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Original Article

Effects of liposomal bupivacaine versus ropivacaine for fascia iliaca compartment block on postoperative pain and delirium in elderly patients undergoing hip arthroplasty

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Abstract: Objective: To compare the effects of fascia iliaca compartment block (FICB) with liposomal bupivacaine versus ropivacaine on postoperative pain and delirium in elderly patients undergoing total hip arthroplasty (THA). Methods: Eighty-six elderly patients who underwent THA were retrospectively enrolled. They were divided into a liposomal bupivacaine group (LB group, n=43) and a ropivacaine group (R group, n=43) based on the medication administered. Perioperative hemodynamic parameters, inflammatory markers, postoperative pain intensity, incidence of delirium, analgesic use, postoperative recovery outcomes, and complication rates were compared between the groups. Results: The LB group had significantly lower Numerical Rating Scale scores than the R group both at rest and on movement at 12, 24, 48, and 72 hours postoperatively (P<0.05). The LB group had significantly lower inflammatory marker levels than the R group at 24 and 48 hours postoperatively. The LB group had a significantly lower incidence of postoperative delirium (POD) than the R group (4.65% vs. 18.60%, P<0.05). The LB group had fewer patient-controlled intravenous analgesia (PCIA) attempts, longer time to first PCIA, and lower sufentanil consumption postoperatively (P<0.05). The LB group had significantly shorter time to first ambulation and length of hospital stay compared with the LB group (P<0.05). Conclusion: FICB with liposomal bupivacaine may be associated with prolonged analgesia, a lower incidence of POD, faster recovery, and fewer complications in elderly patients undergoing THA.

Keywords: Elderly patient, fascia iliaca compartment block, liposomal bupivacaine, delirium, ropivacaine, total hip arthroplasty

Introduction

As the population continues to age, the incidence of hip fractures among elderly individuals is gradually rising. Total hip arthroplasty (THA) is a widely used surgical treatment for hip fractures [1]. Evidence suggests that THA improves joint function and health-related quality of life in patients with hip fractures, thereby facilitating their mobility recovery [2]. However, despite advances in surgical techniques, many elderly patients still experience postoperative complications, including postoperative pain and delirium [3]. Postoperative delirium (POD) is an acute neuropsychiatric syndrome occurring in the postoperative period. It is a common complication following hip fracture surgery in elderly patients. POD is characterized by impaired consciousness and attention deficits, which may prolong the length of hospital stay (LOS), increase healthcare costs, elevate the risk of complications and mortality, and even lead to persistent cognitive impairment [4, 5]. Evidence suggests that postoperative pain is an important risk factor for POD. In addition, pain may impair sleep quality and promote the release of inflammatory factors, thereby contributing to the development of POD [6]. Therefore, effective and long-lasting perioperative analgesia may alleviate surgical pain and stress responses in elderly patients undergoing THA, reduce the incidence of POD, promote postoperative recovery, and improve prognosis and quality of life.

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With advances in ultrasound technology, ultrasound-guided nerve blocks have become an important part of multimodal analgesia for patients with hip fractures [7]. Ultrasound-guided suprainguinal fascia iliaca compartment block (FICB) is believed to provide superior analgesic effects compared with other nerve blocks. However, the main limitation of conventional local anesthetics in postoperative pain management is their short duration of action following a single injection, which may lead to rebound pain and may be insufficient to meet analgesic requirements during the first 48-72 hours postoperatively [8]. Liposomal bupivacaine, a long-acting local anesthetic formulation, provides sustained release of bupivacaine following local injection. Its biphasic release profile covers the postoperative pain period and may provide continuous analgesia for up to 72 hours [9]. In recent years, liposomal bupivacaine has been widely used in regional nerve block techniques for postoperative pain management in orthopedic surgery patients. It provides effective postoperative analgesia, improves clinical outcomes, reduces postoperative complications, and accelerates recovery, leading to shortened LOS. Therefore, it represents a promising option for postoperative multimodal analgesia [10].

However, evidence regarding whether liposomal bupivacaine used for FICB can reduce the incidence of POD in elderly patients undergoing THA remains limited. Therefore, this retrospective controlled study evaluated the clinical effectiveness of liposomal bupivacaine versus ropivacaine for FICB in elderly patients undergoing THA. The aim was to provide a longer-lasting and safer postoperative analgesia strategy for this population.

Materials and methods

Research protocol design

Ethical approval for this retrospective controlled study was granted by the Ethics Committee of Tongxiang First People's Hospital, and all procedures followed the guidelines of the Declaration of Helsinki. Given the retrospective design of this study and the use of anonymized data, the ethics committee waived the requirement for informed consent. Elderly patients undergoing THA who were hospitalized in the Department of Orthopedics at Tongxiang First People's Hospital from February 2025 to January 2026 were consecutively included. This was a retrospective, non-randomized study. Data were extracted from electronic medical records. Patients were assigned to groups according to the type of local anesthetic administered, which was determined at the discretion of the attending anesthesiologist based on routine clinical practice. The study population included patients with femoral neck fractures and those with intertrochanteric fractures. In patients with intertrochanteric fractures, the decision to perform THA was made by orthopedic surgeons based on fracture type, bone quality, and overall patient condition.

Inclusion criteria: (1) individuals aged ≥65 years who underwent THA; (2) American Society of Anesthesiologists (ASA) physical status class I-III; (3) patients with normal preoperative cognitive function who were able to cooperate with pain and delirium assessments; (4) complete medical records.

Exclusion criteria: (1) major organ dysfunction (heart, brain, lung, liver, or kidney); (2) allergy to local anesthetics; (3) puncture site infection; (4) previous inguinal surgery; (5) coagulation disorders; (6) inability to communicate or cooperate; (7) multiple fractures; (8) psychiatric disorders or psychiatric medication use; (9) preoperative delirium or medication use for delirium management; (10) history of acute cerebrovascular disease (intracerebral or subarachnoid hemorrhage) within 6 months; (11) operative time >3 hours or intraoperative blood loss >800 mL.

After screening according to the above criteria, 86 patients were included. Among them, 43 patients who underwent FICB with liposomal bupivacaine were assigned to the liposomal bupivacaine group (LB group), and 43 patients who underwent FICB with ropivacaine were assigned to the ropivacaine group (R group).

Anesthetic methods

Patients were instructed to fast for 8 hours and abstain from fluids for 2 hours prior to surgery. After the patient entered the operating room, intravenous access was established, and routine monitoring including blood oxygen saturation, electrocardiogram, and invasive arterial blood pressure was initiated. Oxygen was continuously delivered via a face mask. For sedation and analgesia, midazolam (1 mg) and sufentanil citrate (5 μg) were administered int-

ravenously. Five minutes later, an ultrasound-guided suprainguinal FICB was performed.

(1) FICB [10]: The patient was placed in the supine position, and the puncture site was disinfected and draped. A high-frequency linear array ultrasound probe was used for guidance and positioning. A nerve stimulation needle was connected to a nerve stimulator for nerve block. The probe was positioned above the inguinal ligament and moved medially after identification of the anterior superior iliac spine. The internal oblique muscle, sartorius muscle, iliopsoas muscle, and fascia iliaca were sequentially identified. The internal oblique and sartorius muscles formed a bow-tie image. The in-plane needle insertion technique was then used to advance the needle in a cephalad direction. After penetration of the fascia iliaca, negative aspiration for blood was confirmed, and the local anesthetic was administered. The LB group received liposomal bupivacaine (20 mL, 266 mg), whereas the R group received ropivacaine (20 mL, 75 mg). The doses of local anesthetics were not based on strict equivalent dose conversion, but rather on commonly recommended clinical doses. Specifically, 75 mg/20 mL of ropivacaine represents the standard dose for the suprainguinal FICB, while 266 mg/20 mL of liposomal bupivacaine corresponds to the recommended single-dose regimen. All procedures were performed by the same experienced anesthesiologist.

(2) Anesthesia induction and maintenance: After 30 minutes of FICB, the Numerical Rating Scale (NRS) score was used to evaluate the effectiveness of the block. Anesthesia induction: 0.05 mg/kg of midazolam, 0.3 μg/kg of sufentanil, 2 mg/kg of propofol, and 0.6 mg/kg of rocuronium bromide were administered intravenously. Subsequently, endotracheal intubation was performed, and mechanical ventilation was initiated. The intermittent positive pressure ventilation mode was selected with the following parameters: tidal volume ranging from 6 to 8 mL/kg, a respiratory rate of 12 breaths per minute, and an end-tidal carbon dioxide partial pressure maintained at 35-45 mmHg. Anesthesia was maintained with continuous administration of propofol at 4-6 mg/(kg·h) combined with remifentanil at 0.1-0.3 μg/(kg·min). The bispectral index was maintained at 45-55. The mean arterial pressure (MAP) and heart rate (HR) were maintained within 20% of the baseline value. Vasoactive agents were used as needed to maintain hemodynamic stability. Upon completion of the surgery, patients were transported to the post-anesthesia care unit. Following successful extubation, patient-controlled intravenous analgesia (PCIA) was initiated. Patients were discharged from the post-anesthesia care unit and returned to the ward after meeting standard discharge criteria.

(3) Postoperative analgesia: After surgery, all patients underwent PCIA. The PCIA solution was prepared by diluting 100 μg of sufentanil with normal saline to a final volume of 100 mL. The background infusion rate was 1 mL/h, the bolus dose was 2 mL, and the lockout interval was 15 minutes.

Outcome measures

Primary outcomes: (1) POD: The Confusion Assessment Method (CAM) [11] was used to evaluate the incidence of delirium in patients daily from 1 to 7 days postoperatively. The CAM was evaluated daily by ward nurses who had received standardized training, and the results were recorded in the electronic medical record system. Data were extracted retrospectively from the recorded CAM assessments. The assessors were not blinded to group allocation, as blinding is difficult to achieve in routine clinical practice. Delirium was defined as a positive CAM assessment on any day during hospitalization. No sedatives or antipsychotic medications were routinely administered during the study period. (2) Postoperative pain: The NRS [12] was used to evaluate the intensity of pain at rest and on movement at 6, 12, 24, 48, and 72 hours postoperatively. A score of 0 indicates no pain, and a score of 10 indicates severe pain. The NRS assessments were performed by the same group of nurses who had received standardized training, using a standardized verbal approach. For patients with hearing or communication impairments, written or visual aids were provided. The assessment results were documented in nursing records and incorporated into the medical records.

Secondary outcomes: (1) Baseline characteristics: Age, sex, body mass index, ASA classification, fracture type, and comorbidities were recorded. (2) Hemodynamic parameters: MAP and HR were recorded before anesthesia induction, 10 minutes after anesthesia induction, 30 minutes after the start of surgery, and at the

end of surgery. (3) Surgery-related indicators: Operative time, intraoperative blood loss, and intraoperative fluid volume were recorded. (4) Analgesic usage: The number of PCIA attempts within 72 hours postoperatively, the time to first PCIA, and the total sufentanil consumption were recorded. (5) Postoperative recovery outcomes: The time to first ambulation, time to first flatus, and LOS were recorded. (6) Complications: The incidence of complications, including nausea and vomiting, urinary retention, hypotension, delirium, deep vein thrombosis (DVT) of the lower limbs, pulmonary infection, and nerve block-related complications, was recorded. (7) Preoperative cognitive function assessment: Cognitive function screening was performed in all included patients 1 day before surgery using the Mini-Mental State Examination, which has a maximum score of 30 points. This assessment was used to evaluate the comparability of baseline cognitive status between the groups and to provide a reference for the interpretation of POD results. (8) Inflammatory markers: Peripheral venous blood samples were collected at 24 and 48 hours postoperatively. Serum interleukin-6 (IL-6) levels were measured using the enzyme-linked immunosorbent assay to assess the effects of the two local anesthetics on perioperative inflammatory stress responses and their potential association with POD.

Statistical approach

All data were analyzed using the Statistical Package for the Social Sciences (version 26.0). Continuous variables were assessed for normality using the Shapiro-Wilk test. All continuous data were normally distributed and are expressed as mean ± standard deviation. Differences between groups were analyzed using the independent samples t-test. Categorical variables were presented as number of cases and percentages [n (%)]. Differences between groups were compared using the χ^2 test or Fisher's exact test. For categorical variables with expected frequencies less than 5, Fisher's exact test was used, and the corresponding odds ratios (ORs) with 95% confidence intervals (CIs) were reported. Repeated measures data were analyzed using repeated measures analysis of variance. Statistical significance was defined as $P<0.05$. This retrospective observational study was designed and reported following the Strengthening the Reporting of Observational Studies in Epidemiology guidelines. Retrospective sample size estimation was performed based on the primary outcome, namely the incidence of POD. Previous literature reported an incidence of POD of approximately 20% after hip arthroplasty in elderly patients, and the incidence was expected to decrease to 5% in the LB group. With a two-sided α level of 0.05 and a statistical power of (1-β)=0.80, the required sample size was estimated to be 37 patients per group using Fisher's exact test. In this study, 43 patients were included in each group, which was sufficient to meet the statistical power requirements. Given that this was an exploratory observational study with multiple outcomes, Bonferroni correction for multiple comparisons was not applied to secondary outcomes. However, the *P* values for all primary outcomes were less than 0.05, indicating that the results are reasonably robust. The secondary outcomes should be interpreted with caution because multiple comparisons may increase the risk of false-positive findings.

Results

Comparison of baseline characteristics

Baseline characteristics such as sex, age, body mass index, ASA classification, fracture type, and comorbidities did not differ significantly between the groups (P>0.05), indicating comparability (**Table 1**).

Comparison of perioperative hemodynamic parameters

No statistically significant differences were observed between the two groups in MAP and HR before anesthesia induction, 10 minutes after anesthesia induction, 30 minutes after the start of surgery, and at the end of surgery (P>0.05) (**Figure 1**).

Comparison of surgery-related indicators

Both groups exhibited no statistically significant differences in operative time, intraoperative blood loss, and intraoperative fluid volume (P>0.05) (**Figure 2**).

Comparison of pain scores at different time points after surgery

Both groups demonstrated no statistically significant differences in the NRS scores at rest

Table 1. Comparison of baseline characteristics (mean ± standard deviation)/[n (%)]

Baseline characteristics		Liposomal bupivacaine group (n=43)	Ropivacaine group (n=43)	Fisher/t/χ^2	P
Mean age (years)		73.56±5.82	74.21±6.15	0.508	0.613
Sex	Male	17 (39.53)	19 (44.19)	0.194	0.660
	Female	26 (60.47)	24 (55.81)		
BMI (kg/m^2)		23.18±2.94	23.52±3.08	0.530	0.598
ASA classification	ASA I	5 (11.63)	4 (9.30)	-	0.868
	ASA II	28 (65.12)	30 (69.77)		
	ASA III	10 (23.26)	9 (20.93)		
Fracture type	Femoral neck fracture	25 (58.14)	23 (53.49)	0.190	0.663
	Intertrochanteric fracture	18 (41.86)	20 (46.51)		
Hypertension (cases)		27 (62.79)	25 (58.14)	0.196	0.658
Diabetes mellitus (cases)		15 (34.88)	17 (39.53)	0.197	0.657
Coronary heart disease (cases)		8 (18.60)	10 (23.26)	0.283	0.595
Preoperative MMSE score		27.21±1.81	26.91±2.08	0.712	0.479

BMI: body mass index; ASA: American Society of Anesthesiologists; MMSE: Mini-Mental State Examination.

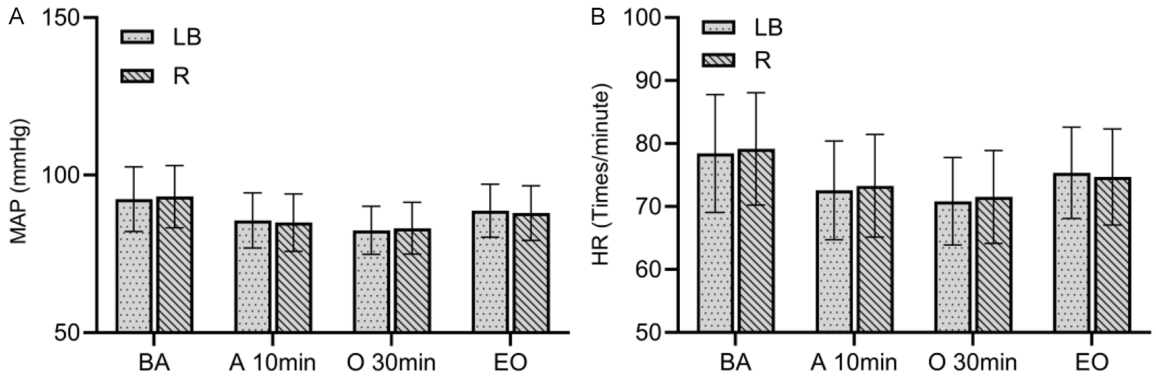

Figure 1. Comparison of perioperative hemodynamic parameters. No statistically significant differences were observed between the two groups in MAP (A) and HR (B) before anesthesia induction, 10 minutes after anesthesia induction, 30 minutes after the start of surgery, and at the end of surgery (P>0.05). Note: MAP: mean arterial pressure; HR: heart rate; LB: liposomal bupivacaine; R: ropivacaine; BA: before anesthesia; A 10 min: 10 minutes after anesthesia; O 30 min: 30 minutes after the start of operation; EO: end of operation.

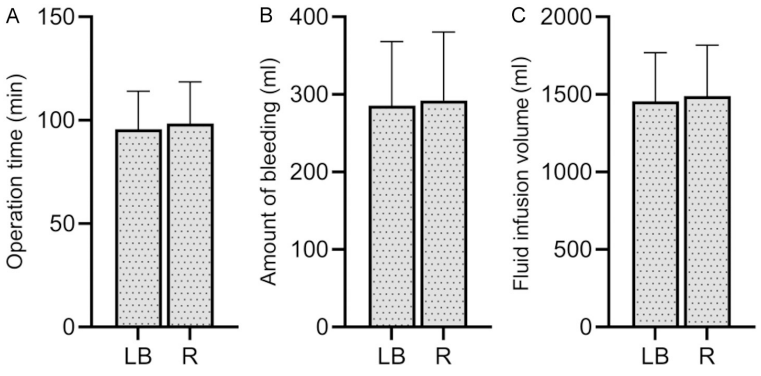

Figure 2. Comparison of surgery-related indicators. Both groups had no statistically significant differences in operation time (A), intraoperative hemorrhage (B), and the amount of fluid infused during the procedure (C) (P>0.05). Note: LB: liposomal bupivacaine; R: ropivacaine.

and on movement at 6 hours postoperatively (P>0.05). At 12, 24, 48, and 72 hours postoperatively, the LB group exhibited significantly lower NRS scores at rest and on movement than the R group (P<0.05) (**Figure 3**).

Comparison of postoperative serum IL-6 levels

The LB group demonstrated significantly lower IL-6 levels at 24 and 48 hours postoperatively compared with the R

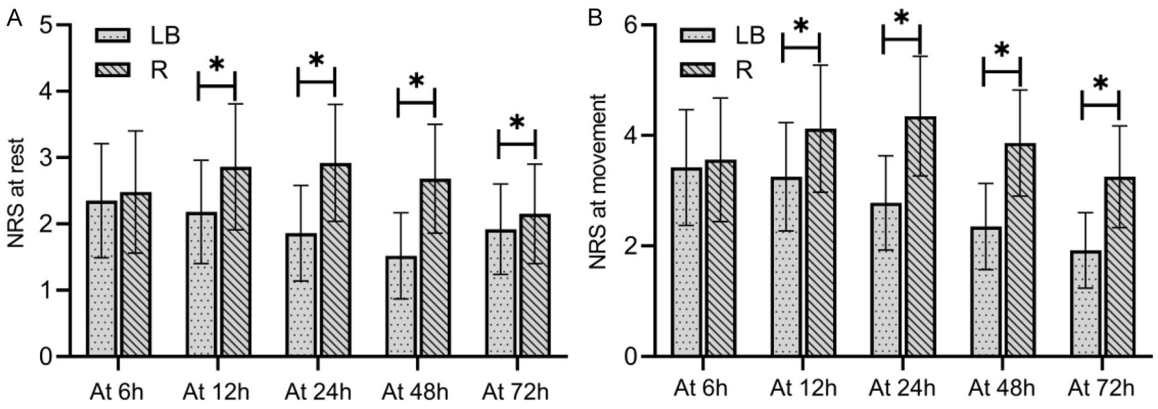

Figure 3. Comparison of pain scores at different time points after surgery. Both groups had no statistically significant differences in the NRS scores at rest (A) and on movement (B) at 6 hours postoperatively (P>0.05). At 12, 24, 48, and 72 hours postoperatively, the LB group exhibited significantly lower NRS scores at rest (A) and on movement (B) compared with the R group (P<0.05). Note: NRS: Numerical Rating Scale; LB: liposomal bupivacaine; R: ropivacaine. * denotes statistical significance between the groups.

Table 2. Comparison of incidence of complications after surgery [n (%)]

Complication type	Liposomal bupivacaine group (n=43)	Ropivacaine group (n=43)	χ^2/Fisher	P	OR (95% CI)
Nausea and vomiting	3 (6.98)	6 (13.95)	1.125	0.289	-
Urinary retention	1 (2.33)	3 (6.98)	1.053	0.305	-
Hypotension	1 (2.33)	2 (4.65)	0.346	0.556	-
Delirium	2 (4.65)	8 (18.60)	-	0.091	0.213 (0.043-1.071)
Deep vein thrombosis of the lower limbs	0 (0.00)	1 (2.33)	-	1.000	-
Pulmonary infection	1 (2.33)	2 (4.65)	0.346	0.556	-
Total incidence	7 (16.28)	15 (34.88)	3.913	0.048	-

group [(45.32±12.61) pg/mL vs. (58.72±15.31) pg/mL, t=4.430, P<0.001; (31.21±9.81) pg/mL vs. (48.62±13.23) pg/mL, t=6.135, P< 0.001], indicating that liposomal bupivacaine for FICB more effectively inhibited the perioperative inflammatory stress responses.

Comparison of incidence of POD

The incidence of POD in the LB group was 4.65% (2/43), which was significantly lower than that in the R group (18.60%, 8/43) (Fisher's exact test, P=0.044), with an OR of 0.21 (95% CI: 0.04-1.07) (**Table 2**). Delirium mainly occurred from 1 to 3 days postoperatively.

Comparison of postoperative analgesic usage

The LB group exhibited fewer PCIA attempts, longer time to first PCIA, and lower total sufentanil consumption compared with the R group within 72 hours postoperatively (P<0.05) (**Figure 4**).

Comparison of postoperative recovery outcomes

The LB group demonstrated significantly shorter time to first ambulation, time to first flatus, and LOS compared with the R group (P<0.05) (**Figure 5**).

Comparison of postoperative complication rates

The total perioperative complication rate was 16.28% (7/43) in the LB group, which was significantly lower than that in the R group (34.88%, 15/43) (χ^2=3.913, P=0.048), with an OR of 0.36 (95% CI: 0.13-1.01) (**Table 2**).

Discussion

Effect of liposomal bupivacaine for FICB on postoperative pain

Pain management is an important link in the perioperative period of hip fractures in the

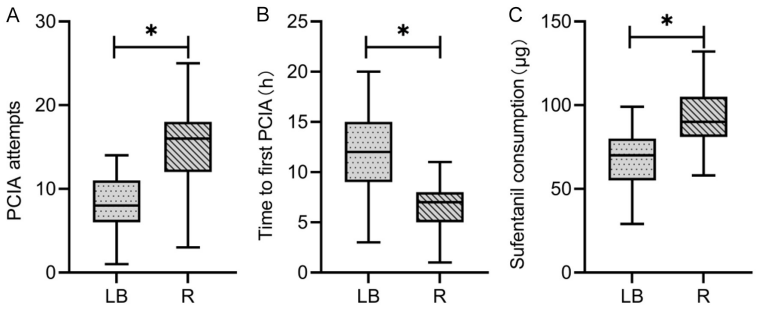

Figure 4. Comparison of analgesic usage after surgery. Within 72 hours after surgery, fewer PCIA attempts (A), longer time to first PCIA (B), and lower total sufentanil consumption (C) were observed in the LB group than those in the R group (P<0.05). Note: PCIA: patient-controlled intravenous analgesia; LB: liposomal bupivacaine; R: ropivacaine. * denotes statistical significance between the groups.

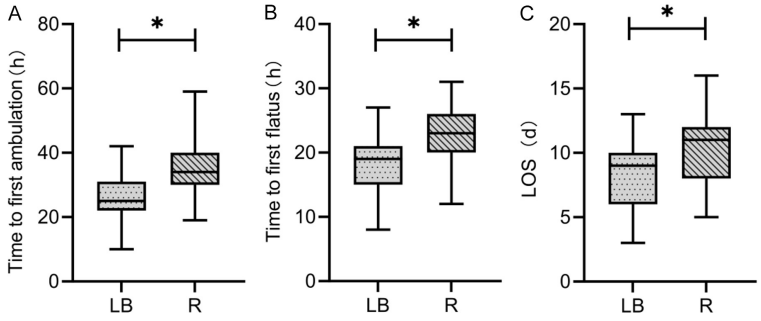

Figure 5. Comparison of recovery indicators after surgery. Significantly shorter time to first ambulation (A), time to first flatus (B), and LOS (C) were observed in the LB group than those in the R group (P<0.05). Note: LOS: length of hospital stay; LB: liposomal bupivacaine; R: ropivacaine. * denotes statistical significance between the groups.

elderly. This study revealed no statistically significant differences in NRS scores at rest and on movement between the groups at 6 hours postoperatively. However, at 12, 24, 48, and 72 hours postoperatively, the LB group demonstrated significantly lower NRS scores, lower analgesic consumption, and longer time to first PCIA attempt compared with the R group. The findings suggest that liposomal bupivacaine may provide a longer-lasting postoperative analgesic effect. The main cause of the above phenomenon is related to the drug mechanism. Specifically, ropivacaine is a conventional long-acting local anesthetic. Following a single injection, the analgesic duration is usually 8-12 hours, which is insufficient to cover the peak pain period of 48-72 hours postoperatively. Liposomal bupivacaine consists of multivesicular liposomes. After local injection, bupivacaine is gradually released over time. Its biphasic release characteristics allow the analgesic effect to last up to 72 hours [13]. In this study, both groups exhibited no significant differences in pain scores at 6 hours postoperatively, which may be related to the fact that both drugs provide effective analgesia at the early stage. However, as time progressed, the analgesic effect of the R group gradually diminished, while the sustained-release advantage of liposomal bupivacaine began to emerge. Previous research has indicated that effective perioperative analgesia facilitates accelerated postoperative rehabilitation, shortens bed rest duration, decreases the incidence of complications such as venous thromboembolism, and improves patients' subjective experiences [14]. This finding is consistent with our results, suggesting the potential value of liposomal bupivacaine in postoperative analgesia following THA in the elderly.

Currently, there is no established equivalence for dose conversion between the two local anesthetics (liposomal bupivacaine 266 mg vs. ropivacaine 75 mg), which may affect the interpretation of the results. The dose of ropivacaine used in this study (75 mg/20 mL) represents a commonly used clinical dose for suprainguinal FICB, while liposomal bupivacaine (266 mg/20 mL) corresponds to the standard recommended single-dose regimen. However, the lack of dose equivalence between the two anesthetics is acknowledged as a limitation and is further discussed in the limitations section. In addition, both groups used sufentanil PCIA as a common analgesic regimen, which may have masked the pain differences between the groups to some extent. However, under the same PCIA regimen, the reduced PCIA consumption observed in the LB group still suggests an additional analgesic benefit of liposomal bupivacaine.

Effect of liposomal bupivacaine for FICB on POD

In our study, the LB group exhibited a lower incidence of POD compared with the R group. POD is a common complication after hip fracture surgery in the elderly. It prolongs LOS, increases the financial burden on patients, and also raises the incidence of complications and mortality. The pathogenesis of POD is complex and involves multiple factors such as neuroinflammation, neurotransmitter imbalance, and stress responses. Pain may be closely related to POD, and persistent pain may increase the risk of delirium, cognitive dysfunction, sleep disorders, and anxiety [15, 16]. In this study, the reduced incidence of POD in the LB group may be related to several aspects. First, the long-lasting analgesia provided by liposomal bupivacaine may reduce the stimulation of pain to the central nervous system. Second, effective analgesia may reduce the use of opioids, which are considered an important inducing factor for POD. Third, effective pain control may improve sleep quality and reduce the release of inflammatory factors [17, 18]. It should be emphasized that the findings of serum IL-6 levels in this study further provide objective biological evidence supporting the aforementioned mechanisms. Serum IL-6 levels at 24 and 48 hours postoperatively were significantly lower in the LB group compared with the R group, suggesting that sustained and effective local analgesia can more effectively inhibit the systemic inflammatory stress responses induced by surgical trauma. Previous studies have shown that persistent increase of pro-inflammatory cytokines (e.g., IL-6) may promote the development of POD through mechanisms including blood-brain barrier disruption and glial cell activation [15]. Therefore, the advantage of liposomal bupivacaine in reducing postoperative IL-6 levels may represent one of the important mechanisms underlying its ability to decrease the incidence of POD, providing stronger pathophysiological support for the findings of this study.

However, due to the retrospective design, limited sample size, and the lack of control for important confounding factors, including baseline cognitive function, perioperative blood transfusion, sleep status, and the use of relevant medications, the above mechanisms remain speculative. The findings of our study suggest that liposomal bupivacaine for FICB may help reduce the incidence of POD in elderly patients undergoing THA by providing longer-lasting and effective analgesia. This has important clinical implications for improving the postoperative prognosis of elderly patients.

Effect of liposomal bupivacaine for FICB on hemodynamics

In this study, there were no statistically significant differences in MAP and HR between the two groups at each time point during the perioperative period. It suggests that the two local anesthetics used for FICB have similar effects. As a peripheral nerve block technique, FICB mainly acts on local nerves and has a relatively small impact on systemic hemodynamics, which is one of its important advantages over neuraxial anesthesia [19]. The sustained-release property of liposomal bupivacaine enables the drug to be gradually released into the bloodstream, avoiding a sharp increase in blood drug concentration and theoretically offering better cardiovascular safety [20]. Nevertheless, both groups exhibited no significant differences in hemodynamics in this study. It confirms that liposomal bupivacaine has good hemodynamic stability for FICB and is suitable for elderly patients with poor cardiovascular reserve.

Effect of liposomal bupivacaine for FICB on postoperative recovery

In this study, the LB group demonstrated earlier time to first ambulation, earlier time to first flatus, and shorter LOS compared with the R group. The shortening of the time to first ambulation is mainly attributed to effective analgesia. Persistent and effective analgesia enables patients to start activities earlier, which is of great significance for preventing bedridden complications such as DVT of the lower limbs and pulmonary infection [21]. The shortened time to first flatus reflects the early recovery of the patient's gastrointestinal function. The significant reduction in opioid consumption in the LB group may be an important reason for the shortened time to first flatus. The shortened LOS decreases the patient's medical expenses and reduces the risk of nosocomial infection,

which is especially important for elderly patients [22]. It should be noted that this study did not record a standardized protocol for early postoperative mobilization, and it remains unclear whether both groups received identical rehabilitation guidance. This potential confounding factor may have affected the postoperative recovery outcomes.

Safety of liposomal bupivacaine for FICB

In this study, the LB group exhibited significantly lower total complication rate compared with the R group. Neither group exhibited nerve block-related complications. It indicates that ultrasound-guided FICB exhibits a good safety profile. The incidence of complications in the LB group was relatively low, which might be related to the following aspects. First, the reduction in the incidence of delirium directly decreases the total number of complications. Second, effective analgesia reduces the consumption of opioids and lowers the incidence of adverse reactions related to opioids. Third, earlier ambulation reduces the risk of DVT of the lower limbs and pulmonary infection [23]. Previous research [24] has reported that liposomal bupivacaine exhibits similar safety to bupivacaine hydrochloride. Our study further verifies that liposomal bupivacaine is safe for FICB in elderly patients undergoing THA.

Clinical implications and limitations

The results of this study indicate that liposomal bupivacaine for FICB has significant advantages in THA among elderly patients. It may provide longer-lasting postoperative analgesia, reduce the incidence of POD, facilitate postoperative recovery, and decrease complications. From the perspective of health economics, although the drug cost of liposomal bupivacaine is higher than that of ropivacaine, it shortens LOS, reduces complications, and decreases the consumption of opioids, thereby reducing the overall medical expenses. However, this study did not perform a formal cost-effectiveness analysis, and the economic impact needs to be evaluated in prospective studies.

Our research also has some limitations. (1) In this single-center retrospective analysis, patients were grouped based on their actual clinical medication use rather than randomization, which introduced inherent selection bias. Therefore, the influence of baseline patient characteristics or physician preference on the outcomes cannot be entirely excluded. Propensity score matching was not performed in this study, and selection bias could not be further adjusted statistically. Future studies should consider employing propensity score matching or randomized controlled trial designs to validate these findings. (2) The limited sample size restricts the wide applicability of the findings, which should be validated in multicenter studies with larger cohorts. (3) The follow-up period for the patients was relatively short. The long-term impact on outcomes such as persistent pain and functional recovery remains unclear. (4) The study did not involve a formal cost-effectiveness analysis. (5) Although preoperative Mini-Mental State Examination scores were included in this study as a baseline cognitive indicator, important delirium-related confounders, including physical status/frailty scores, perioperative hemoglobin levels and transfusion status, sleep status, and the use of benzodiazepines or anticholinergic medications, were not assessed, which may affect the interpretation of delirium outcomes. (6) CAM assessments were not performed in a blinded manner, which may have introduced observer bias. (7) The two local anesthetics were not administered according to equivalent dosing principles. It remains uncertain whether the R group received a relatively insufficient dose, which may lead to systematic bias favoring liposomal bupivacaine. (8) The early postoperative mobilization protocol was not standardized, which may have affected the comparability of recovery outcomes. (9) The analysis of complications was presented as a combined report; no distinction was made between anesthesia-related and surgery-related events. (10) The measurement of IL-6 in this study was retrospectively extracted, and the limited number of time points may not fully reflect the dynamic changes in inflammation. Future studies should include multiple time-point assessments and incorporate additional inflammatory markers such as tumor necrosis factor-α and interleukin-1β. Additionally, all FICBs analyzed in our research were performed by anesthesiologists with clinical experience under ultrasound guidance. Therefore, when applying this technique in clinical practice, the technical training of

operators should be emphasized. In the future, multicenter, large-sample randomized controlled trials should be implemented to verify the efficacy and safety of liposomal bupivacaine for FICB.

FICB with liposomal bupivacaine may be associated with longer analgesic duration, reduced opioid consumption, faster postoperative recovery, lower complication rates, and reduced incidence of POD in elderly patients undergoing THA compared with ropivacaine, suggesting that it is a safe and effective option for postoperative analgesia. However, due to the retrospective nature and small sample size of this study, these findings require further validation in prospective randomized controlled trials prior to broad clinical implementation.

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Disclosure of conflict of interest

None.

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