Article

Effects of Ultrasound-Guided Pericapsular Nerve Group Block Combined With Lumbar Anesthesia on Analgesia and Cognitive Function in Elderly Patients After Hip Arthroplasty

Ann. Ital. Chir., 2026 97, 4: 732–740
https://doi.org/10.62713/aic.4230

Yuanyuan He[1], Hua Zhuo[1], Jia Wang[1]

[1]Department of Anesthesiology, The First People's Hospital of Xiaoshan District, 311201 Hangzhou, Zhejiang, China

AIM: With population aging, hip arthroplasty among elderly patients has become increasingly common. This study investigated the effects of ultrasound-guided pericapsular nerve group block (PENG) combined with lumbar anesthesia versus general anesthesia on circulatory and respiratory stability, analgesia, cognitive function, and safety in elderly patients after hip arthroplasty.
METHODS: A total of 86 patients who underwent hip arthroplasty in our hospital between June 2022 and June 2024 were retrospectively selected and divided into a control group (n = 50, general anesthesia) and an observation group (n = 36, ultrasound-guided PENG combined with lumbar anesthesia) according to different anesthesia conditions. Circulatory and respiratory indices, including mean arterial pressure, systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygenation index, and lung function, were compared between the two groups before and after surgery. Analgesia was evaluated using visual analogue scale (VAS). Cognitive function was assessed using the Mini-Mental State Examination (MMSE) score, and the incidence of postoperative delirium (POD) was compared between the two groups. Adverse reactions related to anesthesia were also recorded.
RESULTS: Mean arterial pressure, SBP, and DBP showed no significant differences between the two groups at different perioperative time points (all $p > 0.05$). The oxygenation index also remained stable postoperatively, with no statistically significant difference between groups. At 1, 6, and 24 hours after the operation, the incidence of adverse events in the observation group (2.78%, 8.33%, and 13.89%, respectively) was lower than in the control group (6%, 14%, and 26%). VAS scores decreased significantly over time, with a significant time effect ($p < 0.001$). In addition, a significant time × group interaction was observed ($p < 0.001$), suggesting a greater reduction in the observation group. The incidence of postoperative delirium in the observation group showed a lower trend (8.33% *vs* 14% at 6 hours; 16.67% *vs* 24% at 24 hours), though the difference was not statistically significant ($p > 0.05$). The overall incidence of adverse reactions was significantly lower in the observation group (13.89%) compared with the control group (26.00%, $p < 0.05$). There was no significant difference in the preoperative MMSE scores between the two groups (control group: 27.50 ± 2.10 points, observation group: 27.80 ± 1.90 points, $t = 0.58$, $p = 0.46$). The postoperative MMSE score of the observation group (27.00 ± 2.50 points) was significantly higher than that of the control group (25.20 ± 2.99 points, $t = 3.13$, $p = 0.01$).
CONCLUSIONS: Ultrasound-guided PENG combined with lumbar anesthesia is a safe and effective anesthesia method for elderly patients undergoing hip arthroplasty, providing better analgesia, preserving cognitive function, and reducing adverse reactions.

Keywords: ultrasound guidance; pericapsular nerve group block; hip arthroplasty; analgesia; cognitive function

Introduction

With the acceleration of population aging, the incidence of hip diseases in the elderly is increasing year by year. Epidemiological study shows that the prevalence of hip fracture, hip osteoarthritis, and other related conditions is high in the elderly population [1]. Recent data indicate that the global incidence of hip fractures among adults over 65 years has reached 215 per 100,000 person-years, with a projected 240% increase by 2050 due to population aging [2].

Submitted: 24 June 2025 Revised: 17 October 2025 Accepted: 5 November 2025 Published: 10 April 2026
Correspondence to: Jia Wang, Department of Anesthesiology, The First People's Hospital of Xiaoshan District, 311201 Hangzhou, Zhejiang, China (e-mail: 13732292704@163.com).
Editor: Andrea Bondurri

For elderly patients, anesthesia management faces unique challenges, including age-related physiological decline, increased sensitivity to anesthetics, and a higher risk of perioperative complications such as delirium and cardiovascular instability [3,4]. Globally, the incidence of hip fractures in the elderly is increasing at a rate of 1%–3% per year, which not only causes significant pain for patients but also places a heavy burden on health care systems [5]. Treatment options for elderly patients with hip diseases are diverse, including both conservative and surgical approaches. Conservative treatment often fails to achieve the ideal recovery effect, whereas surgical treatment can effectively improve joint function but carries higher risks due to age-related declines in physiological and physical reserve function [6]. Among various factors, the choice of anesthesia during the operation is particularly critical. Traditional anesthesia methods may significantly affect circulatory and respiratory function, while also being associated with poor postoperative analgesia and an increased risk of postoperative cognitive dysfunction [7]. Ultrasound-guided pericapsular nerve group block (PENG) combined with lumbar anesthesia has unique advantages in anesthesia management for elderly hip surgery patients. Ultrasound guidance can improve the accuracy of nerve blocks, allowing the PENG to more precisely target the relevant nerves while minimizing injury to surrounding tissues [8]. Moreover, combining it with lumbar anesthesia can reduce the dose required for each technique while maintaining adequate anesthesia effect, thereby decreasing the adverse effects of anesthetic drugs on circulatory and respiratory systems [9]. This combined technique also provides more effective postoperative analgesia, reduces pain, and promotes postoperative rehabilitation. In addition, compared with traditional anesthesia, it has less impact on postoperative cognitive function, helping lower the incidence of postoperative cognitive dysfunction and improving the quality of life of elderly hip surgery patients [10].

Traditional general anesthesia suppresses the central nervous system, leading to circulatory effects (vasodilation, reduced cardiac contractility, hypotension) and respiratory depression (decreased tidal volume, impaired gas exchange) in elderly patients. These effects are more pronounced due to age-related physiological decline, increasing the risk of perioperative complications.

However, few studies have examined the application of ultrasound-guided PENG combined with lumbar anesthesia in elderly patients undergoing hip surgery. Based on this, the present study selected elderly patients undergoing hip replacement as the study population to analyze the clinical value of ultrasound-guided PENG combined with lumbar anesthesia.

Methods

General Information

The study population was retrospectively selected from patients who underwent hip arthroplasty at The First People's Hospital of Xiaoshan District, Hangzhou, between June 2022 and June 2024. Patients were assigned to the control group (n = 50; general anesthesia) or the observation group (n = 36; ultrasound-guided PENG combined with lumbar anesthesia) based on the anesthesia method used during surgery (nonrandomized). The choice of anesthesia was determined by the anesthesiologist's clinical judgment, considering factors such as patient comorbidities (e.g., severe cardiopulmonary disease potentially precluding regional anesthesia) and surgical complexity.

Inclusion criteria: (1) patients scheduled for hip arthroplasty; (2) stable vital signs; (3) absence of other malignant diseases; (4) voluntary participation in the study, with informed consent from patients and their families. Exclusion criteria: (1) severe hepatic or renal dysfunction; (2) cognitive or behavioral impairment precluding normal communication; (3) history of drug allergy; (4) multiple systemic fractures; (5) inability to complete study follow-up.

This study has been approved by the Ethics Review Committee of The First People's Hospital of Xiaoshan District, Hangzhou (Approval No. 2024-136) and strictly adheres to the Declaration of Helsinki.

The detailed study design and patient grouping process are shown in Fig. 1.

Study Methods

Control group: patients in this group received general anesthesia, and the specific operative steps were as follows: (1) preoperative preparation: a comprehensive preoperative evaluation was performed, including assessment of physical condition, cardiopulmonary function, and laboratory tests. Patients were informed of the risks and precautions associated with general anesthesia, and written informed consent was obtained. After the patient entered the operating room, intravenous access was established and electrocardiographic (ECG) monitoring was initiated to monitor vital signs. (2) Anesthesia induction: anesthesia induction was performed with sufentanil, etomidate, and cisatracurium to achieve adequate anesthesia and muscle relaxation. After loss of consciousness and adequate muscle relaxation, endotracheal intubation was performed and the patients were connected to an anesthesia machine for mechanical ventilation. (3) Anesthesia maintenance: anesthesia was maintained with continuous infusion of propofol and remifentanil, with doses adjusted according to surgical requirements and hemodynamic parameters. The dose of anesthetic drugs was adjusted according to the operation need and changes in the patient's vital signs. Blood pressure, heart rate, respiration rate, oxygen saturation, and other parameters were closely monitored, and any intraoperative abnormalities were managed promptly. (4) Postoperative treatment: after the operation, the infusion of anesthetic drugs was stopped, and endotracheal intubation was removed after recovery of spontaneous breathing and consciousness. Patients were transferred to the post-anesthesia care unit for observation and were returned to the ward after the vital signs were stable.

Observation group: patients receiving ultrasound-guided PENG combined with spinal anesthesia underwent the following specific operation steps: (1) preoperative preparation: preoperative preparation was carried out simultaneously with the control group, including preoperative assessment, signing informed consent forms, establishing intravenous access, and connecting monitoring equipment. (2) PENG operation: the PENG was performed in the supine position under ultrasound guidance. Using the iliopubic eminence (IPE) as the core ultrasound marker, the fascia space deep to the iliopsoas muscle was identified. Under real-time ultrasound guidance, the puncture needle was advanced into this gap, and after confirming the correct needle-tip position, a total of 20–30 mL of 0.5% ropivacaine

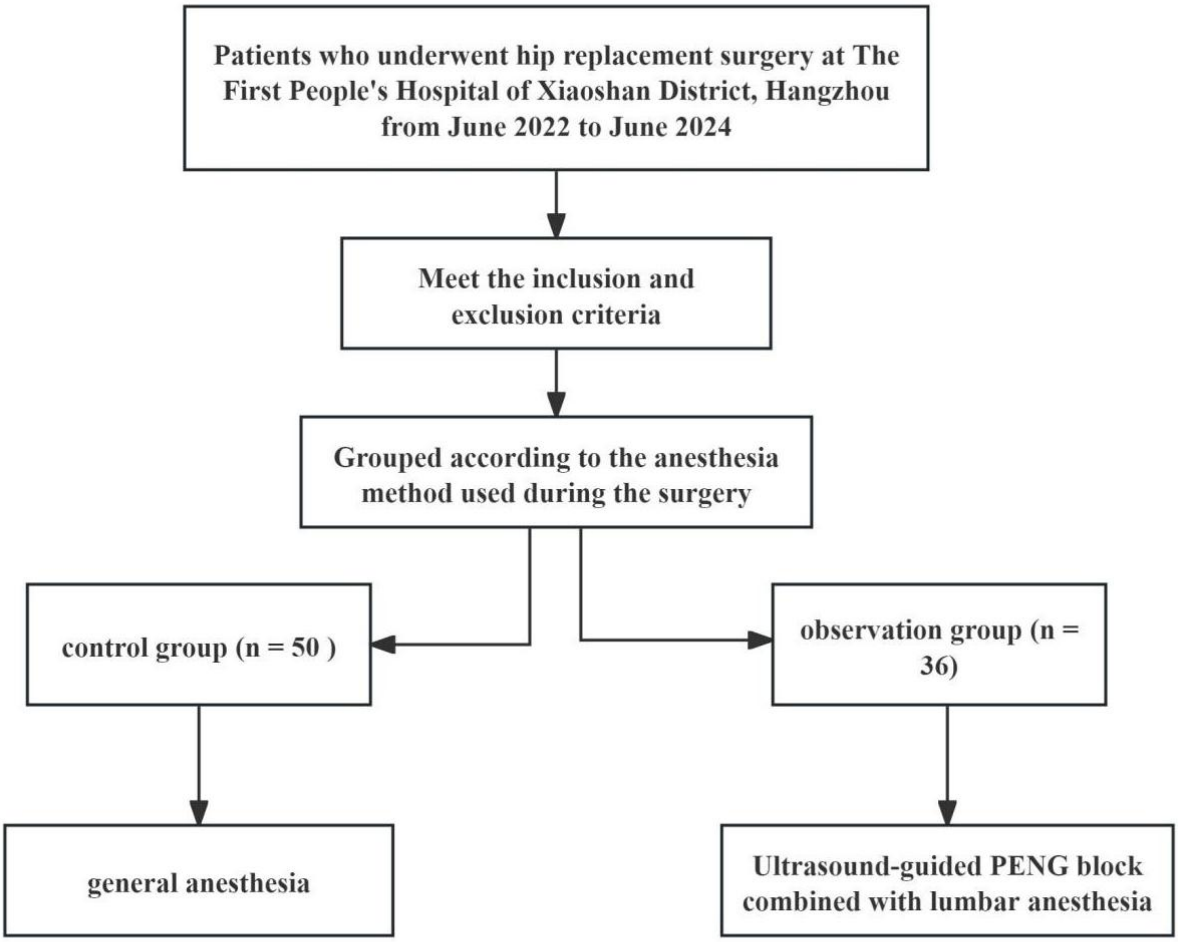

Fig. 1. Study design and group flow chart. PENG, pericapsular nerve group block.

(within the recommended safe dosage range) was slowly injected. The diffusion of local anesthetic in the subiliopsoas space was closely observed to ensure adequate coverage of the articular branches innervating the hip joint, so as to achieve an effective blocking effect. (3) Spinal anesthesia operation: the patient was placed in a lateral position, with the back perpendicular to the bed surface, the head tilted towards the chest, and the legs bent towards the abdomen as much as possible. An appropriate lumbar intervertebral space (usually L3–L4 or L2–L3) was selected, and dural puncture was performed under strict aseptic conditions using a spinal anesthesia needle. When the needle penetrates the dura mater, a sensation of puncture and breakthrough will be felt. At this point, pulling out the needle core and observing the outflow of cerebrospinal fluid indicates a successful puncture. The dose of local anesthetic was adjusted according to patient's height and clinical response. Typically, 1.5–2.5 mL of 0.5% ropivacaine was administered. After removal of the spinal anesthesia needle, the patient was assisted into a supine position for 15–20 minutes, and the sensory block height was controlled to remain below the T10 dermatome by adjusting the body position. (4) Intraoperative monitoring and management: vital signs, level of anesthesia, and quality of the block were continuously monitored, and sedatives were administered as required according to the surgery and patient condition. Intraoperative complications, such as hypotension or bradycardia, were managed promptly. (5) Postoperative management: the patient's recovery was closely observed after surgery. Once vital signs were stable, the patient was transferred back to the ward. The PENG procedure under ultrasound guidance is illustrated in Fig. 2.

All patients underwent either total hip arthroplasty (THA) or hemiarthroplasty (HA). The distribution of surgical types was balanced between groups.

Observed Indicators

(1) Hemodynamic and respiratory parameters: the mean arterial pressure, systolic blood pressure (SBP), diastolic blood pressure (DBP) and oxygenation index were compared between the two groups before and after treatment.

(2) Analgesia: the visual analogue scale (VAS) score was used to evaluate the degree of pain at 1 h, 6 h and 24 h after surgery, with a total score ranging from 0 to 10 points. Higher scores indicated greater pain intensity.

Table 1. Comparison of the two groups of general data.

Variable	Control group (n = 50)	Observation group (n = 36)	t/χ^2	p
Gender (male/female)	26/24	20/16	0.11	0.74
Operation time (minutes)	115.63 ± 10.59	112.68 ± 10.27	1.29	0.20
BMI (kg/m^2)	22.56 ± 1.85	22.78 ± 1.63	–0.57	0.57
Age (years)	67.56 ± 3.44	68.17 ± 3.52	–0.80	0.43
Fracture types, n (%)			0.23	0.64
Between the medial trochanters of the femur	28 (56.00)	22 (61.11)		
Femoral neck	22 (44.00)	14 (38.89)		
Causes of injury, n (%)			0.07	0.97
Fall	25 (50.00)	19 (52.78)		
Traffic accident	15 (30.00)	10 (27.78)		
Others	10 (20.00)	7 (19.44)		
Fractured side (left/right)	26/24	19/17	0.01	0.94
Complications, n (%)			0.13	0.99
Hypertension	18 (36.00)	13 (36.11)		
Diabetes	12 (24.00)	8 (22.22)		
Cardiovascular diseases	9 (18.00)	6 (16.67)		
There are no complications	11 (22.00)	9 (25.00)		
Surgical type, n (%)			0.00	0.98
Total hip arthroplasty (THA)	29 (58.00)	21 (58.33)		
Hemiarthroplasty (HA)	21 (42.00)	15 (41.67)		

BMI, body mass index.

Fig. 2. Ultrasound-guided PENG procedure.

(3) Postoperative cognitive function: the Mini-Mental State Examination (MMSE) was used to evaluate postoperative cognitive function. Higher scores indicated better cognitive performance. The incidence of postoperative delirium (POD) was recorded in both groups. The MMSE was assessed preoperatively and 24 h postoperatively, while POD was monitored at 6 h and 24 h postoperatively.

(4) Adverse reaction: the occurrence of adverse reactions such as nausea, vomiting, hypotension, and hypoxemia after surgery was compared and recorded between the two groups. Adverse reactions were recorded at 1 h, 6 h, and 24 h after surgery, and the overall incidence of adverse reactions was statistically analyzed. The overall incidence was defined as the occurrence of at least one adverse event during the 24-hour postoperative period.

All assessments (VAS score, MMSE score, and adverse reaction recording) were performed by trained assessors who were blinded to the patients' anesthesia group allocation to minimize bias.

Statistical Methods

Data were analyzed using SPSS 26.0 (IBM SPSS statistics, Armonk, NY, USA) statistical software. Measurement data were expressed as ($\bar{x} \pm$ s), and count data were expressed as [n (%)]. The Shapiro-Wilk test was used to assess the normality of continuous variables. Intergroup comparisons of normally distributed data were performed using the independent samples t-test, while intragroup comparisons were analyzed using the paired samples t-test. Non-normally distributed data were analyzed using the Mann-Whitney U test. Repeated measurement data were analyzed by analysis of variance (ANOVA) with a sphericity test. The χ^2 test was used for comparison of categorical variables between groups. A significance level of $\alpha = 0.05$, and $p < 0.05$ was considered statistically significant.

Table 2. Changes in mean arterial pressure, heart rate, SBP, DBP, and oxygenation index at different time points in the two groups.

Indicator	Group	After entering the operating room	One hour after the operation began	The operation is over	When returning to the ward	F/*t*	*p*
Mean arterial pressure (mmHg)	Control group	88.31 ± 3.75	94.97 ± 3.08	91.27 ± 3.15	89.19 ± 3.58	1.82	0.15
	Observation group	87.18 ± 3.85	89.07 ± 3.89	90.53 ± 3.51	90.74 ± 3.46		
Heart rate (beats per minute)	Control group	67.58 ± 4.16	68.33 ± 3.87	69.73 ± 3.94	72.46 ± 4.11	2.01	0.12
	Observation group	67.29 ± 4.58	69.38 ± 4.28	69.79 ± 3.91	70.66 ± 4.16		
SBP (mmHg)	Control group	138.55 ± 8.19	149.63 ± 7.55	142.63 ± 6.25	141.52 ± 5.79	2.36	0.08
	Observation group	138.37 ± 8.23	141.31 ± 8.25	142.63 ± 5.81	140.56 ± 6.92		
DBP (mmHg)	Control group	82.29 ± 5.28	85.27 ± 4.18	84.73 ± 4.35	82.52 ± 4.28	1.56	0.20
	Observation group	81.09 ± 4.81	82.37 ± 4.39	83.73 ± 4.23	84.96 ± 4.35		
Oxygenation index (mmHg)	Control group	435.68 ± 27.81	431.56 ± 25.78	425.60 ± 25.11	413.46 ± 24.16	2.11	0.11
	Observation group	438.78 ± 25.44	426.33 ± 25.51	421.89 ± 24.93	418.78 ± 23.86		

Note: SBP, systolic blood pressure; DBP, diastolic blood pressure.

Results

Comparison of General Data Between the Control Group and the Observation Group

There were no statistically significant differences in general data such as age, sex, or cause of fracture between the control group and the observation group (all $p > 0.05$), as shown in Table 1.

Changes in Mean Arterial Pressure, Heart Rate, SBP, DBP, and Oxygenation Index at Different Time Points in the Two Groups

Both groups showed similar trends in mean arterial pressure, heart rate, systolic blood pressure, diastolic blood pressure, and oxygenation index at different perioperative time points. The fluctuations in hemodynamic parameters were relatively small throughout the perioperative period. Repeated-measures ANOVA demonstrated no statistically significant differences between the two groups at any time point for mean arterial pressure (F = 1.82, $p = 0.15$), heart rate (F = 2.01, $p = 0.12$), systolic blood pressure (F = 2.36, $p = 0.08$), diastolic blood pressure (F = 1.56, $p = 0.20$), or oxygenation index (F = 2.11, $p = 0.11$), as shown in Table 2.

Comparison of Analgesia Score Between the Control and the Observation Groups

Repeated-measures ANOVA showed VAS scores decreased progressively over time, with a significant time effect ($p < 0.001$). In addition, a significant time × group interaction was observed ($p < 0.001$), indicating different temporal trends between the two groups (Table 3).

Table 3. Comparison of the VAS scores at different times between the two groups.

Group	Time point	VAS (component)
Control group (n = 50)	1 h after surgery	3.94 ± 0.55
	6 h after surgery	2.88 ± 0.33
	24 h after surgery	1.98 ± 0.38
Observation group (n = 36)	1 h after surgery	3.97 ± 0.51
	6 h after surgery	2.17 ± 0.45
	24 h after surgery	1.58 ± 0.50
$F_{time\ point}$		16.34
$p_{time\ point}$		<0.001
$F_{time\ point \times group}$		22.54
$p_{time\ point \times group}$		<0.001

Note: VAS, visual analogue scale.

Comparison of Postoperative Cognitive Function Scores and Number of Delirium Cases Between the Control Group and the Observation Group

There was no significant difference in MMSE scores between the two groups before the operation ($p > 0.05$). The MMSE score of the observation group was significantly higher than that in the control group after the operation ($p < 0.05$). Six hours after the operation, delirium occurred in 7 cases (14.00%) in the control group and 3 cases (8.33%) in the observation group. Twenty-four hours after the operation, delirium occurred in 12 cases (24.00%) in the control group and 6 cases (16.67%) in the observation group. The incidence of postoperative delirium in the observation group showed a relatively lower trend. However, statistical analysis revealed no significant difference in the incidence of delirium between the two groups at 6 hours ($p = 0.28$) and 24 hours ($p = 0.31$) after the operation, as shown in Table 4.

Comparison of the Incidence of Adverse Reactions Between the Control Group and the Observation Group

The incidence of adverse reactions at different time points after the operation was as follows: 1 hour after the operation, 1 case (2.78%) occurred in the observation group and 3 cases (6.00%) occurred in the control group. Six hours after the operation, 3 cases (8.33%) occurred in the observation group and 7 cases (14.00%) occurred in the control group. At 24 hours after the operation, 5 cases (13.89%) occurred in the observation group and 13 cases (26.00%) occurred in the control group. In the observation group, 1

Table 4. Comparison of postoperative cognitive function scores and number of delirium cases between the control group and the observation group.

Comparison project	Control group (n = 50)	Observation group (n = 36)	t/χ^2	p
Preoperative MMSE score (points)	27.50 $\pm$ 2.10	27.80 $\pm$ 1.90	0.58	0.46
Postoperative MMSE score (points)	25.20 $\pm$ 2.99	27.00 $\pm$ 2.50	3.13	0.01
The incidence of POD 6 hours after the operation	7 (14.00)	3 (8.33)	0.87	0.35
The incidence of POD 24 hours after the operation	12 (24.00)	6 (16.67)	0.68	0.41

Note: MMSE, Mini-Mental State Examination; POD, postoperative delirium.

Table 5. Incidence of adverse reactions at different postoperative time points.

Group	n	1 hour after the operation	6 hour after the operation	24 hour after the operation
Control group	50	3 (6.00%)	7 (14.00%)	13 (26.00%)
Observation group	36	1 (2.78%)	3 (8.33%)	5 (13.89%)

Table 6. Distribution of adverse reaction types within 24 hours after surgery.

Group	n	N and V	Hypotension	Hypoxemia	Total incidence
Control group	50	4	5	4	13 (26.00%)
Observation group	36	1	2	2	5 (13.89%)
χ^2					4.31
p					0.04

Note: N and V, nausea and vomiting.

patient experienced nausea and vomiting, 2 had hypotension, and 2 developed hypoxemia. In the control group, 4 patients had nausea and vomiting, 5 had hypotension, and 4 had hypoxemia ($p < 0.05$) (Tables 5,6).

Discussion

With population aging, the number of elderly patients with hip diseases is increasing, and hip replacement has become a common treatment [11]. Anesthesia plays a crucial role in surgery for elderly hip patients. Because the physical functions of elderly patients are relatively weak and their pain tolerance is low, effective anesthesia ensures a painless state during surgery and reduces patients' pain and fear [12]. In addition, anesthesia relaxes the patients' muscles and facilitates surgical manipulation. Hip replacement requires precise handling of the hip joint, and muscle relaxation provides surgeons with a clear field of vision and adequate operating space, thereby improving surgical success rates [13]. Moreover, anesthesia helps inhibit the stress response of patients. Surgery is a significant stressor that triggers physiological responses such as increased blood pressure and heart rate. Anesthesia effectively inhibits these responses and maintains the stable vital signs [14]. Elderly hip patients often have various comorbidities, such as cardiovascular and respiratory diseases, which reduce their tolerance to anesthesia. General anesthesia may have a greater impact on the circulatory and respiratory systems, increasing the risk of surgery [15]. Ultrasound-guided PENG combined with lumbar anesthesia can reduce the use of general anesthetics and minimize their adverse effects on circulation and respiration. This technique injects local anesthetics into the nerve space around the hip joint, blocking pain signal transmission with minimal impact on the whole body [16]. Lumbar anesthesia provides effective regional anesthesia, and the combination of both methods offers safer and more efficient anesthesia for elderly patients. Furthermore, elderly patients are prone to postoperative complications such as cognitive dysfunction, and appropriate anesthesia techniques can reduce their incidence. Ultrasound-guided PENG combined with lumbar anesthesia effectively alleviates pain, reduces stress and inflammatory responses, and helps preserve patients' cognitive function [17].

General anesthetics usually inhibit the central nervous system, including cardiovascular and respiratory centers. They can cause vascular dilation and lower peripheral resistance by affecting the balance between sympathetic and parasympathetic nervous systems, leading to a decrease in blood pressure [18]. At the same time, inhibition of cardiac automaticity, conductivity, and contractile force may alter the heart rate. In addition, inhibition of the respiratory center by general anesthetics slows the respiratory rate, reduces the tidal volume, and thereby impairs pulmonary ventilation function. In the observation group, ultrasound-guided PENG combined with lumbar anesthesia was used, producing fewer effects on the circulatory and respiratory systems. The mechanisms are as follows: the PENG involves the accurate injection of local anesthetics into the specific nerve space around the hip joint under ultrasound guidance. This mainly blocks sensory nerve conduction around the hip joint and reduces the transmission of surgical pain stimuli to the central nervous system. When the pain stimulation is reduced, the body's stress response also lessens, preventing sympathetic excitation caused by pain stress and helping maintain stable blood pressure and heart rate. In the respiratory system, because PENG mainly acts on peripheral nerves, it has no direct inhibitory effect on the respiratory center [19]. Lumbar anesthesia involves the injection of local anesthetics into the subarachnoid space, mainly acting at the spinal cord level. Its effect on the sympathetic nerve is relatively limited, so it does not inhibit the cardiovascular or respiratory systems as general anesthesia does. Moreover, lumbar anesthesia does not cause significant muscle relaxation, which has little impact on the movement of thoracic and diaphragm, and helps to maintain normal pulmonary ventilation. Therefore, the circulatory and respiratory parameters of the observation group remain relatively stable [20].

The main reason for the higher postoperative VAS score in the control group is that the general anesthesia is mainly achieved by inhibiting the central nervous system, and the local pain control at the surgical site is relatively weak. When the effect of general anesthesia subsides, the pain signal caused by surgical trauma will be strongly transmitted to the central nervous system, resulting in obvious pain sensation [21]. In addition, under general anesthesia, the pain during the operation, and the sudden appearance of postoperative pain will make the patient feel more intense discomfort. The mechanism of the low VAS score after ultrasound-guided PENG combined with lumbar anesthesia in the observation group is that PENG directly acts on the sensory nerve around the hip joint, blocking the conduction of pain signal from the source, and greatly reducing the pain feeling at the surgical site. Waist anesthesia can also reduce the pain at the surgical site to some extent, and it can synergize with PENG to provide a more perfect postoperative analgesic effect. Over time, the inflammatory response caused by the surgical trauma gradually decreases, and pain is gradually relieved. However, because the observation group had effective pain control from the beginning, VAS scores at 6 h and 24 h after surgery were lower than those in the control group. The observed differences in VAS scores, MMSE scores, and adverse reaction rates have meaningful clinical implications. A reduction in VAS score (e.g., 6 hours after the operation, the value for the control group was 2.88, while for the observation group it dropped to 2.17, a decrease of 0.71 units) is clinically relevant because it correlates with improved patient comfort, enhanced participation in early mobilization, and reduced risk of opioid-related complications, all of which accelerate postoperative recovery [22]. For MMSE scores, the higher postoperative values in the observation group (27.00 *vs* 25.20) suggest better preservation of cognitive function, which is critical for elderly patients to adhere to rehabilitation protocols and maintain independence [23]. Our findings align with a recent study showing that regional anesthesia techniques, including PENG, offer superior analgesia and fewer adverse effects compared to general anesthesia in elderly hip surgery patients [24]. However, unlike Martínez Martín *et al*. [25], who focused solely on analgesic outcomes, our study further demonstrates preservation of cognitive function with the combined PENG-lumbar anesthesia approach. This unique contribution emphasizes the multimodal benefits of this anesthesia strategy beyond pain control.

This study also found that although the incidence of postoperative delirium in the observation group was lower than that in the control group (8.33% *vs* 14.00% at 6 h and 16.67% *vs* 24.00% at 24 h after surgery), the difference was not statistically significant ($p > 0.05$). This finding suggests that the combined anesthesia regimen may have potential advantages in reducing the incidence of delirium. However, larger sample size studies are needed for further verification. The reasons are as follows: general anesthesia provides weak local pain control; as its effect subsides, surgical trauma-induced pain signals are strongly transmitted, leading to higher VAS scores. Ultrasound-guided PENG directly blocks hip joint sensory nerve conduction, while lumbar anesthesia synergistically enhances analgesia, resulting in sustained lower pain scores [26,27].

Finally, this study found that the incidence of adverse reactions in the observation group was significantly lower than that in the control group. The higher incidence of adverse reactions under general anesthesia in the control group is mainly due to the extensive inhibitory effect of general anesthesia drugs on the cardiovascular and respiratory systems. As mentioned earlier, general anesthesia can cause decreased blood pressure, altered heart rate, and respiratory depression, thereby increasing the risk of hypotension and hypoxemia. In addition, general anesthetics may cause gastrointestinal reactions such as nausea and vomiting, as they can impair the peristalsis and secretion functions of the gastrointestinal tract and affect the central nervous system regulation of the gastrointestinal tract [28]. The lower incidence of adverse reactions of PENG under ultrasound guidance combined with lumbar anesthesia in the observation group may be attributed to the reduced use of general anesthetic agents, thus reducing the adverse effects on the cardiovascular and respiratory systems. The PENG mainly acts on the peripheral nerves, has minimal systemic effects, and generally does not cause obvious adverse reactions. Although lumbar anesthesia may induce complications such as hypotension, the incidence is relatively low compared with general anesthesia. Furthermore, effective pain control can reduce the occurrence of gastrointestinal adverse reactions, such as nausea and vomiting, since pain-induced stress can cause gastrointestinal spasm and increased secretion. Adequate analgesia alleviates these symptoms and thereby reduces the incidence of adverse reactions [29,30].

Notably, this retrospective study did not involve randomization of patients into anesthesia groups in the original dataset. The assignment of general anesthesia versus ultrasound-guided PENG combined with lumbar anesthesia was based on clinical decisions at the time of surgery, which may have introduced confounding factors (e.g., patient-specific comorbidities influencing anesthesia selection) and affected the validity of group comparisons.

Conclusions

This study indicates that ultrasound-guided PENG combined with spinal anesthesia offers significant advantages over general anesthesia in elderly patients undergoing hip replacement surgery. This combined anesthesia protocol better maintains circulatory and respiratory stability, provides superior postoperative analgesic effects, has less impact on cognitive function, and results in a lower incidence of adverse reactions. This study provides a strong basis for optimizing anesthesia strategies in elderly patients with hip disease, thereby improving the safety of surgery and postoperative outcomes.

However, this study has several limitations that should be considered. First, it is a retrospective analysis, and random grouping was not applied. The selection of anesthesia methods depended on clinical decisions, which may have been affected by patients' comorbidities (such as severe cardiopulmonary diseases), introducing selection bias. Second, the sample size is relatively small (n = 86), which may limit the statistical power and generalizability of the results. Third, as with many retrospective studies, incomplete or inconsistent clinical records may have introduced information bias. Fourth, the analysis process did not include multivariate adjustments (for example, accounting for comorbidity severity or operation duration stratification), and potential confounding factors could not be fully controlled. Finally, no subgroup analyses were conducted based on key patient characteristics (age stratification, fracture type, or sex), making it difficult to determine potential differences in benefits among subgroups. Additionally, the follow-up period was limited to 24 hours after the operation, and data on continuous cognitive function, pain status, and long-term prognosis were lacking.

Future research should include large-scale, prospective randomized controlled trials to verify these findings, implement long-term follow-up observations (3 to 6 months), explore the neuroprotective mechanisms of the PENG, and conduct subgroup analyses to identify the populations most likely to benefit. Such studies would further strengthen the clinical evidence supporting this anesthesia protocol.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

YH, HZ and JW contributed to the study design, data collection, and analysis. YH drafted the manuscript. All authors have been involved in revising the manuscript 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 Ethics Review Committee of The First People's Hospital of Xiaoshan District, Hangzhou (Approval No. 2024-136) and strictly adheres to the Declaration of Helsinki. The patients themselves or their guardians included in the study have signed the informed consent form.

Acknowledgment

The authors thank the medical staff of the Department of Anesthesiology and Orthopedics for their assistance in data collection and patient management.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest.

References

[1] Cassidy RS, Bennett DB, Beverland DE, O'Brien S. Decision regret after primary hip and knee replacement surgery. Journal of Orthopaedic Science. 2023; 28: 167–172. https://doi.org/10.1016/j.jos.2021.10.007.

[2] Niemi-Nikkola V, Saijets N, Ylipoussu H, Kinnunen P, Pesälä J, Mäkelä P, *et al*. Long-term Posttraumatic Survival of Spinal Fracture Patients in Northern Finland. Spine. 2018; 43: 1657–1663. https://doi.org/10.1097/BRS.0000000000002687.

[3] Fleisher LA, Fleischmann KE, Auerbach AD, Barnason SA, Beckman JA, Bozkurt B, *et al*. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines. Journal of the American College of Cardiology. 2014; 64: e77–e137. https://doi.org/10.1016/j.jacc.2014.07.944.

[4] Sardar ZM, Coury JR, Cerpa M, DeWald CJ, Ames CP, Shuhart C, *et al*. Best Practice Guidelines for Assessment and Management of Osteoporosis in Adult Patients Undergoing Elective Spinal Reconstruction. Spine. 2022; 47: 128–135. https://doi.org/10.1097/BRS.0000000000004268. Erratum in: Spine. 2022; 47: E581. https://doi.org/10.1097/BRS.0000000000004450.

[5] Blakeney WG, Kuster M. Advances in Hip Replacement Surgery. Journal of Clinical Medicine. 2023; 12: 3439. https://doi.org/10.3390/jcm12103439.

[6] Frassanito L, Vergari A, Nestorini R, Cerulli G, Placella G, Pace V, *et al*. Enhanced recovery after surgery (ERAS) in hip and knee replacement surgery: description of a multidisciplinary program to improve management of the patients undergoing major orthopedic surgery. Musculoskeletal Surgery. 2020; 104: 87–92. https://doi.org/10.1007/s12306-019-00603-4.

[7] Pervukhin SA, Ageenko AM, Lebedeva MN, Golikov RI. CASE REPORT: PNEUMOCEPHALIA AFTER EPIDURAL ANESTHESIA

FOR HIP REPLACEMENT SURGERY. Anesteziologiia i Reanimatologiia. 2017; 61: 233–235. (In Russian)

[8] Aygun H, Tulgar S, Yigit Y, Tasdemir A, Kurt C, Genc C, *et al*. Effect of ultrasound-guided pericapsular nerve group (PENG) block on pain during patient positioning for central nervous blockade in hip surgery: a randomized controlled trial. BMC Anesthesiology. 2023; 23: 316. https://doi.org/10.1186/s12871-023-02245-3.

[9] Duan L, Zhang L, Shi CG, Huang LG, Ao H, Wang ZP, *et al*. Comparison of continuous pericapsular nerve group (PENG) block versus continuous fascia iliaca compartment block on pain management and quadriceps muscle strength after total hip arthroplasty: a prospective, randomized controlled study. BMC Anesthesiology. 2023; 23: 233. https://doi.org/10.1186/s12871-023-02190-1.

[10] Marrone F, Graziano G, Paventi S, Tomei M, Gucciardino P, Bosco M. Analgesic efficacy of Pericapsular Nerve Group (PENG) block compared with Fascia Iliaca Block (FIB) in the elderly patient with fracture of the proximal femur in the emergency room. A randomised controlled trial. Revista Espanola de Anestesiologia y Reanimacion. 2023; 70: 501–508. https://doi.org/10.1016/j.redare.2022.10.010.

[11] Kappenschneider T, Maderbacher G, Weber M, Greimel F, Holzapfel D, Parik L, *et al*. Special orthopaedic geriatrics (SOG) - a new multiprofessional care model for elderly patients in elective orthopaedic surgery: a study protocol for a prospective randomized controlled trial of a multimodal intervention in frail patients with hip and knee replacement. BMC Musculoskeletal Disorders. 2022; 23: 1079. https://doi.org/10.1186/s12891-022-05955-w.

[12] Wainwright TW, Gill M, McDonald DA, Middleton RG, Reed M, Sahota O, *et al*. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Acta Orthopaedica. 2020; 91: 3–19. https://doi.org/10.1080/17453674.2019.1683790.

[13] Li JQ, Yuan H, Wang XQ, Yang M. Dexmedetomidine-induced anesthesia in elderly patients undergoing hip replacement surgery. World Journal of Clinical Cases. 2023; 11: 3756–3764. https://doi.org/10.12998/wjcc.v11.i16.3756.

[14] Song Y, Zou XJ. Remimazolam dosing for intraoperative sedation in elderly patients undergoing hip replacement with combined spinal-epidural anesthesia. European Review for Medical and Pharmacological Sciences. 2023; 27: 7485–7491. https://doi.org/10.26355/eurrev_202308_33399.

[15] Li WX, Luo RY, Chen C, Li X, Ao JS, Liu Y, *et al*. Effects of propofol, dexmedetomidine, and midazolam on postoperative cognitive dysfunction in elderly patients: a randomized controlled preliminary trial. Chinese Medical Journal. 2019; 132: 437–445. https://doi.org/10.1097/CM9.0000000000000098.

[16] Duan J, Ju X, Wang X, Liu N, Xu S, Wang S. Effects of Remimazolam and Propofol on Emergence Agitation in Elderly Patients Undergoing Hip Replacement: A Clinical, Randomized, Controlled Study. Drug Design, Development and Therapy. 2023; 17: 2669–2678. https://doi.org/10.2147/DDDT.S419146.

[17] Endersby RVW, Moser JJ, Ho ECY, Yu HC, Spencer AO. Motor blockade after iliopsoas plane (IPB) and pericapsular nerve group (PENG) blocks: A little may go a long way. Acta Anaesthesiologica Scandinavica. 2021; 65: 135–136. https://doi.org/10.1111/aas.13707.

[18] Lu S, Reddy AJ, Fei M, Wagh H, Iskandar NP, Lien J, *et al*. A Systematic Review of the Usage of Lidocaine in Hip Replacement Surgery. Cureus. 2023; 15: e37498. https://doi.org/10.7759/cureus.37498.

[19] Nielsen ND, Bendtsen TF. In response: Motor blockade after iliopsoas plane (IPB) and pericapsular nerve group (PENG) blocks: A little may go a long way. Acta Anaesthesiologica Scandinavica. 2021; 65: 137–138. https://doi.org/10.1111/aas.13708.

[20] Pires Sousa I, Leite da Silva Peixoto CI, Fernandes Coimbra LA, da Costa Rodrigues FM. Comparison of pericapsular nerve group (PENG) block and epidural analgesia following total hip arthroplasty: A retrospective analysis. Revista Espanola de Anestesiologia y Reanimacion. 2022; 69: 632–639. https://doi.org/10.1016/j.redare.2022.10.002.

[21] Matharu GS, Garriga C, Rangan A, Judge A. Does Regional Anesthesia Reduce Complications Following Total Hip and Knee Replacement Compared With General Anesthesia? An Analysis From the National Joint Registry for England, Wales, Northern Ireland and the Isle of Man. The Journal of Arthroplasty. 2020; 35: 1521–1528.e5. https://doi.org/10.1016/j.arth.2020.02.003.

[22] Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care & Research. 2011; 63: S240–S252. https://doi.org/10.1002/acr.20543.

[23] Inouye SK, Westendorp RGJ, Saczynski JS. Delirium in elderly people. Lancet. 2014; 383: 911–922. https://doi.org/10.1016/S0140-6736(13)60688-1.

[24] Calkins TE, Johnson EP, Eason RR, Mihalko WM, Ford MC. Spinal Versus General Anesthesia for Outpatient Total Hip and Knee Arthroplasty in the Ambulatory Surgery Center: A Matched-Cohort Study. The Journal of Arthroplasty. 2024; 39: 1463–1467. https://doi.org/10.1016/j.arth.2023.12.020.

[25] Martínez Martín A, Pérez Herrero M, Sánchez Quirós B, López Herrero R, Ruiz Bueno P, Cocho Crespo S. Benefits of analgesic blocks, PENG block (PEricapsular Nerve Group), in fast recovery after hip surgery. Revista Espanola de Cirugia Ortopedica y Traumatologia. 2023; 67: T27–T34. https://doi.org/10.1016/j.recot.2022.10.005.

[26] Braun AS, Peabody Lever JE, Kalagara H, Piennette PD, Arumugam S, Mabry S, *et al*. Comparison of Pericapsular Nerve Group (PENG) Block Versus Quadratus Lumborum (QL) Block for Analgesia After Primary Total Hip Arthroplasty Under Spinal Anesthesia: A Retrospective Study. Cureus. 2023; 15: e50119. https://doi.org/10.7759/cureus.50119.

[27] 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. Anesthesia, Essays and Researches. 2021; 15: 352–356. https://doi.org/10.4103/aer.aer_119_21.

[28] Schwenk ES, McCartney CJ. General anesthesia is an acceptable choice for hip fracture surgery. Regional Anesthesia and Pain Medicine. 2023; 48: 428–429. https://doi.org/10.1136/rapm-2023-104454.

[29] Huang Y, Huang Y, Chen Y, Yang Q, Yin B. Complications and hospitalization costs in patients with hypothyroidism following total hip arthroplasty. Journal of Orthopaedic Surgery and Research. 2023; 18: 567. https://doi.org/10.1186/s13018-023-04057-0.

[30] Girón-Arango L, Peng PWH, Chin KJ, Brull R, Perlas A. Pericapsular Nerve Group (PENG) Block for Hip Fracture. Regional Anesthesia and Pain Medicine. 2018; 43: 859–863. https://doi.org/10.1097/AAP.0000000000000847.