Am J Transl Res 2026;18(2):1264-1277
www.ajtr.org /ISSN:1943-8141/AJTR0169498

Original Article

Influence of different anesthesia methods on outcome of elderly patients undergoing hip surgery

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Received October 23, 2025; Accepted January 28, 2026; Epub February 15, 2026; Published February 28, 2026

Abstract: Objective: To compare the effects of general anesthesia (GA) combined with ultrasound-guided iliac fascia compartment nerve block (NB) versus GA alone on perioperative outcomes, inflammatory response, and recovery in elderly patients undergoing hip surgery. Methods: A retrospective analysis was conducted on 200 elderly patients undergoing hip surgery at Liuzhou People's Hospital between Jan 2022 and Jan 2023. Patients were divided into a control group (n=102, GA alone) and an observation group (n=98, GA+NB). Primary outcomes included anesthesia satisfaction, hemodynamic stability, recovery indices (anesthesia recovery time and extubation time), postoperative pain scores, and complications. Serum levels of pro-inflammatory cytokines, interleukin-6 (IL-6), and tumor necrosis factor-α (TNF-α), were detected preoperatively and 3 days postoperatively to evaluate the inflammatory response. Results: The observation group showed significantly higher anesthesia satisfaction (P<0.001) and more stable hemodynamics (all P<0.05) compared to the control group. Recovery indicators were significantly improved in the observation group, with shorter anesthesia recovery time and extubation time (all P<0.001). The observation group had lower postoperative visual analog scale (VAS) pain scores and required fewer supplementary analgesics (all P<0.05). Three days post-surgery, the observation group demonstrated greater improvement in functional outcomes, a lower incidence of nausea/vomiting and postoperative complications (all P<0.05), and lower serum levels of IL-6 and TNF-α compared to the control group (all P<0.001). Conclusion: GA+NB improves anesthesia satisfaction, stabilizes hemodynamics, alleviates inflammation, reduces pain and complications, and accelerates recovery in elderly hip surgery patients, supporting its routine clinical application.

Keywords: Anesthesia methods, ultrasound-guided nerve blockade, general anesthesia, elderly hip surgery, postoperative analgesia

Introduction

The global population of individuals aged 60 years and above is projected to reach a maximum of approximately 482 million in 2053 [1]. Aging is accompanied by progressive deterioration in the structure and function of multiple organs and tissues, resulting in reduced physiologic adaptability and resistance to external stressors [2]. Hip joint disease is one of the most prevalent orthopedic conditions affecting the elderly population, primarily including femoral head avascular necrosis and femoral neck fracture. Early surgical treatment remains the most effective strategy for these conditions [3, 4]. Artificial hip replacement is a well-established and widely performed surgical procedure, that enables rapid restoration of joint function, facilitates early rehabilitation, and reduces the incidence of complications such as deep venous thrombosis (DVT), pulmonary infection, and pressure sore due to prolonged bed-rest [5].

However, elderly patients often present with chronic comorbidities, which complicate their conditions. These comorbidities impair tolerance to trauma, infection, surgery, and anesthesia, thereby increasing perioperative risk [6, 7]. Therefore, the selection of appropriate anesthesia techniques to maintain organ function and assure perioperative safety and stability is critical for favorable surgical outcomes.

In recent years, anesthesia methods combining general anesthesia with ultrasound-guided

https://doi.org/10.62347/NJEA5722

nerve block have been increasingly applied in different surgical fields, demonstrating favorable perioperative outcomes based on evidence-based anesthetic practice [8, 9]. Although several studies have discussed the benefits of nerve blockade as an adjuvant to general anesthesia, evidence specifically focusing on elderly patients undergoing hip surgery remains limited. Therefore, this study aimed to compare the effects of general anesthesia alone versus general anesthesia combined with ultrasound-guided nerve blockade in elderly patients undergoing hip surgery.

Patients and methods

Study design and participants

In this single-center, retrospective cohort study, a total of 200 elderly patients who underwent total hip arthroplasty or hemiarthroplasty at Liuzhou People's Hospital between January 1, 2022 and January 31, 2023 were included. Clinical data of eligible patients were retrospectively collected from the hospital's electronic medical record system (EMRS).

The sample size was determined using the formula $n = \frac{Z^2 \times p \times (1 - p)}{d^2}$, where Z standard normal deviate corresponding to the desired confidence level (95% confidence level, yielding Z=1.96); The expected postoperative complication rate (p) was set at 30% based on previously published studies and a preliminary review of medical records at our institution [10]. Accordingly, (1-p) the probability of no complications (0.70). The allowable margin of error (d) was defined as 0.065, indicating that the difference between the estimated and true complication rates would not exceed 6.5%, which was considered acceptable for a clinical observational study. Based on these criteria, a total of 200 patients were ultimately included in the study.

Inclusion criteria: (1) Patients who met the indications for total hip arthroplasty or hemiarthroplasty [11]; (2) Complete patient data available.

Exclusion criteria: (1) Presence of mental illness or disturbance of consciousness; (2) cognitive or language impairment; (3) coagulation disorders; (4) malignant tumors; or (5) severe systemic infection.

Patients were divided into a control group (n=102, general anesthesia alone) and an observation group (n=98, general anesthesia combined with ultrasound-guided nerve block) based on the anesthesia method documented in the medical records. The study was conducted in strict adherence to the Helsinki Declaration and was approved by the Ethics Committee of Liuzhou People's Hospital (Approval Number: KY2024-082-01). The study flow chart is shown in **Figure 1**.

Anesthesia protocols

Patients in the control group received general anesthesia alone. Preoperative anesthesia consultations were conducted to evaluate lesion extent and medical history. Routine premedication, including anticholinergics agents (atropine sulfate injection; Manufacturer: TianJini Jinyao Pharmaceutical Co., Ltd., TianJin, China; Lot number: H12020383), was administered to reduce salivary secretions. Upon entering the operating room, routine monitoring was initiated, including electrocardiogram, noninvasive blood pressure, and pulse oximetry. General anesthesia was induced with intravenous propofol (Sichuan Guorui Medicine Co., Ltd., Sichuan, China; Lot number: H20163404) (2-3 mg/kg), fentanyl (Hubei Yichang Renfu Pharmaceutical Co., Ltd., Hubei, China; Lot number: H1130407) (3-5 μg/kg), and rocuronium (Zhejiang Xianju Medicine Co., Ltd., Lianyungang, China; Lot number: H20093186) (0.6 mg/kg), followed by tracheal intubation. Anesthesia was maintained with 1-2% sevoflurane (Shanghai Hengrui Medicine Co., Ltd., Shanghai, China; Lot number: H20070172) in a 50% oxygen mixture. Additional rocuronium was administered as needed to maintain muscle relaxation. Intraoperative hemodynamics was monitored, with blood pressure maintained at ≥80% of the baseline values. Phenylephrine (Abmole, USA; Lot number: M3330) was administered in case of hypotension. After surgery, patients were extubated once the standard clinical extubation criteria were met.

Patients in the observation group received general anesthesia combined with ultrasound-guided fascia iliac compartment block (FICB). Preoperative evaluation were consistent with the control group. All ultrasound-guided FICB procedures were performed by anesthesiolo-

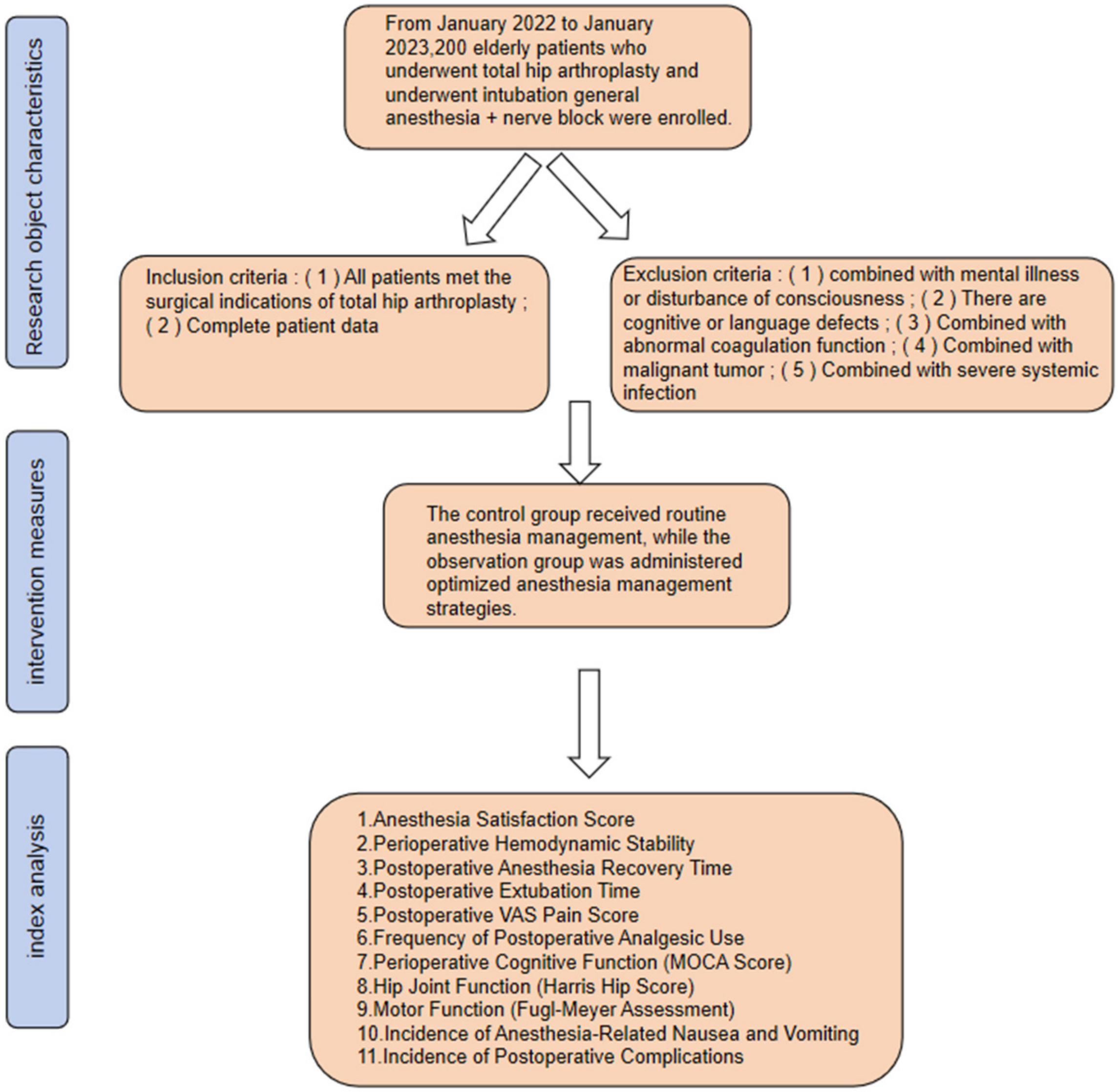

Figure 1. Research flow chart. Note: VAS, visual analog scale; MoCA, Montreal Cognitive Assessment.

gists with attending physician or higher professional title and at least 5 years of clinical anesthesia experience. All operators completed standardized training and achieved a first puncture success rate of 95.2% (93/98 cases in this group) and a block onset time (local injection to sensory block score ≥2 points) of 12.5±2.3 minutes.

The ultrasound-guided nerve blockade was performed strictly prior to general anesthesia induction. A 6-12 MHz linear probe was used to visualize the space between the iliacus and psoas muscles anteriorly. Under real-time ultrasound guidance, a 22G block needle was advanced using an in-plane technique. After two consecutive negative aspirations to exclude intravascular injection, 30 mL of 0.375% ropivacaine (Shanghai Zhaohui Medicine Co., Ltd., Shanghai, China; Lot number: C21I016) was injected at a constant rate of 6-10 mL/min over a total injection duration of 3-5 minutes. The spread of the local anesthetic was monitored in real-time by ultrasound to ensure uniform distribution within the target nerves, achieving adequate coverage of the femoral nerve and its branches. General anesthesia induction and maintenance regimens were consistent with the control group, except that fentanyl dose was reduced by 50% (1.5-2.5 μg/kg). All anesthetics, except ropivacaine, were sourced from the same man-

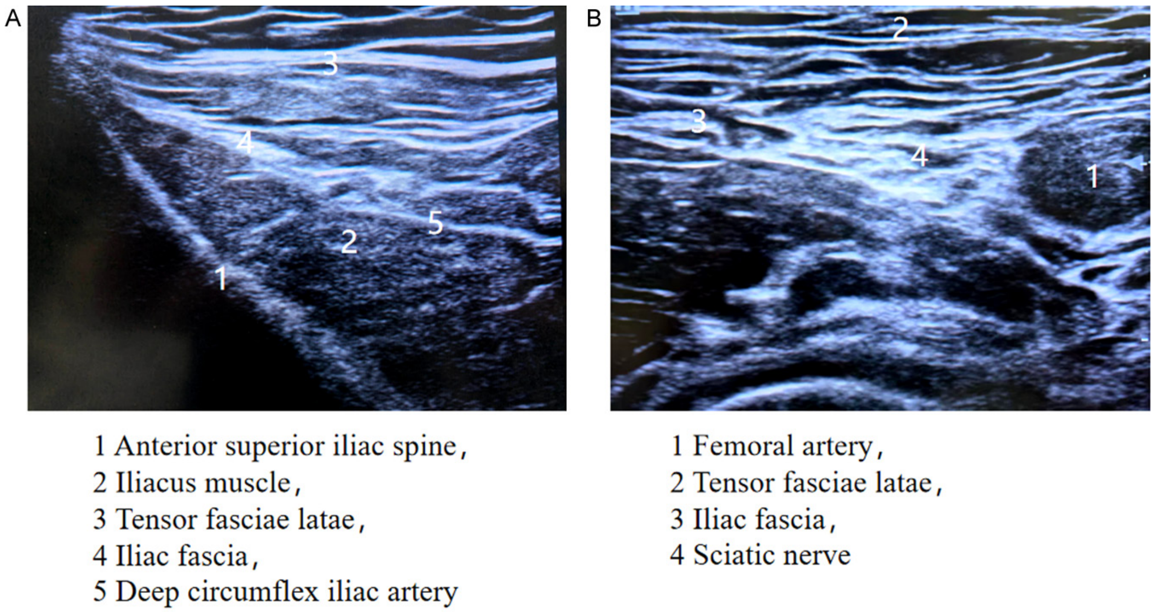

Figure 2. Ultrasound images of relevant anatomic structures for the iliac fascia compartment block. A: Ultrasound anatomic view of the anterior superior iliac spine region, used for initial localization of the block; B: Ultrasound anatomic view adjacent to the femoral artery, assisting in confirmation of vascular and neural structures within the block area.

ufacturer and lot numbers as those used in the control group. Routine hemodynamic monitoring was performed, and no additional fluid management or temperature control strategies were implemented beyond standard practice. Postoperative extubation criteria were identical to the control group. The anatomic landmarks for ultrasound-guided FICB are shown in **Figure 2**.

The blocking effect was evaluated using sensory and motor block scoring systems at 5, 10, and 15 minutes after the completion of local anesthetic injection. Sensory block score was assessed using a pinprick test and graded on a 4-point scale (0= no block, 1= hypoalgesia, 2= analgesia, 3= complete anesthesia), while the motor block score was evaluated using the modified Bromage scale (0= no motor block, 1= inability to lift the thigh, 2= inability to bend the knee, 3= inability to flex the ankle); a sensory block score ≥2 was defined as an effective block, and the time taken to achieve this effective block was recorded. All block assessments were documented in the anesthesia records by independent nurses who were blinded to group allocation to ensure the objectivity of the assessment.

Outcome measures

Three days after the surgery, patients' satisfaction with the anesthetic technique was evaluated using a specifically designed questionnaire. The anesthesia satisfaction questionnaire was developed by a multidisciplinary team comprising experts in anesthesiology, psychology, and public health, based on an exhaustive literature review and in-depth expert consultations. The questionnaire was multidimensional and focused exclusively on patient experience related to the anesthetic technique, including pain during intravenous injection, nausea or dizziness after induction, and discomfort during emergence from anesthesia. The total score ranged from 0 to 100 points, with higher scores indicating greater satisfaction with the anesthetic method used. The scale demonstrated a satisfactory level of internal consistency, with a Cronbach's α coefficient of 0.713.

Anesthetic recovery was evaluated using two variables: anesthesia recovery time and extubation time. Anesthesia recovery time was defined as the interval from anesthesia initiation to the time when the patient was able to obey verbal commands, while extubation time was defined as the interval from the end of surgery to extubation. These indices were used to comprehensively assess the effect of different anesthetic techniques (GA alone versus GA combined with ultrasound-guided nerve block) on postoperative recovery.

Cardiovascular response to anesthesia and surgical stress were assessed through monitoring hemodynamic parameters at four predefined time points: before anesthesia (t0), at skin incision (t1), at the end of surgery (t2), and 1 hour postoperatively (t3). Hemodynamic values, including systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR), were continuously monitored using a multi-parameter monitor.

Postoperative pain was assessed using the visual analog scale (VAS) at the following time points: immediately after extubation (T1), 1 hour (T2), 6 hours (T3), 12 hours (T4), 24 hours (T5) and 48 hours (T6) postoperatively [12]. The VAS scale ranges from 0 to 10 points, with 0 indicating no pain and 10 indicating extreme pain.

Postoperative pain management was adjusted according to the anesthetic method used. Patients in the control group received a multimodal analgesic regimen, including oral paracetamol (0.3-0.6 g per dose, maximum 2 g/day) and ketorolac tromethamine (30 mg every 6-8 hours). When VAS pain scores was ≥6, tramadol was administered at an initial dose of 50 mg, with repeat doses every 4-6 hours up to a maximum of 400 mg/day. On the other hand, patients in the research group received a longer duration of local anesthesia. Paracetamol was administered at a reduced dosage of 0.3-0.4 g per dose (maximum 1.5 g/day) and the dosing interval for ketorolac was extended to 8-12 h. Tramadol was administered only when the VAS score exceeded 7, with a total daily dose less than 300 mg/day. All the doses were tailored according to real-time pain assessments and clinical monitoring to maximize analgesic efficacy while minimizing opioid use.

Cognitive function was evaluated on the day before and after surgery using the Montreal Cognitive Assessment (MoCA) [13]. The scale evaluates cognitive performance across eight dimensions: visuospatial and execution, naming, memory, attention, language, abstraction, delayed recall, and orientation. The total score ranges from 0 to 30, with higher score indicating better cognitive function.

Post-operative functional recovery was evaluated using the Harris Hip Score (HHS) [14], a 100-point scale in which higher score indicating better hip joint function. The HHS assesses pain, mobility, and deformity. Motor function was evaluated using the simplified Fugl-Meyer Motor Assessment Scale [15], with dysfunction classified as severe (<50), significant (50-85), moderate (85-95), and mild (95-100). Both assessments were conducted 1 day preoperatively and on postoperative day 3.

Peripheral venous blood samples (5 mL) were collected from all patients preoperatively and on postoperative day 3. Serum levels of inflammatory factors interleukin-6 (IL-6) and tumor necrosis factor-α (TNF-α) were detected using enzyme-linked immunosorbent assay (ELISA) kits (IL-6 kit: R&D Systems, USA; Lot: 20230615; TNF-α kit: Thermo Fisher Scientific, USA; Lot: PA1-73011) in strict accordance with the manufacturers' instructions. Absorbance was measured at 450 nm using a microplate reader (Bio-Rad, USA), and concentrations were calculated based on standard curves.

Immediate anesthesia-related adverse reactions were compared between the two groups, including nausea/vomiting, hypotension, and bradycardia. Postoperative anesthesia-related complications were also compared, including fever (≥38°C for >2 hours), and nausea/vomiting. Postoperative infection was evaluated as a secondary outcome, defined by laboratory tests, including white blood cell count (WBC) $>10\times10^9$/L, C-reactive protein (CRP) >10 mg/L, and erythrocyte sedimentation rate (ESR) >20 mm/h. Blood samples were collected at 24 hours postoperatively using a Mindray BC5390 analyzer, with repeated measurements at 48 and 72 hours, and mean values were used for analysis to assess the effect of anesthesia methods on surgical stress responses.

Statistical analysis

Statistical analyses were performed using SPSS 27.0 statistical software. Continuous variables were presented as mean ± standard deviation (SD) with corresponding 95% confi-

Table 1. Comparison of clinical characteristics between the two groups

	control group (n=102)	observation group (n=98)	t/χ^2	*P* value
Age	70.53±5.99	69.31±6.09	1.432	0.154
Sex (male/female)	48/54	38/60	1.399	0.237
BMI	23.01±3.81	23.34±3.93	-0.590	0.556
Smoking (yes/no)	16/86	18/80	0.255	0.614
Alcohol consumption (yes/no)	24/78	16/82	1.621	0.203
Hypertension (yes/no)	34/68	32/66	0.010	0.919
Diabetes (yes/no)	24/78	20/78	0.284	0.594
Hyperlipidemia (yes/no)	18/84	14/84	0.420	0.517
Classification of fracture			3.369	0.510
osteonecrosis of the femoral head	36	46		
transcervical fracture	44	32		
intertrochanter fracture of femur	2	2		
congenital hip dysplasia with hip arthritis	8	10		
poor postoperative fracture healing	12	8		
Marital status			0.554	0.758
unmarried	6	4		
married	82	78		
divorced or widowed	14	16		

dence interval (CI). Inter-group comparisons were conducted using the independent-samples *t*-test. Changes in VAS scores across different time points were analyzed using repeated-measures analysis of variance. Categorical variables were expressed as counts and percentages and were compared using the χ^2 test or Fisher's exact test, as appropriate. A two-sided *p*-value less than 0.05 was considered significant.

Results

Baseline characteristics of patients

As shown in **Table 1**, no significant differences were observed between the two groups in age, sex distribution, fracture type, marital status, prevalence of hypertension, smoking history, or other baseline characteristics (all $P>0.05$), indicating that the two groups were comparable at baseline.

Anesthesia efficacy assessment

In the observation group, effective block (sensory block score ≥2) was achieved in all patients within 15 minutes after local anesthetic injection, with an effective rate of 100%. The mean time to effective block was 12.5±2.3 minutes. Specifically, the mean sensory block scores at 5, 10, and 15 minutes after injection were 1.2±0.4, 2.1±0.3, and 2.8±0.5, respectively, while the mean motor block scores were 0.5±0.2, 1.0±0.3, and 1.5±0.4, respectively. These results indicate that ultrasound-guided FICB was successfully performed in all patients in the observation group, providing a reliable basis for subsequent perioperative analgesia and anesthetic-sparing effect.

Hemodynamic stability during the perioperative period

As shown in **Table 2**, the control group exhibited significant fluctuations in hemodynamic indices, including DBP, SBP, and HR, at t1, t2, and t3 compared to baseline values at t0 (all $P<0.05$). In contrast, the observation group showed relatively stable hemodynamic parameters, with no significant differences compared to t0. Moreover, all hemodynamic values in the observation group were significantly lower than those of the control group at t1-t3 ($P<0.05$).

Anesthesia satisfaction and recovery indices

After operation, the anesthesia satisfaction score in the observation group was 88.82±4.83, significantly higher than 81.49±5.50 in the control group ($P<0.001$; **Figure 3**).

Table 2. Comparison of hemodynamic values between the two groups at different time points

Group	n	DBP (mmHg)	SBP (mmHg)	HR (beats/min)
Control group	102			
t0		70.06±5.93	114.86±10.40	70.65±7.45
t1		74.82±6.66*	123.95±13.64*	79.20±9.46*
t2		78.48±:8.13*	135.84±16.53*	86.28±10.13*
t3		75.97 ±7.03*	126.15±12.03*	80.28±9.99*
Observation group	98			
t0		69.68 ±6.21	115.95±10.83	69.82±7.50
t1		70.89 ±7.11#	117.45±11.42#	71.08±7.80#
t2		72.29 ±7.58#	120.36±13.34#	72.90±9.31#
t3		72.27 ±7.57#	118.07±10.53#	71.71±8.78#

Note: **P*<0.05 vs. the same group at time point t0; #*P*<0.05 vs. the control group at the same time point. SBP, systolic blood pressure; HR, heart rate; SD, standard deviation.

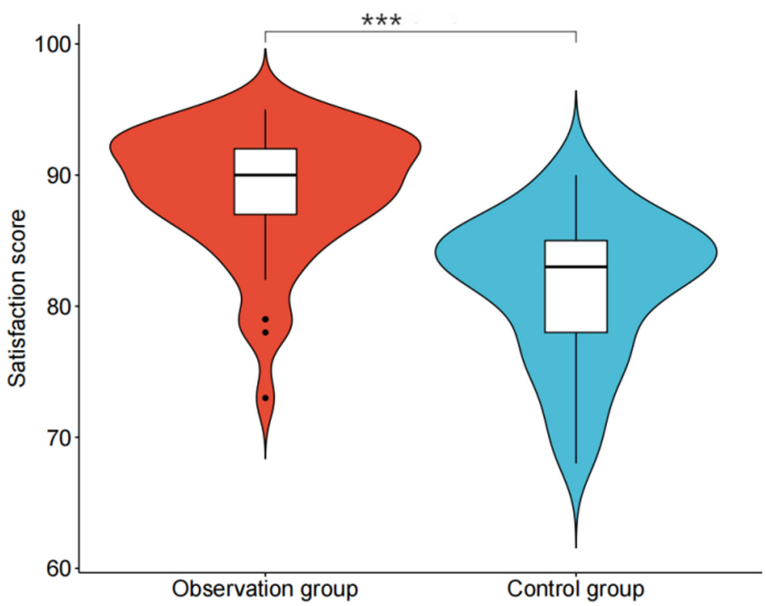

Figure 3. Comparison of anesthesia satisfaction scores between the two groups.****P*<0.001.

The mean anesthesia recovery time was (36.76±3.27) min in the observation group, significantly shorter than (47.53±4.01) min in the control group (*P*<0.001). In addition, the mean extubation time was (52.18±8.33) min in the observation group, compared to (68.14±9.42) min in the control group (*P*<0.001), as shown in **Figure 4**.

Postoperative pain scores and analgesic consumption

Repeated-measures analysis of variance revealed significant main effects of group (F=437.90, P<0.001, partial η^2=0.689) and time (F=75.99, *P*<0.001, partial η^2=0.277), as well as a significant group × time interaction (F=12.19, *P*<0.001, partial η^2=0.058). These results indicate that postoperative pain trajectories differed significantly between groups: the observation group maintained consistently lower VAS scores (1-2 points) across all time points, while the control group showed a pattern of gradual increase followed by a decrease in VAS scores (2-3 points) (**Figure 5**). At each postoperative assessment time point (T1-T6), VAS scores in the observation group were significantly lower than those of the control group (all *P*<0.05).

In terms of postoperative opioid consumption, 6 patients in the observation group required a single 50-mg dose of tramadol, resulting in a total supplementary tramadol dosage of 300 mg. In the control group, 30 patients received one 50-mg dose and 14 patients received two consecutive 50-mg doses, resulting in a total supplementary tramadol dosage of 2900 mg. The total supplementary tramadol dosage in the observation group was significantly lower than that in

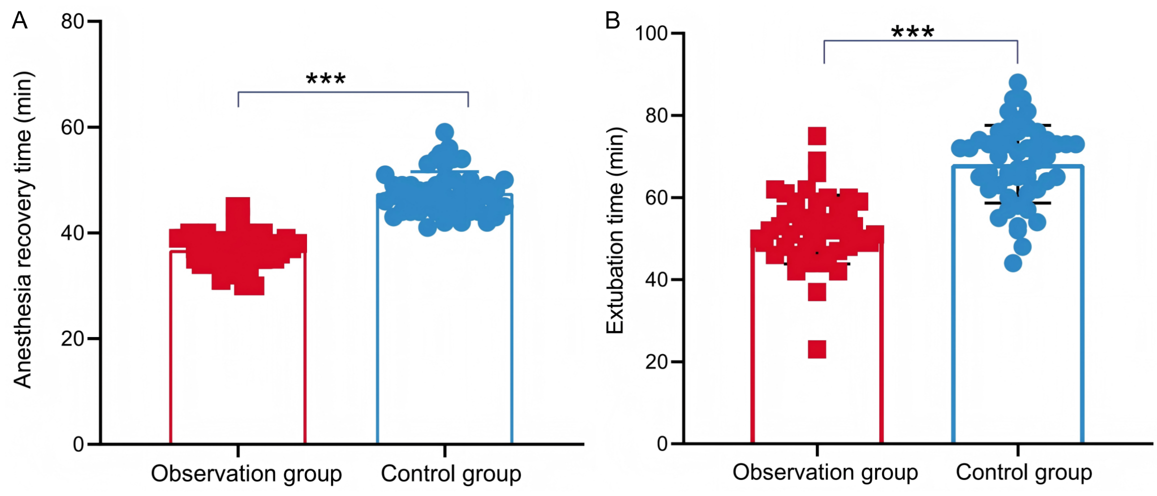

Figure 4. Comparison of anesthesia recovery and extubation times between the two groups. ***P<0.001.

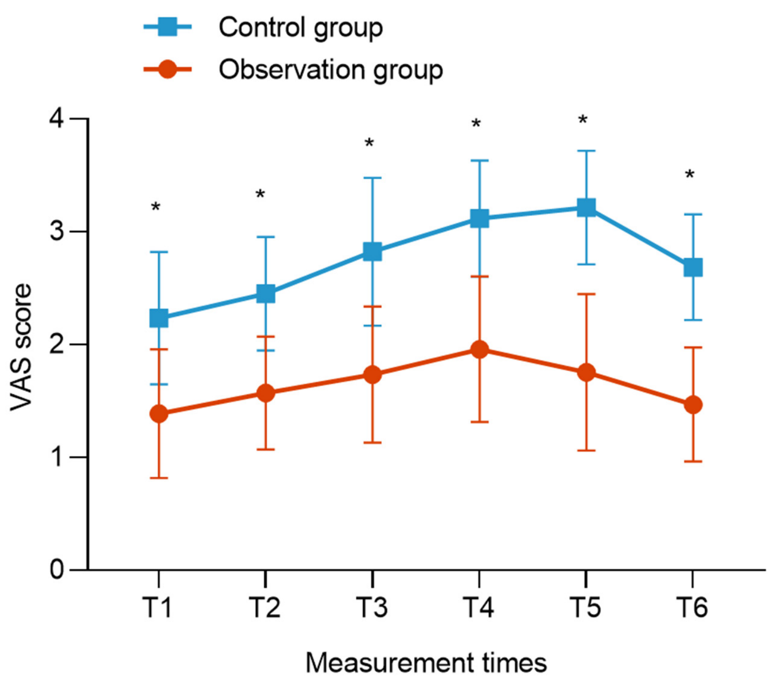

Figure 5. Comparison of VAS scores at different time points between the two groups. Notes: T1: post-extubation, T2: 1 h postoperatively, T3: 6 h postoperatively, T4: 12 h postoperatively, T5: 24 h postoperatively, T6: 48 h postoperatively. *P<0.05; VAS, visual analog scale.

the control group (P<0.001), representing an 89.7% reduction (**Table 3**).

Postoperative cognitive and functional recovery

Assessment of cognitive function showed no significant difference in preoperative MOCA scores between the two groups (27.90±0.64 vs. 27.88±0.72, P>0.05). Postoperatively, the observation group achieved markedly higher MoCA scores (25.18±0.75 vs. 23.73±1.00, P<0.001) (**Figure 6**).

Regarding functional recovery, preoperative HHS and Fugl-Meyer motor function scores were comparable between the two groups (both P>0.05). On postoperative day 3, both scores improved in both groups, with the observation group achieving significantly higher scores than the control group (both P<0.001; **Figure 7**).

Postoperative serum levels of inflammatory cytokines (IL-6 and TNF-α)

As shown in **Table 4**, both groups exhibited elevated serum IL-6 and TNF-α levels on postoperative day 3 compared to preoperative levels. However, the observation group exhibited significantly lower levels of IL-6 and TNF-α compared to the control group (all P<0.05).

Incidence of adverse events

As shown in **Table 5**, the observation demonstrated significantly lower incidence of anesthesia-related adverse reactions, including nausea (2.01% vs. 15.69%; χ^2=11.363, P<

Table 3. Comparison of postoperative tramadol supplementation between the two groups

Tramadol Supplementation Times	Control group (n=102)	Observation group (n=98)	χ^2	*P* value
1st dose (50 mg)	30	6	5.698	0.017
2st dose (50 mg)	14	0	14.463	<0.001
Total dose	2900 mg	300 mg	-	-

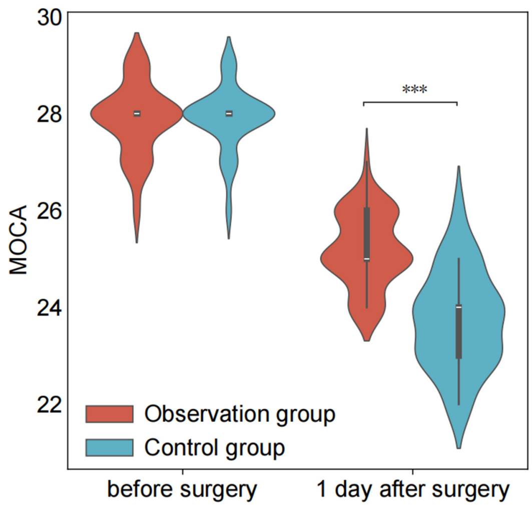

Figure 6. Comparison of MOCA scores between the two groups.****P*<0.001; MoCA, Montreal Cognitive Assessment.

0.001) and vomiting (2.04% vs. 9.80%; χ^2=5.341, P=0.021). Additionally, the incidence of postoperative complications was significantly lower in the observation group compared to the control group (3.06% vs. 13.73%; χ^2=7.308, P=0.007). However, no significant differences were observed between the two groups in terms of infection (5.88% vs. 3.06%; P=0.499). Importantly, no incidence of hypotension, bradycardia, or headache was noted in both groups.

Discussion

Elderly patients tend to have multiple chronic comorbidities and age-related degenerative changes in organ function, resulting in reduced drug metabolism and tolerance compared to younger patients. Consequently, optimizing anesthesia outcomes in geriatric populations has become a major focus of perioperative research [16].

Our results demonstrated that patients in the observation group (GA combined with ultrasound-guided nerve block) exhibited significantly higher anesthesia satisfaction scores, shorter anesthesia recovery and extubation times, and consistently lower postoperative VAS pain scores at all evaluated time points compared to the control group (GA alone). These findings are consistent with those of Abd El-Radi et al. [17], who reported in a prospective randomized controlled trial in elderly patients undergoing hip arthroplasty that GA combined with ultrasound-guided suprainguinal iliac fascia block improved anesthesia satisfaction, shortened emergence times, and reduced 24h VAS scores compared with GA alone. These beneficial effects may be largely attributed to the precise analgesia provided by ultrasound-guided FICB. By targeting the femoral nerve, lateral femoral cutaneous nerve, and obturator nerve, this technique attenuates nociceptive input at its source, thereby reducing intraoperative anesthetic dosage and perioperative stress responses - critical for elderly patients with compromised organ reserve and drug tolerance [18, 19]. Nerve blocks, achieved by injecting local anesthetics around specific nerves or plexuses, interrupt nerve conduction and provide temporary sensory and motor blockade. They are commonly used for surgical anesthesia, postoperative analgesia, and perioperative pain control, and can be classified according to anatomical targets, such as brachial plexus, lumbar plexus, or sciatic nerve blocks [20].

The superiority of this combined anesthesia approach appears to arise from a dual mechanism. First, ultrasound guidance allows accurate injection of 30 ml of 0.375% ropivacaine into the iliac fascia compartment, providing a long-lasting blockade of the femoral, lateral femoral cutaneous, and the obturator nerves. This broad coverage of hip sensory innervation significantly reduces the requirement for systemic opioids, as evidenced by the markedly lower postoperative tramadol consumption by 89.7% in the observation group. This opioid-sparing effect is consistent with previous evidence: a meta-analysis of lumbar spine surgery

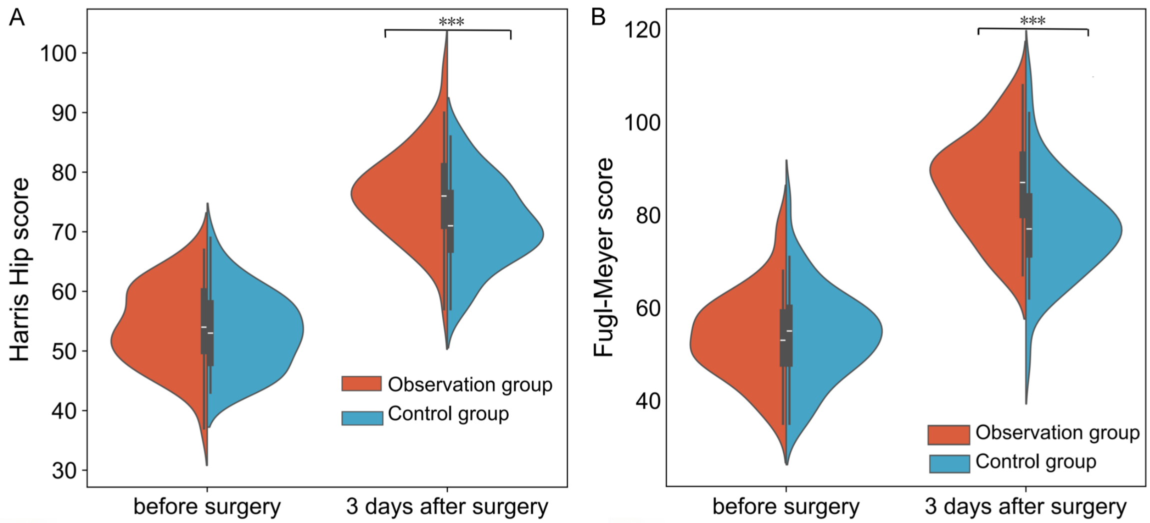

Figure 7. Comparison of hip function and motor recovery between the two groups.****P*<0.001.

Table 4. Comparison of postoperative serum IL-6 and TNF-α levels between the two groups

Inflammatory cytokine	Time point	Control group (n=102)	Observation group (n=98)	*t*	*P* Value
IL-6 (pg/mL)	Before surgery	32.5±5.7	33.8±6.4	-1.518	0.131
	3 days after surgery	65.4±10.8	43.2±9.6	15.342	<0.001
TNF-α (pg/mL)	Before surgery	12.5±4.1	12.3±3.9	0.311	0.756
	3 days after surgery	25.3±4.9	18.7±4.2	10.209	<0.001

Note: IL-6, interleukin-6; TNF-α, tumor necrosis factor-α.

Table 5. Comparison of adverse events between the two groups

Adverse events	control group (n=102)	observation group (n=98)	χ^2	*P* value
Nausea	16	2	11.363	<0.001
Vomiting	10	2	5.341	0.021
Fever	14	3	7.308	0.007
Infection	6	3		0.499*
hypotension	0	0		
bradycardia	0	0		
headache	0	0		

Note: * indicates the result of Fisher's exact test.

confirmed that regional nerve blocks (e.g., erector spinae plane block) markedly reduce postoperative opioid use and pain scores, and similar findings were observed in pediatric adenotonsillectomy, where ultrasound-guided maxillary nerve block decreased intraoperative and postoperative opioid requirements. These studies collectively validate that precise nerve blockade can effectively [21, 22]. Second, the addition of nerve blockade allows a 50% reduction in fentanyl dosage during anesthesia induction, minimizing cardiovascular depression and maintaining hemodynamic stability - evidenced by significantly smaller fluctuations in blood pressure and HR at critical time points (T1-T3) compared with the GA group. This anesthetic-sparing effect aligns with a study on pediatric cheiloplasty, where bilateral infraorbital nerve block reduced intraoperative anesthetic requirements and stabilized hemodynamics. Moreover, similar hemodynamic benefits have been reported in diabetic patients undergoing foot surgery, where peripheral nerve block effectively attenuated perioperative blood pressure fluctuations, highlighting the universal value of nerve block in optimizing anesthesia management and maintaining circulatory stability [23, 24]. Ropivacaine, a commonly used anesthetic, provides sustained and long-lasting anesthesia, making it effective for various surgeries. Nevertheless, factors such as tissue diffusion and metabolic variability may influence its clinical efficacy [25, 26].

Importantly, the superiority of GA combined with ultrasound-guided nerve blockade is particularly well suited to the physiologic characteristics of elderly patients. Age-related degeneration of multiple organs (e.g., impaired liver/kidney metabolism, reduced cardiac reserve) lead to poor anesthetic tolerance and higher adverse reaction risks in elderly individuals. Ultrasound-guided precise positioning addresses these limitations by enabling real-time visualization of the iliac fascia compartment and target nerves, thereby ensuring accurate deposition of local anesthetics. This targeted delivery maximizes analgesia with minimal diffusion, thereby reducing systemic anesthetic dosage (e.g., 50% fentanyl reduction) and avoiding excessive organ exposure. Supporting this, a study on pediatric caudal epidural block demonstrated that ultrasound guidance significantly improved first puncture success rate (90.6% vs. 64.2% for blind puncture) and reduced puncture attempts (1.09±0.30 vs. 1.45±0.67), while minimizing vascular/dural injury [27]. Though focused on pediatrics, this core merit - real-time anatomical visualization [28] - applies equally to iliac fascia compartment block in elderly hip surgery. For elderly patients with fragile vascular and neural structures, fewer punctures and precise targeting directly lower iatrogenic injury risk, further contributing to the reduced adverse reactions and stable hemodynamics observed in the observation group.

Notably, the observation group also demonstrated a markedly lower incidence of postoperative fever and attenuated inflammatory responses, which is likely due to reduced surgical stress and suppression of systemic inflammatory cascades triggered by effective nerve blockade [29]. Serum levels of IL-6 and TNF-α were elevated in both groups after operation, consistent with previous reports that surgical trauma universally induces inflammatory response [30]. However, the magnitude of elevation in the observation group was significantly smaller.

The anti-inflammatory effects observed in the observation group are not accidental but closely linked to its dual mechanism. First, precise nerve block attenuates peripheral pain signals, thereby reducing activation of the hypothalamic-pituitary-adrenal (HPA) axis and sympathetic nervous system. This modulation may limit the excessive release of pro-inflammatory cytokines from immune cells in response to surgical stress. Second, the 50% reduction in fentanyl dosage and reduced systemic anesthetic exposure may help preserve immune function and prevent a potential "second hit" to inflammatory regulatory pathways [31]. As key mediators of postoperative pathological processes, elevated levels of IL-6 and TNF-α can induce peripheral and central sensitization, exacerbate pain, induce oxidative stress and neuronal injury, impair cognitive function, and increase the risk of nausea, vomiting and fever [32]. Thus, the attenuated postoperative elevation of IL-6 and TNF-α provides a plausible biological link between the combined anesthesia regimen and its superior clinical outcomes, making our conclusions more robust and persuasive.

This anti-inflammatory effect correlates with better preservation of cognitive function, as reflected by significantly higher postoperative MoCA scores in the observation group, potentially resulting from minimized central nervous system depression caused by reduced general anesthetic exposure [33]. For elderly patients with compromised organ function, these advantages carry particular clinical significance. For instance, improved perioperative hemodynamic stability - with blood pressure maintained within approximately 10% of baseline values - may reduce the risk of myocardial ischemia in patients with cardiovascular comorbidities. Additionally, shorter extubation times and a lower incidence of postoperative nausea/vomiting in the observation group directly contributed to accelerated postoperative recovery, aligning with the physiological benefits of reduced anesthetic residue and opioid-sparing effects [34].

Beyond the molecular mechanism, this combined anesthesia regimen also exhibits good feasibility for popularization in primary hospitals, which further expands its clinical value. With the advancement of hierarchical diagnosis and treatment systems, access to portable ultrasound devices suitable for bedside nerve block has been gradually improved in grassroots medical institutions. For technical popularization, standardized training programs for physicians in primary hospital have been widely recognized to effectively enhance operational proficiency, enabling the regimen to meet basic clinical application requirements in grassroots settings.

Nevertheless, technical considerations need to be addressed to facilitate widespread clinical implementation of GA combined with ultrasound guided nerve block. Accurate ultrasound-guided needle placement and appropriate assessment of local anesthetic spread require specific training. In elderly patients with varying renal function, ropivacaine dosage protocols are important to avoid ropivacaine toxicity [35].

This study has several limitations. First, its retrospective design may have introduced selection bias and incomplete clinical capture. Second, as a single-center study with a relatively limited sample size, the generalizability of the findings may be constrained. Third, the follow-up was short without long-term outcome data. Finally, ultrasound block efficacy may have been influenced by variable operator experience. Future research should adopt a prospective, multicenter design, expand sample size, extend follow-up, and standardize protocols to improve reliability.

Conclusion

Our study provides robust evidence that general anesthesia combined with ultrasound-guided iliac fascia compartment block offers clinically meaningful advantages over general anesthesia alone in elderly patients undergoing hip surgery, supporting its routine use as an evidence-based anesthesia technique to enhance perioperative outcomes and quality of life in this vulnerable population.

Acknowledgements

This study was supported by the 2023 Guangxi Zhuang Autonomous Region Health and Health Commission self-funded scientific research project fund (Z-B20231353).

Disclosure of conflict of interest

None.

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