoperative) × group	3.522	6.542	10.924	<0.001
Time (48 h postoperative) × group	2.016	4.208	9.156	<0.001

ing the VAS, which ranges from 0–10. A score of 0 indicates no pain, 1–3 indicates mild pain, 4–6 indicates moderate pain with sleep disturbance, and 7–10 indicates severe pain with significant sleep disturbance [11].

Pain medication consumption: Opioid consumption was recorded at 6, 12, 24, and 48 hours postoperatively for both groups.

Statistical Methods

Data were analyzed and processed using SPSS software (version 27.0; IBM Corp., Armonk, NY, USA). Categorical variables were expressed as [n (%)] and analyzed using chi-square or Fisher's exact tests (Fisher's test was applied when T <1 or n <40). The normality of continuous variables was assessed using the Shapiro-Wilk test. Data following normal distribution were presented as mean ± standard deviation and analyzed using the *t*-test, while non-normally distributed data were reported as median (P25, P75) and analyzed using the Mann-Whitney U test. The generalized estimating equation was employed for repeated measurements at different time points. A p-value < 0.05 was considered statistically significant.

Results

Comparison of General Demographic Information and Surgery-Related Indicators

A comparison of the clinical characteristics of patients in the two groups revealed that demographic factors such as sex, age, weight, ASA classification, education level, marital status, type of occupation, and average monthly family income, as well as surgery-related indicators including the duration of surgery, patient diagnosis, surgical site, and intraoperative bleeding, were comparable between the exposed and control groups. There were no statistically significant differences between the groups ($p > 0.05$) (Table 1).

Comparison of Inflammatory Stress Response

The test results of model effect showed that the interaction effect between "group × time" was statistically significant (χ^2 group × time = 48.739, $p < 0.001$). Therefore, simple effect should be analyzed. The simple effect analysis between groups showed that there was no difference in the levels of Cor, TNF-α and IL-6 between two groups on the day before surgery ($p > 0.05$). However, at 1 day, 3 days, and 7 days post-surgery, the observation group exhibited significantly lower levels of Cor, TNF-α, and IL-6 compared to the control group ($p < 0.001$). The levels of these inflammatory markers and the results of the simple effect analysis are presented in Tables 2,3.

Comparison of S100β Levels

On the day before surgery, there was no statistically significant difference in S100β levels between the control and observation groups ($p > 0.05$). However, the S100β level in the control group was significantly higher than in the observation group at postoperative 1 day ($p < 0.001$), as shown in Table 4.

Comparison of Pain Levels

The test results of model effect showed that the interaction effect between "group × time" was statistically significant (χ^2 group × time = 43.226, $p < 0.001$). Therefore, simple effect should be analyzed. The simple effect analysis between groups showed that there was no difference in VAS scores between two groups before surgery ($p > 0.05$). Postoperatively, the VAS scores were markedly lower in the observation group compared to the control group at 6 hours, 12 hours, 24 hours, and 48 hours ($p < 0.001$). The VAS scores and simple effect analysis are detailed in Tables 5,6.

Comparison of Postoperative Pain Medication Consumption

The analysis of the model effect revealed a statistically significant interaction effect between group and time (χ^2 group × time = 39.763, $p < 0.001$), indicating the need for further simple effect analysis. The simple effect analysis revealed that the cumulative opioid consumption in the observation group was significantly lower than that in the control group within 48 hours post-surgery ($p < 0.001$). Detailed opioid consumption data and simple effect analysis results are shown in Tables 7,8.

Table 7. Postoperative opioid consumption between the two groups [M (P25, P75), mg].

Group	n	6 h postoperative	12 h postoperative	24 h postoperative	48 h postoperative
Control group	60	5.32 (1.86, 7.92)	11.66 (10.43, 13.09)	18.79 (15.83, 23.61)	24.79 (19.81, 28.11)
Observation group	60	2.94 (1.68, 3.98)	7.59 (6.42, 8.49)	13.86 (11.34, 16.34)	21.63 (15.50, 26.19)

Table 8. Analysis of simple effect for postoperative opioids consumption.

Simple effect between groups	OR	95% Wald CI (lower)	95% Wald CI (upper)	*p*-value
Time (6 h postoperative) × group	3.184	6.820	11.961	<0.001
Time (12 h postoperative) × group	3.099	8.241	16.920	<0.001
Time (24 h postoperative) × group	2.542	5.751	9.011	<0.001
Time (48 h postoperative) × group	4.382	7.241	12.334	<0.001

Discussion

This study aimed to compare the effects of different ultrasound-guided nerve block modalities on the inflammatory stress responses following THA in elderly patients. The observation group received ultrasound-guide PENG block combined with general anesthesia, while the control group received FNB combined with general anesthesia. Our findings align with previous study, such as those by Gu *et al.* [12], which suggested that ultrasound-guided multiplexed nerve block could be a viable alternative to conventional anesthesia in elderly hip fracture patients, and Xu *et al.* [13], which demonstrated the efficacy of ultrasound-guided lower limb nerve blocks in suppressing postoperative inflammatory responses and promoting postoperative recovery in elderly patients.

Inflammatory markers such as serum IL-6 are critical indicators of inflammatory status and prognosis after knee or hip replacement surgery [14]. Our study revealed that levels of Cor, TNF-α, and IL-6 significantly increased in both groups after THA compared to preoperative levels. The increase can be attributed to the activation of the peripheral immune system due to mechanical invasion, trauma, and the stress response induced by surgery, leading to the release of various inflammatory factors.

However, the observation group showed significantly lower levels of Cor, TNF-α, and IL-6 at 1, 3, and 7 days postoperatively compared to the control group. These findings suggest that the PENG block combined with general anesthesia is more effective in reducing the inflammatory response in elderly patients undergoing THA. Our findings are consistent with those of Huang *et al.* [15], who reported that ultrasound-guided lumbar sciatic nerve block combined with epidural anesthesia significantly reduced coagulation and inflammatory factors in the peripheral blood of elderly patients after hip arthroplasty, thus mitigating the inflammatory stress response in both groups before surgery.

The PENG block is simple and easy to locate, spreading the local anesthetic solution over the pubic surface is sufficient. In contrast, FNB is a well-established technique with a high success rate and low complication rate. Cortisol, an adrenocorticotropic hormone, is a key indicator of the stress response by the body. The trauma and postoperative pain associated with hip arthroplasty can trigger a strong stress response, leading to elevated serum Cor levels, which can cause excitotoxicity to hippocampal pyramidal neurons, inhibit dentate gyrus nerve cells, and impair cognitive function. Inflammation also plays a role in the development and enhancement of postoperative pain, and central nervous system inflammation can contribute to cognitive impairment.

Both PENG block and FNB are lumbosacral plexus nerve blocks that enhance anesthesia block nerve impulses from peripheral injuries to the central nervous system, and provide substantial analgesia. The blocks reduce catecholamine secretion during and after surgery, improving hemodynamic stability and alleviating the stress response. The use of long-acting amide local anesthetic ropivacaine in these blocks inhibits nerve excitation and conduction, blocks the transmission of injurious stimuli, suppresses the activation of the sympathetic-adrenomedullary system, decreases catecholamine secretion, and improves postoperative pain and inflammation.

In addition, the study results indicated that the postoperative VAS scores and opioid consumption in the observation group were significantly lower than in the control group. This finding aligns with the results of Uesugi *et al.* [16], suggesting that the combination of two ultrasound-guided nerve blocks can significantly enhance analgesic efficacy, reduce postoperative opioid use, and contribute to effective postoperative motor-sparing analgesia. This result may be attributed to the distribution of sensory nerves in the hip joint area, which are primarily located in the anterior capsule and innervated by the articular branches of the femoral nerve, obturator nerve, and the parasympathetic nerve. The PENG block effectively targets the entire anterior hip capsule area related to the articular branches of the femoral nerve, the obturator nerve, and the accessory obturator nerve, providing substantial analgesia without impairing motor function [17].

Furthermore, the study showed that the S100β levels in the control group were higher than in the observation group at 1 day postoperatively. S100β, a low-molecular-weight calcium-binding protein, is predominantly expressed in astrocytes, oligodendrocytes, and Schwann cells. Under conditions of cerebral ischemia and hypoxia, the production and secretion of S100β are elevated due to an acute neuroglial reaction [18]. These findings suggest that the ultrasound-guided PENG block combined with FNB may improve cerebral blood supply in elderly patients following surgery.

Conclusions

Ultrasound-guided PENG block combined with general anesthesia can effectively reduce pain degree, stress, and inflammatory responses in elderly patients after THA.

Availability of Data and Materials

The datasets used or analysed during the current study were available from the corresponding author upon reasonable request.

Author Contributions

JL and HLX designed the research study; XL, JJC, and JHW performed the research; YMJ analyzed the data. JL wrote the manuscript. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study has been approved by the Medical Ethics Committee of Hebei Province Cangzhou Hospital of Integrated Traditional and Western Medicine (Approval No.: CZX2024-KY-038.1). Patient records were collected and organized through the electronic medical records systems with the informed consent of all participants. The study complied with the principles of the Declaration of Helsinki (2013).

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

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